AWI Exhibit 1

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July 31, 2015

BY ELECTRONIC MAIL

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

Dear Mr. Stone:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Additional comments:

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

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

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

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

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

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

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

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[2] S*ee Metcalf v. Daley*, 214 F.3d 1135, 1138, 9th Cir. (2000), quoting the International Convention for the Regulation of Whaling, 62 Stat. 1716, 1717 (1946). See also, 161 United Nations Treaty Series 72.

[3] Metcalf v. Daley, Id., citing 62 Stat. 1718-19.

[4] *Anderson v. Evans*, 371 F.3d 475, 483 (2002).

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Marine Mammal Protection Act

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

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

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

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

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

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

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

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

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

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

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

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

2. The Makah MMPA waiver application:

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

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

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

Treaty of Neah Bay:

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

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

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

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

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

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

Limitations and legal implications of the MMPA waiver request:

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

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

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

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

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

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

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

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

Additional limited waiver request:

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

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

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

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

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

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

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

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

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

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

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[13] At a minimum, if NMFS makes a preliminary determination to issue an MMPA waiver to the Makah Tribe it must make a stock determination for PCFG whales before the administrative law judge hearing in order to meet the requirements of the MMPA.

[14] The revisions are available at http://www.nmfs.noaa.gov/pr/pdfs/sars/gamms3_appendix4.pdf

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

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

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

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

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

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

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

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

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

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

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

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

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

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[16] This raises a question as to whether, in calculating a PBR for the OR-SVI PCFG whales that PBR should be lowered based on the proportion of OR-SVI gray whales in Canada.

[17] Furthermore, Lang et al. (2014) notes that “although uncertainty remains, our results indicate that it is plausible that the PCFG represents a demographically independent group and suggest that caution should be used when evaluating the potential impacts of the proposed Makah harvest on this group of animals.”

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Endangered Species Act

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

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

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

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

National Environmental Policy Act

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3. NMFS has failed to define the impact levels used in the DEIS:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Other Federal Agencies and Additional Legal Concerns

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

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

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

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

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

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

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

<u>Olympic Coast National Marine Sanctuary (OCNMS):</u>

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

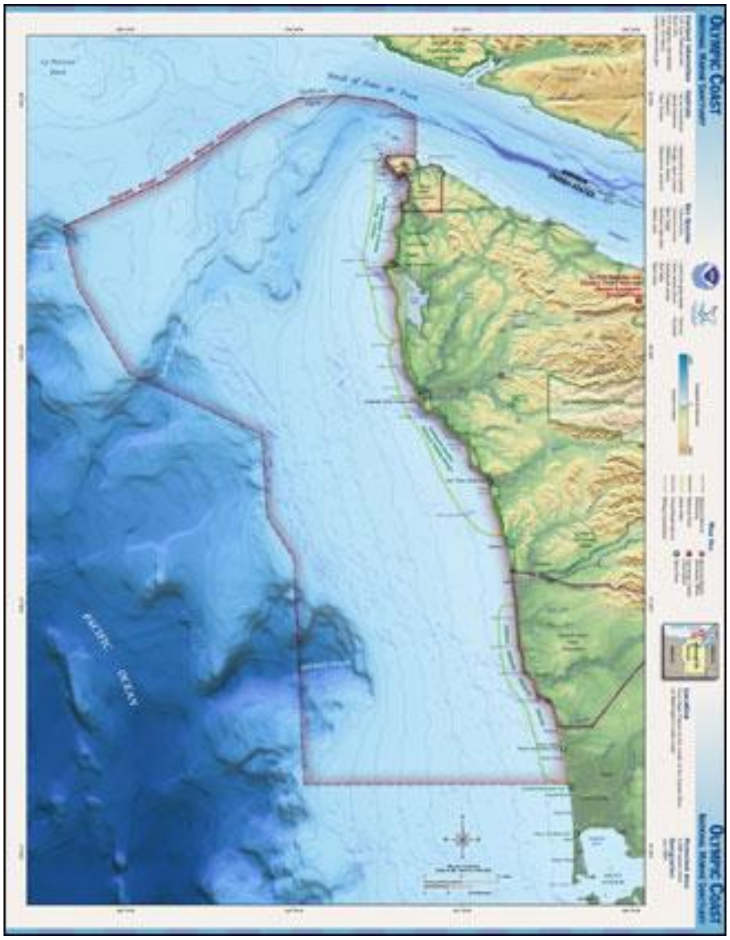

Figure 1: Map of OCNMS (available at http://sanctuaries.noaa.gov/pgallery/atlasmaps/oc.html)

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

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

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

15 CFR § 922.152(a)(6)

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

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

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

<u>(Final Management Plan and EA at 10; emphasis added).</u>

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

<u>*Washington Islands National Wildlife Refuges:*</u>

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

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

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

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

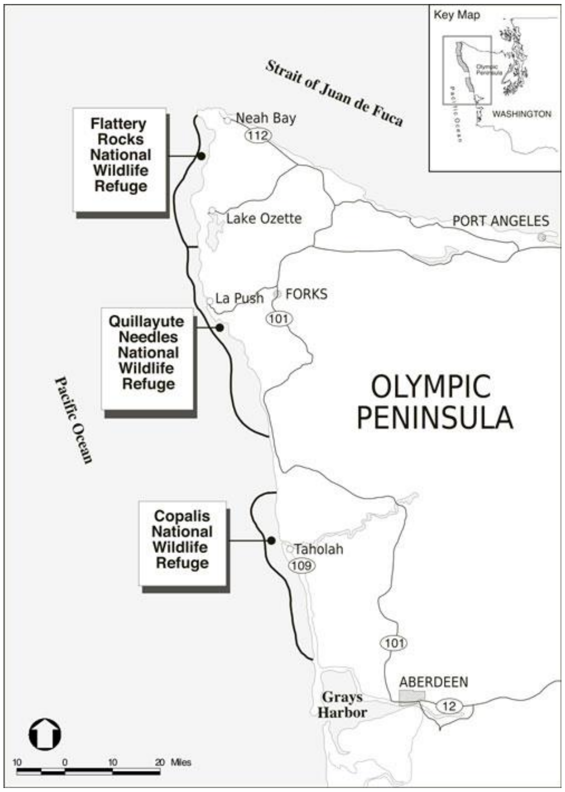

Figure 2: Map of the Washington Islands National Wildlife Refuges (available at http://www.thearm chairexplorer.com/washington/w-images/nwr-photos/Washington_Maritime_NWRC_Ma.jpg)

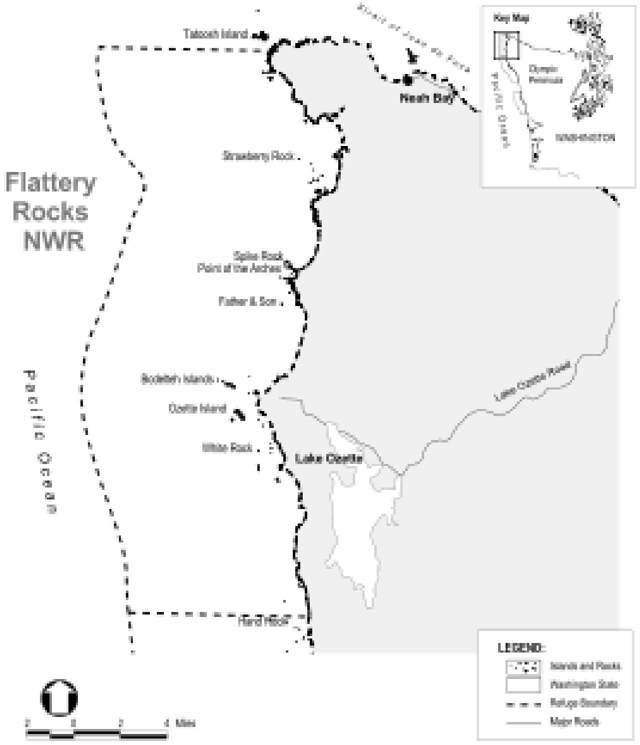

Figure 3: Map of Flattery Rocks National Wildlife Refuge (available at https://upload.wikimedia.org.wikipedia/commons/thumb/7/70/Flattery_Rocks_NWR_Map.svg/283px-Flattery_Rocks_NWR_Map.svg.png

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

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

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

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

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

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

Olympic National Park:

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

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

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

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

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

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

The Wilderness Act

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

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

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

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

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

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

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

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

Scope and focus of DEIS analysis:

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

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

DEIS at 3-122.

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

Pacific Coast Feeding Group:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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[25] This finding is included in the analysis of Alternative 4. However, NMFS also notes in the DEIS that “Alternative 4 is less likely to affect PCFG viability compared to Alternatives 2 and 3 because the hunt would target males and would not affect matrilineal recruitment.” DEIS at 4-101.

[26] Data obtained from https://iwc.int/table_aboriginal

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

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

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

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

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

Western North Pacific gray whales:

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

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

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

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

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

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

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

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

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

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

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

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

Alternative 1:

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

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

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

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

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[29] Data obtained from https://iwc.int/table_aboriginal

[30] Based on discussions at recent IWC meetings, the Russian Federation may attempt to increase the ASW quota for gray whales in the future to compensate for “stinky” whales that are reportedly inedible.

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

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

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

Alternative 2:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Alternative 3:

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

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

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

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

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

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

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

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

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

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

Alternative 4:

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

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

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

Alternative 5:

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

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

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

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

Alternative 6:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

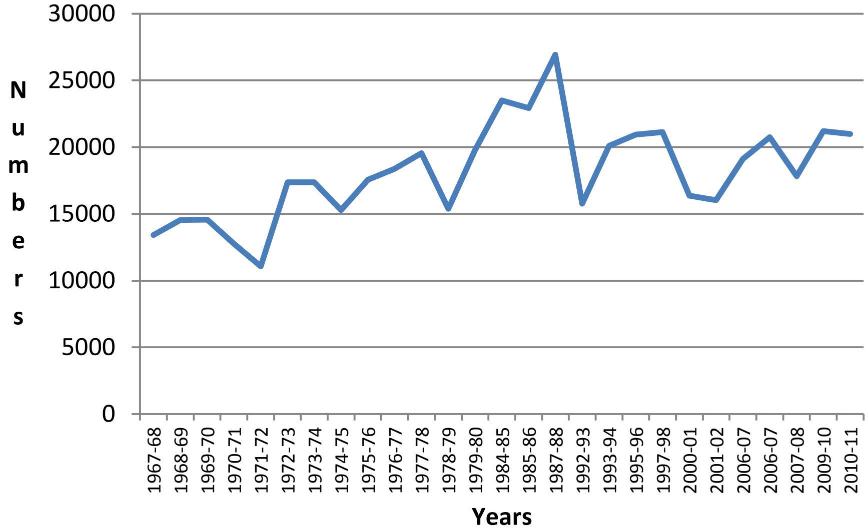
nesting or if they are foraging just off shore" but then concludes that it is "difficult to determine what impact this type of direct short-term effect would have on the long-term productivity of populations as a whole, although it might be a negligible loss." DEIS at 4-130. Or it claims such long-term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

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

<u>Gray whale population trends and carrying capacity</u>

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

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



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

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

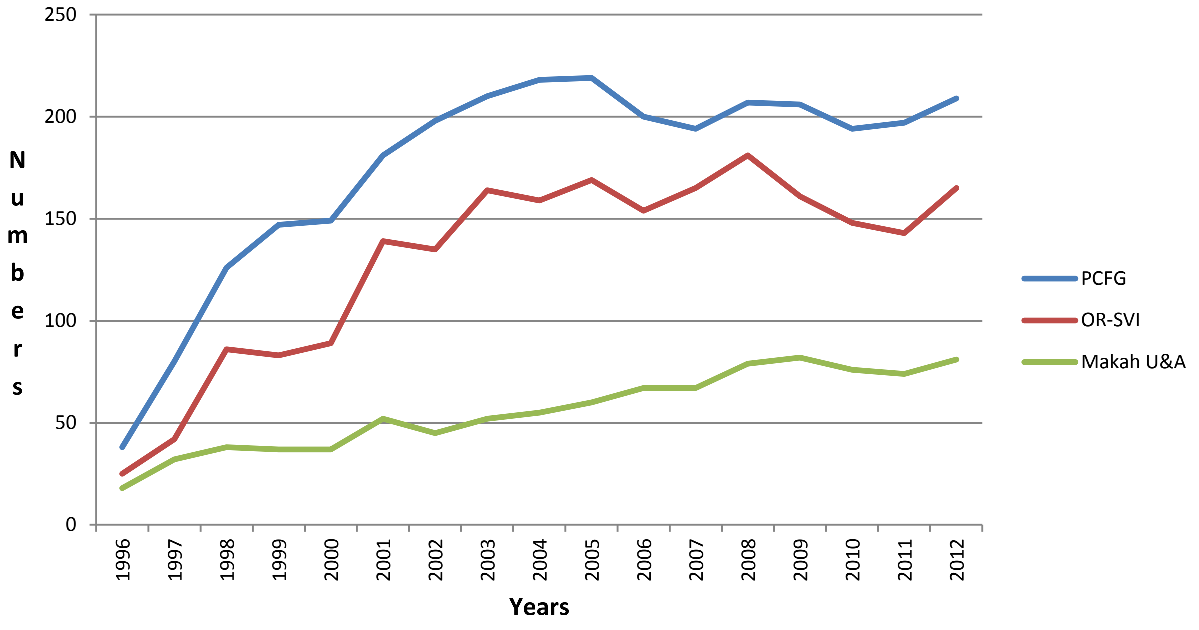

Figure 6: PCFG, OR-SVI and Makah U&A Gray Whale Population Trend (1996-2012)

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

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

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

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

Id.

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

Lack of disclosure of critical information and deficient analysis of impacts

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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[38] See http://www.economagic.com/em-cgi/data.exe/blsap/APU0400FC3101

[39] http://www.walmart.com/ip/Great-Value-100-Extra-Virgin-Olive-Oil-25.5-oz/10316039

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

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

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

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

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

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

<u>NMFS has improperly applied the environmental justice concept to the proposed Makah whale hunt:</u>

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

<u>NMFS has failed to comprehensively evaluate the adverse impacts of the proposed hunt on aesthetics:</u>

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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[45] See K. Rogers, American Hunter Killed Cecil, Beloved Lion That Was Lured Out of Its Sanctuary, New York Times, July 28, 2015 (available at http://www.nytimes.com/2015/07/29/world/africa/american-hunter-is-accused-of-killing-cecil-a-beloved-lion-in-zimbabwe.html?emc=eta1).

[46] See http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=DEC_10_DP_DPDP1&prodType=table?

[47] See http://www.peninsuladailynews.com/article/20110225/NEWS/302259982

[48] See http://quickfacts.census.gov/qfd/states/02000.html

[49] See https://www.google.com/?gws_rd=ssl#safe=active&q=how+many+people+live+in+Barrow%2C+AK

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Importantly, as noted in the DEIS:

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

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

While the concentration of persistent organic pollutants in whale blubber is typically higher or comparable to those in other tissues, heavy metal concentrations are typically higher in muscle tissues compared to blubber. Mean metal concentrations (in µg/kg dry weight) found in gray whales, as reported in the DEIS, range from 0.4 to 0.86 cadmium, 3.1 to 4.1 copper, 305 to 1,009 iron, 0.6 to 1.11 lead, 0.33 to 0.8 manganese, 0.145 mercury, 1.39 nickel, and 120 to 279 zinc.

Considering that contaminants are already found in foods presently consumed by the Makah, including fish and shellfish, as well as store-bought food, whether adding whale products will have a positive or negative effect is unclear. Since, as NMFS admits, no database is available to "compare the amount of contaminants currently being consumed by the Makah Tribe with the amount of contaminants found in fresh whale products," it is "difficult to determine the net change in contaminants to which tribal members would be exposed." DEIS at 4-257.

Nevertheless, since whale products, particularly blubber, “would likely contain higher levels of certain contaminants (e.g., PCBs) than other foods consumed by the Makah,” *id*., NMFS cautions that whale products may exceed levels that trigger human health concerns based on guidelines published by state and federal agencies. *Id.* Similarly, NMFS reports that “changes in the quantity of freshly harvested whale consumed would probably not appreciably change the potential for food-borne illness to occur in Makah tribal members.” DEIS at 4-258.

There are several deficiencies in the analysis of the impact of environmental contaminants in the DEIS.

First, NMFS has failed to disclose sufficient data to evaluate the relevant impacts of such contaminants on the Makah if they are allowed to hunt whales. Not only are there apparently no data on the current contaminant loads in Makah tribal members from their high-fish diet, but NMFS provides no data on the contaminant profiles of the fish species and other food products typically consumed on the Makah reservation.

Second, although NMFS refers to state and federal food safety standards in the DEIS, it fails to identify those standards, fails to provide any reference to them so that interested stakeholders could examine them, and fails to compare those standards, with the sole exception of the PCB example provided above, to the concentration of contaminants documented in gray whales.

Third, many of the studies cited in Tables 3-47 and 3-48 are also rather dated, which calls into question the accuracy of the documented concentrations in terms of what may be found in gray whales today. Despite these deficiencies, to be precautionary, particularly with regard to the health of Makah tribal members and recognizing that NMFS concedes that consuming whale products may trigger health concerns; NMFS should deny the MMPA waiver application on health grounds alone. Surely NMFS does not want to authorize a gray whale hunt when there is a distinct possibility that consumption of products from the hunt could compromise human health.

<u>NMFS has failed to adequately evaluate the precedential impacts of the issuance of a waiver to the Makah Tribe:</u>

One of the key issues emphasized in the *Anderson* opinion was the potential for a Makah whale hunt to create the precedent for other whale hunts in the United States and around the world. In evaluating this potential impact, NMFS considers the potential change in the number of requests for MMPA waivers to permit the killing of marine mammals in US waters (other than whales) and for regulatory action to permit the killing of whales in US waters. DEIS at 4-260. The DEIS identifies a number of US tribes between the Aleutian Islands and California who hunted gray whales and/or used drift whales for subsistence as part of their cultural and religious traditions. These tribes include the Aleuts, Koniag, Chugash, Tiglit, Haida, Tsimshian, Nootka, Makah (including the Ozette), Quileute, Klallam, and Chomash. DEIS at 3-176. However, this list is incomplete, as it does not include any tribes that live on the east or Gulf coasts that may have historically hunted whales.

NMFS concedes the fact that Northwest Indian tribes have previously expressed an interest in killing marine mammals, that an authorization of a Makah gray whale hunt could revive the interest of the Makah or other tribes in hunting marine mammals, and that it could increase interest by non-Indians in sport or commercial hunting of marine mammals. DEIS at 4-261. Despite this concession, NMFS largely dismisses the potential for an increase in waiver requests if the Makah's MMPA waiver is granted, claiming, for example, that "history suggests that there is little interest by other native groups to seek authorization to harvest whales." *Id*.

This conclusion may be misplaced, however, since both the Makah and other US coastal tribes, including those on the east and Gulf coasts, may simply be waiting for the outcome of the Makah waiver application before proceeding with their own request for whales or other marine mammals. While there is no evidence yet that this will occur, tribes with an interest in obtaining a waiver would not help their own cause – or the cause of the Makah to obtain a waiver to kill gray whales – if they were to prematurely announce their intent before the current process ended. Such an announcement would support the argument that the Makah Tribe's waiver application has had a significant precedential impact, thereby supporting a denial of the waiver.

Many tribes, particularly in the Northwest, have expressed a desire to kill seals and sea lions, given the perceived conflict with fisheries, particularly salmon fisheries. The Northwest Indian Fisheries Commission recently opined that "harbor seal and sea lion populations must be brought back into balance with the reality of today's ecosystems, which cannot support their steadily increasing numbers."[55] It is myopic for NMFS to conclude that the outcome of the Makah Tribe's waiver application will have no influence on the likelihood of these tribes applying for their own waivers. Even the Makah Tribe may choose to pursue additional waivers if its whaling waiver is obtained, considering that it ceased authorizing tribal members to take any marine mammals in 2005 as a result of the *Anderson* opinion. DEIS at 3-215.

Furthermore, the recent decision in *United States v. Washington* opens the door to a significant increase in MMPA waiver requests. In that case, initiated by the Makah Tribe to determine the boundaries of the usual and accustomed fishing grounds of the Quileute and Quinault tribes, the court concluded that "'fish as used in the Treaty of Olympia encompasses sea mammals and that evidence of customary harvest of whales and seals at and before treaty time may be the basis for the determination of a tribe's U&A." *United States v. Washington*, No. C70-9213, slip

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[55] See http://nwifc.org/2015/04/10158/

op. at 78 (W.D. Wa. July 9, 2015; Attachment 7).[56] This is now a legal precedent defining a treaty right to fish to encompass the hunting of marine mammals, including cetaceans. Therefore, the Coalition concludes that MMPA waiver applications are very likely to increase. Admittedly, the ruling in *United States v. Washington*, issued on July 9, 2015, was not available to NMFS when it prepared the DEIS, but it now represents new information that must be considered as NMFS continues with the NEPA and MMPA waiver processes.

NMFS concludes that "it is also unlikely that other countries could use authorization of a Makah whale hunt under Alternatives 2-6 as leverage for increasing commercial or scientific whaling." DEIS at 4-267. To support this conclusion, NMFS cites to the skirmish between Japan and the United States over the Alaskan bowhead whale quota in 2002. While it is true this situation did not result in a "fundamental change in the United States position" on commercial or scientific whaling, it did result in the United States voting in favor of Japan's small-type coastal whaling proposal at a special meeting of the IWC called to address, in particular, the bowhead quota. In that case, though the US vote for small-type coastal whaling did not practically benefit Japan (as there were sufficient no votes to block the proposal even with the United States voting in support), it was clearly a psychological victory for Japan given by the United States in order to secure the bowhead whale quota. To think that Japan would not attempt to block a US ASW quota in the future to compel a change, even temporary, in a US position at a future IWC meeting is naïve.

Admittedly, the Makah ASW request may not provide Japan with the same leverage over the United States as did the bowhead whale quota. This is because the Makah ASW quota is for a small number of whales and, if blocked, the repercussions are not as significant for the Makah as are the implications for Alaska Natives. The Makah, as Japan is well aware, have not regularly engaged in whaling for nearly 90 years (and potentially as long as 165 years) and have access to a variety of other foodstuffs. Conversely, the bowhead quota is for a larger number of whales for which the 11 Alaskan whaling villages have a genuine nutritional, subsistence, and cultural need.

Furthermore, the suggestion that ASW was not a consideration in the effort to construct an agreement leading up to the 2010 IWC meeting that, if approved, would have undermined the commercial whaling moratorium is also without merit. The principal reason the US ASW quotas were not challenged at the 2007 meeting, held in Anchorage, AK, is because the late Senator Ted Stevens negotiated an agreement, believed to be unwritten, with Japan. In its simplest terms, that agreement ensured that Japan did not object to the United States quota request, particularly its request for bowhead whales, at the Anchorage meeting in exchange for US

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[56] In the opinion, the court provides significant details as to the history of whaling, sealing, and fishing by both the Quileute and Quinault tribes. It also identifies several other tribes that also had a tradition of whaling.

leadership in the process that led to the proposed "deal" to lift the commercial whaling moratorium, which was soundly rejected at the 2010 IWC meeting.

Finally, NMFS' dismissal of the potential adverse precedent that Makah whaling could have on other IWC countries seeking whaling opportunities for their own people, including aboriginal people, is in error. Fundamentally, the mere fact that the United States was able to secure a quota for the Makah in 1997, given that the Tribe did not qualify (and still does not qualify) for an ASW quota, has already substantially weakened the ASW criteria within the IWC. NMFS even admits that the Makah whale hunt is different from other aboriginal subsistence hunts because of "the Tribe's 70-80 year hiatus in whaling." DEIS at 4-268. While approval of the Makah quota as recently as 2012 has not been explicitly used by any country to seek IWC approval to allow its own people to engage in whaling, this may occur in the future. Indeed, considering that the Makah hunt has been prevented from occurring as a result of legal action, if NMFS is able to ultimately permit the Makah to begin to actively use the IWC-approved quota, this could be the trigger that other countries are waiting for to exploit the 1997 decision.

This does not mean that the damage done by the United States to the ASW standards in 1997 cannot be reversed. This is possible, but only if the US denies the Makah Tribe's MMPA waiver request and does not pursue another gray whale ASW quota for the Makah at any future IWC meetings. This would not erase the adverse precedent set in 1997, but it would return some integrity to the IWC's ASW standards.

<u>NMFS has failed to fully disclose all relevant information regarding the cumulative impact of the proposed hunt and to adequately analyze such impacts:</u>

NEPA requires federal agencies to evaluate the cumulative impact of any proposed action or other alternatives on the environment. Under NEPA, a "cumulative impact" is defined as an "impact on the environment which results from the incremental impact of the action when added to the past, present, and reasonably foreseeable future actions, regardless of what agency (federal or non-federal) or person undertakes such other actions. DEIS at 5-1 and 40 CFR § 1508.7. Much of the information contained in the cumulative impact analysis (CIA) section of the DEIS overlaps with information regarding other threats to gray whales. Consequently, those issues are addressed together in this section of the comment letter.

The geographic and temporal scope of the CIA included the entire range of ENP gray whales over an indefinite time period. DEIS at 5-2/5-3. These provide an appropriate scope for the CIA although, considering that WNP gray whales are known to emigrate into the ENP region and that one or more could theoretically be killed as a result of the hunt, not including the WNP range in the CIA is in error. DEIS at 5-2. Surely, if a Makah hunt resulted in the death of a WNP gray whale then understanding the impact to a critically endangered population of gray whales given other existing and increasing threats would be relevant and should have been included in the CIA.

In its analysis of the CIA, NMFS ostensibly evaluated past, present, and reasonably foreseeable actions in the following categories: harvest of gray whales, shipping, military exercises, fisheries, tourism, marine energy and mining projects, scientific research, natural mortality, climate change and US government policy. DEIS at 5-4. The background portion of the analysis simply confirms that these activities will continue in the future and will impact gray whales to some degree. NMFS then attempts to evaluate the actual cumulative impacts of these different actions in the section 5.2 of the CIA but its analysis is woefully inadequate. Consequently, it is of no surprise that NMFS concludes that nearly all of the 15 environmental factors evaluated will not result in a significant cumulative impact. The only exceptions to this is for the environmental justice and ceremonial and subsistence resources factors where NMFS concluded that Makah Tribe would experience negative cumulative effects if Alternative 1 (the No Action Alternative) was chosen. DEIS at 5-43, 5.44.

For some actions analyzed, NMFS claims that information was not available (e.g., from the Canadian, Russian, or Mexican governments) to assess certain actions under the control of those countries that may impact gray whales or their habitat. NMFS provides no information about the effort made to obtain such information, causing the Coalition to question whether NMFS adequately attempted to secure such evidence by, for example, contacting the relevant government agencies. Nevertheless, NMFS has failed to comply with the NEPA requirements as to unavailable and incomplete information, which further undermines the sufficiency of its CIA. This error must be corrected in a revised analysis either by obtaining the missing information or providing the requisite evaluation of the relevance of the information to the environmental impacts of the proposed action as required by NEPA.

Similarly, the CIA provides no evidence that NMFS contacted relevant state or provincial agencies to obtain information about past, present, and reasonably foreseeable state-approved actions that may impact gray whales and their habitat. The definition of “cumulative impact” explicitly includes actions by non-federal agencies. Yet, NMFS has apparently limited its analysis to those actions authorized and/or undertaken by federal agencies.

In California, for example, the California Coastal Commission (CCC) is responsible for approving projects that may impact coastal resources, yet there is no indication that NMFS reached out to CCC for information relevant to the CIA. Washington and Oregon have agencies similar to the CCC that review and approve coastal projects. At a minimum, NMFS must contact all appropriate state agencies in Alaska, Washington, Oregon, and California to seek information about coastal projects authorized at the state level that may impact gray whales. It must also contact authorities in British Columbia, Canada and in the state of Baja California Norte and Baja California Sur to seek out information from them to include in the CIA. In addition, NMFS should compile a list of all of the relevant IHAs, LOAs, and other authorizations (as published in the Federal Register) that it has issued at least over the past five years in order to include that information in the CIA.

While many of the individual projects authorized by NMFS (or by other countries or agencies) may not, independently, pose any substantive threat to gray whales, when considered together - as is the entire purpose of the CIA - the impacts become significant. Merely asserting that certain actions will continue into the future and that they will or will not result in cumulative impacts - as NMFS has done in the DEIS – entirely ignores the purpose of a CIA.

That purpose is to combine all of the past, present, and reasonably foreseeable future action that may impact, in this case, gray whales and to subject them to a comprehensive and scientifically robust analysis to determine how, when combined, will impact gray whales today and into the future. Such an analysis cannot be based merely on speculation and opinion but rather, must be credible with predictions or projections about how present and future actions will effect gray whale populations and their habitat. Qualitative conclusions are not entirely sufficient in a legitimate CIA unless they are confirmed through a quantitative analysis.

While there is no required methodology for conducting a CIA, a method that would be advisable in this case would involve a modelling exercise to quantify the potential short and long-term cumulative impacts of the various impacts in order to predict potential outcomes under different scenarios.

NMFS has not engaged in such an analysis in the DEIS. Indeed, the foundation of its CIA is speculation and opinion without any substantive underlying analysis. In many cases, while NMFS acknowledges current and future impacts, it doesn't take the next step to assess the cumulative impact of such threats on gray whales and their habitat or, what analysis it provides is deficient. Until NMFS provide a legitimate CIA in a revised analysis it must not continue the current decision-making process.

For the remainder of this section, the Coalition provides a summary of some of the relevant present and future threats to gray whales. While NMFS has included many of these in the DEIS, in many cases the information is inadequate or incomplete. In other instances NMFS has ignored an existing or future threat that it should have considered.

Harvest of gray whales

As discussed in this comment letter, permitting a new intentional take of gray whales by granting the Makah Tribe's request for an MMPA waiver is biologically reckless. There are too many ongoing threats to the species throughout its range, including in the PCFG region, to purposefully allow additional take. For WNP and PCFG, such take is particularly alarming given their small population sizes. Indeed, even NMFS concedes that "killing even a few animals per year (especially over an extended period of time) from the relatively small PCFG could have long-lasting impacts for a group of whales whose population dynamics are not well understood." DEIS at 5-3. Furthermore, since so little is known about the long-term implications of Arctic ecosystem changes attributable to climate change, there is no guarantee that the ENP gray whale population is secure.

The CIA in the DEIS, had it been done objectively and through a quantitative assessment of the combined threats to gray whales and their habitat, would have concluded that the cumulative impacts are substantial. Conversely, based on its deficient analysis, NMFS found that when adding potential impacts of a gray whale hunt under Alternatives 2 through 6 to past, existing, and future levels of disturbance then "reasonably foreseeable future actions would not be expected to have cumulative effects on gray whales in the PCFG, local survey areas within the PCFG range, and individual gray whales. DEIS at 5-40. Of note, NMFS doesn't appear to make a CIA finding for ENP gray whales (nor for WNP gray whales which, in error, it neglected to consider in the CIA.

Shipping

The DEIS includes information about current shipping traffic and how it will increase throughout the range of the ENP gray whales in the future. DEIS at 5-8/5-9. It recognizes that this will increase risks to gray whales as a consequence of ship strikes, ocean noise, and potential fuel spills. Id. at 5-8. It finds that shipping is a reasonably foreseeable future action, but fails to engage in any legitimate quantitative analysis of the potential threats of shipping traffic to gray whales in relationship to the actions identified.

Military exercises

NMFS largely discounts the potential cumulative impacts of military exercises (in waters of the US, Russia and Mexico).

NMFS reports that it was unable to obtain any information about military activities conducted by Mexico and Russia within their respective Exclusive Economic Zones. For Canada, NMFS notes the role of Maritime Forces Pacific (MARPAC) in ensuring the training and operational readiness for the Royal Canadian Navy but claims that it could not find information detailing the types of training or testing that MARPAC conducts within the NMFS CIA analysis area. The failure of NMFS to obtain such information is an ideal example of a weakness in the CIA. It is improbable that if NMFS or the US State Department, on behalf of NMFS, sought the relevant information from Mexico, Canada, and Russia that those governments would not have responded at least to provide basic information about relevant military training activities in the analysis area. Without that information, the CIA is incomplete.

As for the analysis of the impacts of military activities in US waters, NMFS evaluates the impacts of activities conducted within the Southern California Range Complex (SCRC), Northwest Testing and Training Range (NWTTR), and the Gulf of Alaska Range Complex (GOA). The potential impacts from these testing and training exercise include noise (from ships, explosives, sonar), direct harm (from ship strikes, projectiles, underwater explosions, consumption of expended materials), and indirect harm (hearing impairment and loss, disrupting communications, noise masking, behavioral impacts, general harassment).

Instead of providing a credible analysis of these impacts, NMFS largely dismisses any significant threat to gray whales by citing to its relevant Biological Opinions for the different ranges and complexes. These Biological Opinion's generally conclude the overall impact from such exercises, which they concede will result in harassment (primarily Level B). Notably, for the SCRC, NMFS has authorized 15 Level A takes (through harassment) of ENP gray whales and, in addition, 15 whale injury, mortality, or serious injuries for 15 gray whales of which three, shockingly, can be WNP gray whales. Considering that this population of gray whale is critically endangered, that level of mortality or serious injury rate is excessive. Furthermore, relying on old Biological Opinions for this CIA is inappropriate. NMFS should have engaged in a new analysis of these impacts specific to gray whales and their habitat.

In general, for all gray whales subject to military testing and training activities, NMFS dismisses potential adverse impacts claiming that "any stress responses or disruptions of normal behavior patterns of gray whales would not continue long enough to have fitness consequences for individual animals because these whales are likely to have energy reserves sufficient to meet the demands of their normal behavioral patterns and the additional demands of any stress responses." DEIS at 5-15. Of course, NMFS provides no data to support its contention that gray whale exposure to such military training exercises will be only temporary nor has it disclosed evidence to substantiate the assertions that gray whales have sufficient energy reserves to both meet daily demands and to deal with acute or chronic stress impacts. NMFS must provide such data if it wants to ensure that its CIA is credible and legal.

While NMFS concedes that in past Biological Opinions, WNP gray whales were not considered, it is evaluating impacts to that population in pending decisions regarding continuation of military testing and training activities in the NWTTR and the GOA ranges. In regard to the SCRC, a court recently ruled in favor of plaintiffs challenging a Biological Opinion prepared by NMFS to evaluate the impacts of the military's training and testing in that region. *Conservation Council for Hawaii v. NMFS* (2015 WL 1499589 at *48-50 (D. Hawaii Mar. 31, 2015).

In particular, given the increasing body of scientific evidence documenting the adverse impact of ocean noise, including sonar and seismic testing, on marine mammals and other ocean species, this issue in particular warranted far greater analysis in the CIA. Indeed, surprisingly, while NMFS provides some information about ocean noise in the affected environment and environmental consequences sections of the DEIS, it virtually ignores the issue in its CIA. Not only can such anthropogenic noise directly harm whales through temporary or permanent hearing loss, but the behavioral implications of acute and chronic exposure to human-caused noise sources can cause behavioral changes that can have serious consequences to gray whales. This can include disrupting feeding and breeding activities, abandonment of preferred habitat, and avoidance reactions that may result in increased stress and have adverse bioenergetics consequences.

Considering the increase in anthropogenic noise in the Pacific Ocean, including noise associated with military operations, and recognizing that climate change will increase human activities in the Arctic which, in turn, will increase noise impacts, NMFS must provide a far more substantive and scientifically robust evaluation of noise impacts in a revised document.

Fisheries

NMFS acknowledges the adverse impacts of various fisheries on gray whales and concedes that reported fishery-related mortality is an underestimate of actual mortality. This is, in part, due to the lack of observer coverage in many of the west coast fisheries that are known to pose a risk to gray whales. For example, no observers are assigned to most of the Alaskan gillnet fisheries, including those in Bristol Bay known to interact with gray whales. DEIS at 41. Similarly, due to a lack of observer data for mortality in Canadian commercial fisheries, data is not available but NMFS estimates it to be approximately two whales per year. The DEIS contains no information about any commercial fishery-related mortality of gray whales in Mexico.

Overall, NMFS reports a known, but minimum, estimate of commercial fishery-related mortality was 12.25 ENP gray whales between 2007 and 2011 (Carretta et al. 2014), or an average of 2.45 gray whale per year. DEIS at 3-195. This is limited to reported mortalities in US waters only indicating that the actual number is larger if mortalities in Mexico and Russia were included.

NMFS provides some limited gray whale entanglement data for Mexico for 2013 where six gray whales were reported entangled in fishing gear . DEIS at 5-19. For Russia, NMFS reports that no data on gray whale entanglements were available, *id*., and apparently none could be obtained from Canada either. For PCFG gray whales, for the same period of time, the DEIS reports a mortality rate of one whale or 0.15 whales per year; figures that must be underestimates given the commercial fishing activity within the PCFG range. Punt and Moore (2013) estimate that reported strandings of gray whales represent only 3.9 to 13 percent of actual mortality. DEIS at 3-193. Consequently, average actual fishery-related gray whale mortalities in US waters may range from 18 to 62 animals annually.

When evaluating the cumulative impacts of this action in relationship to the hunt, NMFS should not use reported mortality rates as that will significantly underestimate actual mortality. Furthermore, while the reported mortality statistics above are for US fisheries, there is likely unreported mortality associated with other forms of mortality (i.e., ship strikes, sonar use, seismic testing). If the mortality rate from Punt and Moore is used to determine actual mortality for all types or reported mortality, the estimated number of whales lost due to human-caused mortality may be far higher than expected.

Since gray whales are known to sink when they die, NMFS needs to identify unreported mortality rates for these other forms or mortality so that it can conduct a credible quantitative CIA as well as to determine if human-caused mortality exceeds PBR. This is precisely the type of analysis that NMFS should undertake in a comprehensive CIA.

Tourism

NMFS notes that the number of people engaging in whale-watching in the ENP increased from 2.8 million in 1998 to over 3.3 million in 2008. DEIS at 5-20. Since 2008 the numbers have likely increased. NMFS also acknowledges that the activity of commercial whale-watching vessels and private recreational boats has increased concerns about potential effects on gray whales. DEIS at 5-22. The Coalition concurs with this assessment. While whale-watching provides a unique opportunity for millions of people annually to enjoy whales in their natural habitat, to learn about marine species and marine ecology, and that whale-watching generates billions in revenue worldwide, it is not with potential risk to marine wildlife. Improperly or non-regulated whale-watching operations or even an excessive number of operators in a concentrated area can have adverse impacts on marine mammals and other species.

This constitutes another threat to gray whales which has not been sufficiently studied to understand the full range of direct and indirect impacts to these animals. NMFS has also failed to quantify this effect in its CIA in order to better understand its impact in the context of other impacts on gray whales and their habitat. Instead of engaging in such an analysis, NMFS has concluded that whale-based tourism is a reasonably foreseeable future action that will continue to impact gray whales throughout their range in the ENP. DEIS at 5-22. It does not appear that the CIA provides a determination as to the cumulative impacts to gray whales as a result of tourism when considered alongside the proposed hunt.

Marine energy and mining projects

NMFS discloses information about active and proposed energy and mining projects within the range of the gray whale. For example, it notes the proposed construction of a number of Liquefied Natural Gas terminals (DEIS at 5-9) while also providing some data on oil spills particularly in Washington State waters. It provides a basic explanation of oil and gas development in the Arctic and both its role and the role of the Bureau of Ocean Energy Management in overseeing, authorizing, or permitting such projects.

What it fails to do, however, is to engage in a credible analysis of the direct and indirect impacts of these projects on gray whales and their habitats. There's no serious analysis of the impacts of oil/gas exploration or production activities on gray whales (i.e., seismic testing, drilling noise, ship traffic), no substantive discussion of the lethal and sub-lethal impacts of oil on gray whales, and no assessment of the potential for a significant oil spill within the range of the gray whale or how such a spill would impact gray whales and their habitat. In the Arctic, since summer is the only time when drilling can be commenced, a spill associated with production processes would occur when gray whales are in the region. Given the controversy surrounding President Obama's recent decision to allow Shell Oil to drill in the Arctic, this emphasizes the need for a more complete analysis. The notion that such spills are unrealistic or unlikely due to the efforts made by the oil and gas companies to prevent such accidents is not (and never has been) cause for complacency particularly as a result of the Deepwater Horizon spill in the Gulf of Mexico several years ago.

Notably, NMFS failed to even disclose a mining project in Mexico that may significantly impact gray whales. Although not yet approved, a large phosphorous mining operation has been proposed in the Gulf of Ulloa between Apreojos and Cabo San Lazaro, Mexico. A summary translation of the first few paragraphs of the Environmental Impact Statement[57] prepared on the proposed mine states that:

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[57] The EIS can be accessed at: http://consultaspublicas.semarnat.gob.mx/data/expediente/bcs/estudios /2014/03BS2014M0007.pdf

- The project is to be located within the Mexican EEZ in the Gulf of Ulloa, on the west coast of Baja California Sur between Apreojos and Cabo San Lázaro, about 22 km off the coasts.
- It is projected that 7 million tons of phosphates will be extracted each year for a period of 50 years, equal to a rate of 19,178 tons a day; the digging will be done 24 hour per day, 7 days per week or each year.
- The EIS does not mention the total quantities of other materials that would also be removed and then returned to the ocean as waste. An analysis by Dr. Janette Murillo Jimenez, however, indicated that to produce the quantity of phosphate indicated 150,000 tons of sediment would need to be removed daily. "These quantities are so large that they would require more than one processing vessel, would generate a plume of sediment and waste, of which argillaceous particles would be left permanently in the water in the area due to the continual agitation."
- The company seeking the permit, Exploraciones Oceánicas, S. de R.L. de C.V. (a subsidiary of a US company Odyssey Marine Exploration Inc, Omex) is a vessel salvage company which has no experience in submarine dragging, and even less in mining phosphates. In other countries in which similar proposals have been presented they have not been approved, and Namibia has a moratorium on such activities. This is due to concerns about fisheries.

Furthermore, in a recent article published in Excelsior[58], a periodical in Mexico, Dr. Jorge Urban-Ramirez, head of the Marine Mammal Research Program from the Universidad Autónoma de Baja California Sur, noted that the project would impact the migratory route of gray whales which for millennia have traveled 10,000 kilometers from the Arctic Ocean, through the Bering and Chukchi Seas between Alaska and Siberia, to the Baja California, peninsula in order to rest and give birth.

Dr. Urban-Ramirez, who is respected gray whale biologist with 32 years invested into the study of the species, states that “the underwater noise from the mining activity would mask the acoustic communication that exists between the whales principally in the Laguna complex at Bahia Magdalena, the closest point to the Don Diego (name of mining project) project, where every year a large number of gray whale calves are born,” and that “the greatest potential damage is to the north where the mothers with calves will be precisely in the drag zone.”

While he reports that the noise generated by the mine, if it were allowed, would not kill gray whales, it would trigger a behavioral response that would cause them to divert from their

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[58] See http://www.excelsior.com.mx/nacional/2015/01/18/1003281

normal migratory route which, in turn, would result in greater energy expenditures while also potentially adversely impacting the whale-watching tourism industry in the area.

Natural mortality

NMFS notes the potential impacts of killer whale predation on gray whales but largely ignores the role of sharks as natural predators of gray whales, particularly gray whale calves. In addition, it does not sufficiently consider the potential impact of predation on gray whales in the context of the other threats and stressors on the population. For example, the delay in the south of the southbound migration, which is linked to ocean warming in the Arctic and the expansion of the gray whales' range, has led to an increase in births outside of the Mexican lagoons. Some births are now occurring in coastal waters as far north as central California. Gray whale calves born in these areas are more susceptible to predation than those born in the lagoons. NMFS has not quantified such impacts for the purpose of its CIA. Nor has it considered predation severity throughout the migratory range. Unimak Pass, Alaska, is an area where gray whales may be most susceptible to predation by killer whales, who take advantage of this relatively narrow passage way to kill gray whales. NMFS must provide a far more substantive analysis of the impact of predation on gray whales as both a separate threat to the species as well as in the context of a credible CIA.

Climate change

As previously noted, ocean warming caused by climate change is significantly impacting the Arctic. A regime shift is ongoing whereby a benthic driven ecosystem is transitioning into a pelagic system. This has significant potential implications to gray whales and their prey, including amphipods. As the composition and density of fish stocks increase in Arctic waters, benthic productivity is declining, forcing gray whales to expand their range. The consequences of this shift are documented in the scientific literature but, more recently, evidence of this shift is available in the form of an agreement between the US, Russian Federation, Canada, Norway, and Denmark (representing Greenland) to prevent unregulated commercial fishing in the Arctic. This agreement, signed on July 16, 2015 is a product of the regime shift in the Arctic linked to climate change. According to a press release issued by the US State Department about the agreement:

> The declaration acknowledges that commercial fishing in this area of Arctic Ocean – which is larger than Alaska and Texas combined – is unlikely to occur in the near future. Nevertheless, the dramatic reduction of Arctic sea ice and other environmental changes in the Arctic, combined with the limited scientific knowledge about marine resources in

> this area, necessitate a precautionary approach to prevent unregulated fishing in the area.[59]

The countries have agreed to initiate research in the region to better understand changes occurring to the Arctic. It is precisely this type of precautionary approach that must be applied in the context of the Makah hunt. Given the need to better understand the changing Arctic environment and what it means to whales and other Arctic and sub-Arctic species, permitting direct lethal take of gray whales at this time is reckless.

Another threat to gray whales linked to climate change is ocean acidification. NMFS provides some information about this threat in the DEIS. It notes, for example, that ocean acidification can change the chemical composition of ocean water, which will decrease its ability to absorb sound, thereby making the oceans even noisier than they are at present. DEIS at 3-198. While this could cause both direct and indirect adverse impacts on gray whales, the fact that ocean acidification will reduce the abundance and types of shell forming organisms, "many of which are important in the gray whales diet," DEIS at 3-197, is also a significant concern. While gray whales are expanding their range to find additional food sources, such an expansion will be irrelevant if potential prey species are eliminated or reduced as a consequence of climate change.

Climate change is also increasing human activities in the Arctic, including oil and gas exploration and development and shipping traffic . Both of these activities also can adversely impact gray whales directly and indirectly as well as by impacting their habitat.

NMFS provides some information about hypoxic zones in the DEIS but its analysis is deficient. While it notes that such zones are now increasingly linked to climate change (as well as associated with poor land management activities), it fails to disclose where such zones exist within the ENP gray whale range, if the zones are increasing in size, if they are more prominent in certain seasons, or what direct or indirect impacts they have on gray whales and gray whale prey. Nor has NMFS adequately consider these zones in the CIA.

What NMFS failed to address in its assessment of climate change in the CIA is the predicted "strong" El Nino event for the upcoming winter season.[60] Considering that this prediction was made by NOAA, it is troubling that it was not addressed in the CIA. During a previous "strong" El Nino in 1997-1998, the ENP gray whale population was significantly and adversely impacted as

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[59] Available at http://www.state.gov/r/pa/prs/ps/2015/07/244969.htm

[60] See https://www.climate.gov/news-features/blogs/enso/june-el-ni%C3%B1o-update-damn-torpedoes-full-speed-ahead

a result of substantial mortality. During and after that event, ENP population estimates declined from over 20,000 whales in the late 1990s to approximately 16,000 in the early 2000s. While no one can predict if this predicted El Nino will have similar impacts, the precautionary principle mandates that this potential be considered in management decisions.

Finally, NMFS fails to discuss "the blob," a warm water anomaly in the Northeast Pacific that has led to significant ecological destruction. Bond et al. (2015)(Attachment 8).

US government policy

This issue was addressed previously in this comment letter. No further comments are necessary.

Additional Comments:

The environmental consulting firm used by NFMS to prepare the DEIS has an unacceptable conflict of interest:

NMFS hired Parametrix, a Washington state-based environmental consulting firm, to prepare the 2008 and 2015 DEIS documents. In 2008, AWI and other NGOs raised concerns that Parametrix had a conflict of interest, as it had done work for the Makah Tribe (e.g., on the Cape Flattery Scenic Byway Corridor Management Plan). In 2008, Parametrix had a contract with NMFS and the Makah Tribe simultaneously. Appendix C-22. NMFS dismissed these concerns, claiming that: 1) Parametrix and its subcontractors signed disclosure statements affirming "that there is no conflict of interest by being employed by both the Tribe and NMFS (*id*. at C-23); 2) due diligence reviews by NMFS of Parametrix's role as a contractor for the Tribe did not pose a potential for conflict (*id*.); and 3) "no biased information could be inserted into the DEIS under our sole supervision." *Id*. NMFS also noted that producing an EIS is the responsibility of the Federal action agency and that it did "not consider the relationship between Parametrix and the Tribe to have compromised the integrity of Parametrix's work product." *Id*.

These statements do not reassure the Coalition that Parametrix does not have a conflict of interest and that its role in preparing NEPA documentation for the Makah hunt did not compromise the objectivity and integrity of the 2008 and now the 2015 DEIS documents. In the list of preparers of the DEIS (DEIS at 8-1/8-2), NMFS fails to include the affiliations of all but two of the 27 people identified. One person whose affiliation was disclosed was the DEIS project manager for Parametrix and the other is a NMFS employee. Independent research conducted by the Coalition reveals that of the remaining 25 people identified, 12 are employed by NMFS, nine are (or were) employed by Parametrix, and four were employed elsewhere.

Beyond mere affiliation, however, an examination of the Parametrix website (http://www.parametrix.com/) reveals the following description of who the firm serves:

> Parametrix has served more than 50 tribes, pueblos, and rancherias. We support tribal governments' long-term visions, concern for future generations, and efforts to strengthen their sovereignty. Integrity and trust are the foundation of our efforts to serve tribes and provide the highest level of client service.
>
> We frequently assist tribal clients with infrastructure improvements, economic development, environmental planning and protection, and comprehensive land use planning—all critical to enhancing the quality of life in tribal communities and creating economic self-sufficiency for members and business. We often assist tribes in identifying and obtaining grant funding through our understanding of BIA processes, other governmental funding programs, and innovative partnerships.
>
> We are proud of the relationships we have built with our tribal clients and are committed to growing and nurturing these relationships in the future.

(accessed at http://www.parametrix.com/who-we-serve/tribes-pueblos-rancherias)

This webpage includes a picture of Parametrix employees and Makah Tribal officials. See Figure 7. It is not just a picture that causes concern, but Parametrix's support for "tribal governments' long-term visions" and "strengthen[ing] their sovereignty," which suggests an inherent bias in favor of the Tribe's interests. Such support is admirable, but not for a consulting firm supposedly providing an objective and scientifically sound work product evaluating the environmental impacts of Makah whaling.

Figure 7: Lower left image is of a Parametrix project on the Makah reservation. Available at http://www.parametrix.com/who-we-serve/tribes-pueblos-rancherias

Given the close past and present ties between Parametrix and the Makah Tribe, the use of Parametrix to prepare the DEIS was a poor choice and raises serious questions about the credibility of the content and impartiality of the analysis. While this error cannot be undone, NMFS must cease its relationship with Parametrix and either engage in an internal reevaluation of the content and analysis in the DEIS or hire a new environmental consulting firm with no ties to the Makah or other Native American tribes to perform such a reevaluation.

<u>The Makah Tribe's promulgation of its 2013 Makah Whaling Ordinance raises concerns about the integrity of the DEIS process:</u>

Included in the DEIS is a 2013 Makah Whaling Ordinance that was enacted by the Makah Tribe in August 2013. While the Makah Tribe can adopt any ordinances it deems appropriate, the adoption of a whaling ordinance in 2013 is odd. Considering that the present DEIS would not be published for another 20 months, that the NEPA and MMPA processes that must be completed to determine if the Makah Tribe will receive a waiver could take several years, and that, without the waiver, the Makah Tribe cannot whale, it seems unusual for the Tribe to expend the time, energy, and resources to develop and promulgate a whaling ordinance. While this may simply represent a choice made by the Makah Tribe, it could also reflect the Makah Tribe's understanding that it will receive a waiver and will be allowed to resume whale hunting. If NMFS has tacitly or expressly conveyed any guarantees to the Makah Tribe to cause them to develop such an understanding, it means the outcome of this planning process has been predetermined, in violation of NEPA.

As NMFS may recall, in *Metcalf v. Daley* (214 F.3d 1135 (9th Cir. 2000)), the appellate court found in favor of the plaintiffs because NMFS entered into a cooperative agreement with the Makah Tribe days before it published its Final EA and Finding of No Significant Impact. The court held this action predetermined the outcome of the NEPA process. The facts here are different, but the concern is the same. While it is unknown if NMFS suggested, recommended, or directed the Makah Tribe to adopt a whaling ordinance in 2013, this issue warrants some discussion and explanation by NMFS.

<u>Conclusion:</u>

Based on the foregoing evidence and analysis, NMFS must deny the Makah Tribe's request for an MMPA waiver application and terminate the NEPA process. There is no other legal option. It is time for this 20-year effort to end. The Makah Tribe does not qualify for an IWC-approved ASW quota and NMFS cannot issue an MMPA waiver to allow a Makah hunt without violating the law. Furthermore, as exhaustively demonstrated in this letter, the DEIS is woefully inadequate—failing to satisfy the requirements of NEPA. The purpose and need statements are invalid, NMFS has not considered a reasonable range of alternatives, it has failed to disclose all relevant information, and its analysis of the environmental consequences of the hunt is neither complete nor accurate.

If NMFS, despite the overwhelming evidence, makes a preliminary determination to issue the MMPA waiver, the Coalition will participate in the process in order to demonstrate conclusively that issuance of the waiver is illegal and that, therefore, the Makah's whale hunt cannot be allowed.

Thank you in advance for considering this information. Should you have any questions or require additional information, please contact me at dj@awionline.org or, by telephone, at (609) 601-2875.

Sincerely,

DJ Schubert
Wildlife Biologist

cc: Dr. Rebecca Lent, Executive Director, Marine Mammal Commission

Attachments:

Attachment 1: C. Wold and M. Kearney. 2015. The Legal Effect of Greenland's Unilateral Aboriginal Subsistence Whale Hunt. American University International Law Review. Vol. 30, Issue 3, Article 5.

Attachment 2: Lang, A. R., Calambokidis, J., Scordino, J., Pease, V. L., Klimek, A., Burkanov, V. N., Gearin, P., Litovka, D. I., Robertson, K. M., Mate, B. R., Jacobsen, J. K. and Taylor, B. L. 2014. Assessment of genetic structure among eastern North Pacific gray whales on their feeding grounds. Marine Mammal Science, 30(4), 1473–1493. doi:10.1111/mms.12129

Punt, A.E. 2015. An Age Structured Model of Exploring the Conceptual Models Developed for Gray Whales in the North Pacific. SC/SC65b/BRGx.

Attachment 4: Øen, E.O. Killing efficiency in the Icelandic fin whale hunt 2014. Report to the Directorate of Fisheries in Iceland, February 19, 2015. Wildlife Management Service-Sweden.

Attachment 5: Kuczaj, S. 2007. Considerations of the Effects of Noise on Marine Mammals and other Animals. International Society for Comparative Psychology.

Attachment 6: Conservation Council of Hawaii v. United States

Attachment 7: United States v. Washington

Attachment 8: Bond, N.A., Cronin, M.F., Freeland, H., and Mantua, N. 2015. Causes and impacts of the 2014 warm anomaly in the NE Pacific. Geophysical Research Letters. 42.

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THE LEGAL EFFECT OF GREENLAND'S UNILATERAL ABORIGINAL SUBSISTENCE WHALE HUNT

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I. INTRODUCTION

For three decades, two issues have dominated discussions within the International Whaling Commission ("IWC"): the persistence of the moratorium on commercial whaling[1] and Japan's scientific research whaling[2] under the International Convention for the

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[1] International Convention for the Regulation of Whaling art. XI, ¶ 10, Dec. 2, 1946, 62 Stat. 1716, 161 U.N.T.S. 72 (entered into force Nov. 10, 1948) [hereinafter ICRW]. The Schedule is an integral part of the ICRW. *Id.* art. I(1). The Schedule was last amended at the 65th Annual Meeting of the IWC in September 2014. At the moment, however, the IWC's website only provides a link to the Schedule as amended in 2012. *See* International Convention for the Regulation of Whaling, Schedule art. III, ¶ 10(e), Dec. 2, 1946, 62 Stat. 1716, 161 U.N.T.S. 72 [hereinafter Schedule]. The 2014 amendments can be found in Int'l Whaling Comm'n [IWC], *Summary of Main Outcomes, Decisions and Required Actions from the 65th Meeting*, at 6 (Sept. 18, 2014), *available at* http://iwc.int/iwc65docs [hereinafter *Summary of Main Outcomes*].

[2] Between 1987 and 2001, the IWC has condemned Japan's so-called

Regulation of Whaling ("ICRW").[3] Indeed, Japan's scientific research whaling has led, uniquely, to a television show (*Whale Wars*) documenting the efforts of the Sea Shepherd Conservation Society to stop Japanese scientific research whaling in Antarctica,[4] an episode of *South Park*,[5] and a decision of the International Court of Justice, which ruled in March 2014 that Japan's Antarctic whaling was not for purposes of scientific research.[6]

Recently, however, a third issue has created controversy: aboriginal subsistence whaling ("ASW") and, in particular,

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scientific whaling for failing to meet the criteria for scientific whaling and the IWC's Scientific Committee has stated that Japan's scientific whaling does not provide data relevant to any critically important management purpose. *See, e.g.*, IWC, *Resolution on Whaling Under Special Permit in the North Pacific Ocean*, IWC Res. 2000-5 (2000); IWC, *Resolution on Whaling Under Special Permit in the Southern Ocean Sanctuary*, IWC Res. 2000-5 (2000); IWC, *Resolution on Whaling Under Special Permit*, IWC Res. 1998-4 (1998); IWC, *Resolution on Special Permit Catches in the North Pacific by Japan*, IWC Res. 1997-6 (1997); IWC, *Resolution on Special Permit Catches in the Southern Ocean by Japan*, IWC Res. 1997-5 (1997); IWC, *Resolution on Special Permit Catches by Japan*, IWC Res. 1996-7 (1996); IWC, *Resolution on Special Permit Catches by Japan in the Southern Hemisphere*, IWC Res. 1994-10 (1994); IWC, *Resolution on Special Permit Catches by Norway*, IWC Res. 1994-11 (1994); IWC, *Resolution on Special Permit Catches by Japan in the Southern Hemisphere*, IWC Res. 1993-7 (1993); IWC, *Resolution on Special Permit Catches by Japan in the Southern Hemisphere*, IWC Res. 1991- App'x 2 (1991); IWC, *Resolution on Special Permit Catches by Japan in the Southern Hemisphere*, IWC Res. 1990-2 (1990); IWC, *Resolution on the Proposed Take by Japan of Whales in the Southern Hemisphere Under Special Permit*, IWC Res. 1989-3 (1989); IWC, *Resolution on Japanese Proposal for Special Permits*, IWC Res. 1987-4 (1987); *see also* Petition to Certify Japan Pursuant to 22 U.S.C. § 1978 for Trading in the Meat of Minke, Bryde's, and Sperm Whales from the North Pacific and the Southern Hemisphere (Nov. 14, 2000), *available at* http://law.lclark.edu/clinics/international_ environmental_law_project/ our_work/ whaling (discussing the aforementioned IWC resolutions).

[3] ICRW, *supra* note 1, art. VIII.

[4] *About Whale Wars*, ANIMAL PLANET (July 13, 2012), http://www.animalplanet.com/tv-shows/whale-wars/about-this-show/about-whale-wars.

[5] *South Park: Whale Whores* (Comedy Central television broadcast Oct. 28, 2009). In truth, the *South Park* episode, *Whale Whores*, is a satirical look at the efforts and members of the Sea Shepherd Conservation Society and its show *Whale Wars*, which has been broadcast on Animal Planet for several years.

[6] *See* Whaling in the Antarctic (Austl. v. Japan), 2014 I.C.J. 148, ¶¶ 35-37 (Mar. 31); *see also* Cymie R. Payne, *Australia v. Japan: ICJ Halts Antarctic Whaling*, 18 AM. SOC'Y OF INT'L L., no. 9, 2014, *available at* http://www.asil.org/insights/volume/18/issue/9/australia-v-japan-icj-halts-antarctic-whaling (criticizing the ICJ's decision).

Greenland's ASW. Since 1985, a large number of whales have been killed pursuant to ASW—more than 9,700[7]—compared to 16,039 killed pursuant to scientific research whaling permits[8] and 23,484 whales killed for commercial purposes.[9] The ICRW's regulations require that the number of whales killed for aboriginal subsistence align with subsistence needs; national governments are responsible for providing the IWC with evidence of the cultural, nutritional, and subsistence needs of their people.[10] The IWC's Scientific Committee makes recommendations on quotas for the stocks,[11] and the IWC adopts catch limits, more commonly called quotas, based on the Scientific Committee's recommendations and the advice of the IWC's ASW sub-committee. Since 1997, the IWC has set ASW quotas in five-year blocks,[12] although it now sets them in six-year blocks.[13]

While the IWC has long recognized the importance of ASW for certain aboriginal groups, the approval of ASW quotas has sometimes met resistance. For example, the IWC has challenged Greenland's request for fin and humpback whales[14] as well as the

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[7] *Catches Taken: ASW*, INT'L WHALING COMM'N (2014), http://iwc.int/table_aboriginal. Under current IWC regulations, aboriginal groups in Greenland, the Russia Federation, St. Vincent and the Grenadines, and the United States may hunt whales. *Catch Limits & Catches Taken*, INT'L WHALING COMM'N (2014), http://iwc.int/index.php?cID=html_76#aborig.

[8] *Catches Taken: Special Permit*, INT'L WHALING COMM'N (2014), http://iwc.int/table_permit.

[9] *Catches Taken: Under Observation or Under Reservation*, INT'L WHALING COMM'N (2014), http://iwc.int/table_objection.

[10] *See* Schedule, *supra* note 1, ¶ 13(a).

[11] *Id.* ¶ 13(a)(3) ("The above provisions will be kept under review, based upon the best scientific advice.").

[12] *See Aboriginal Subsistence Whaling*, WHALE &DOLPHIN CONSERVATION, http://us.whales.org/issues/aboriginal-subsistence-whaling (last visited Jan. 31, 2015).

[13] Because the IWC now meets every two years instead of every year, it changed ASW quotas from five-year blocks to six-year blocks in 2012. *See* IWC, *Annual Report of the International Whaling Commission 2012*, at 19 (2013) [hereinafter *IWC Annual Report 2012*] (discussing ASW quotas for bowhead, gray, and humpback whales and the move from five-year to six-year quotas).

[14] In 2008, the IWC rejected Greenland's proposal to add humpback whales to its ASW quota. IWC, *Annual Report of the International Whaling Commission 2009*, at 22-23 (2010). In 2010, Greenland's ASW quota was approved only after Greenland agreed to reduce the number of fin whales and humpback whales killed for aboriginal subsistence purposes in its proposal. IWC, *Annual Report of the*

taking of humpback whales by individuals in St. Vincent and the Grenadines.[15] However, the ASW debate significantly intensified in 2012 when the IWC rejected Greenland's request for an ASW quota starting with the 2013 season.[16] IWC members expressed concerns over the size of the quota, Greenland's conversion factors used to calculate the yield of meat from each whale, and evidence of the commercial sale of whale meat in restaurants.[17] According to a recent large-scale study of consumption patterns in Greenland, Greenland's Inuit consume approximately ten kilograms of *cetacean* meat per capita per year (including meat from thousands of small cetaceans, such as belugas, narwhals, and killer whales, killed each year).[18] This is considerably less than twelve to thirteen kilograms of *whale* meat from large whales (bowhead, fin, humpback, and minke) alone that Greenland claimed in its 2012 needs statement[19] and the fifteen kilograms it claimed in its 2014 need statement.[20]

Despite the IWC's rejection of its ASW request, Greenland unilaterally established an ASW quota for 2013 and 2014.[21]

International Whaling Commission 2010, at 17 (2011).

[15] A frequent concern of the IWC is the ongoing killing of what many consider to be calves by those engaged in ASW in St. Vincent and the Grenadines. *See, e.g.*, IWC, *Annual Report of the International Whaling Commission 2000*, at 18 (2001) [hereinafter *IWC Annual Report 2000*]; *see also* WHALE & DOLPHIN CONSERVATION SOC'Y, ANALYSIS OF THE REPORTS OF THE IWC'S INFRACTION SUB-COMMITTEE FROM 1991 TO 2004: REVIEW OF COMPLIANCE AT THE IWC (2005) (reviewing the history of attempts to label this killing as an infraction).

[16] *See* Press Release, Int'l Whaling Comm'n (2012), *available at* https://archive.iwc.int/pages/view.php?ref=3476&search=press%2C+release&order_by=relevance&sort=DESC&offset=0&archive=0&k=&curpos=0 (discussing the impasse within the IWC over Greenland with a vote of twenty-five to thirty-four with three abstentions).

[17] *See IWC Annual Report 2012*, *supra* note 13, at 22 (describing concern from Brazil, Ecuador, and Argentina over Greenland's ASW whaling practices).

[18] Charlotte Jeppesen et al., *Assessment of Consumption of Marine Food in Greenland by a Food Frequency Questionnaire and Biomarkers*, INT'L J. OF CIRCUMPOLAR HEALTH, May 2012, at 4 (May 17, 2012).

[19] IWC, *White Paper on Management and Utilization of Large Whales in Greenland, May 2012* 3 (White Paper Supp. IWC/64/ASW 8, 2012), *available at* https://archive.iwc.int/pages/search.php?search=!collection84.

[20] IWC, *Utilization of Large Whales in Greenland: A Need Statement*, at 13, IWC/65/17 (July 2014).

[21] *See* PS, *Whale Quotas Create Rift Between Greenland and Denmark*, COPENHAGEN POST (July 11, 2013), http://cphpost.dk/news/whale-quotas-create-rift-between-greenland-and-denmark.5962.html. Prior to establishing its unilateral

Australia,[22] Denmark,[23] other IWC members,[24] and conservationists[25] argued that the IWC's rejection of Greenland's ASW quota precludes Greenland from conducting ASW in 2013 and beyond until the IWC approves a new quota. Nonetheless, Greenland allowed the hunt. The United States,[26] St. Lucia,[27] and the Alaska

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quota, Greenland solicited comments from IWC Members on its proposal to allocate ASW quotas to itself for 2013 and 2014, without IWC approval. Letter from Jens K. Lyberth, Greenland Deputy Minister, Ministry of Fisheries, Hunting, and Agric., to IWC Comm'rs, Regarding Greenland Quotas on Large Whales (Nov. 30, 2012).

[22] Letter from Donna Petrachenko, Austl.'s Comm'r to the IWC, to Gitte Hundahl, Den.'s Comm'r to the IWC (Dec. 17, 2012), *available at* iwc.int/document_3159.download (objecting to Greenland's proposal).

[23] PS, *supra* note 21 (reporting that "[t]he Danish government argues that by setting its own independent quota, Greenland is contravening IWC regulations"). Denmark also said that it would have to withdraw from the IWC as a result of Greenland's ASW hunt. *Id.*

[24] On behalf of EU IWC Commissioners from EU member States, the IWC Commissioner for Cyprus wrote:

> Cyprus had already expressed, on behalf of the above-listed EU IWC Commissioners, the coordinated position on the proposal submitted by Denmark (Greenland) at IWC 64 Panama, in July of this year. As we had stated on that occasion, we were ready to support a roll-over proposal from Greenland, just as we supported the other, joint, proposal submitted by the USA, Russia and St. Vincent and the Grenadines. At this stage, I am compelled to inform you that this position remains unaltered and that, consequently, we remain unable to support your suggested approach. We would also be interested to understand how you, together with the Government of Denmark, would see the next steps unfolding, particularly in light of the IWC Rules of Procedure and the possibility of making use of IWC Rule E.4, considering that the next IWC meeting will take place in 2014.

Letter from Myroula Hadjichristoforou, IWC Comm'r to Cyprus, to Minister Lyberth (Dec. 14, 2012) (on file with author); *see also 2014 IWC 65 Meeting in Slovenia*, ANIMAL WELFARE INST., https://awionline.org/content/2014-iwc-65-meeting-slovenia (last visited Jan. 20, 2015) (providing that at the IWC's 2014 meeting, Argentina, Chile, Uruguay, and other members of the Latin American group of countries known as the Buenos Aires Group stated that Denmark's failure to report Greenland's ASW as commercial whaling constituted an infraction).

[25] The letter is signed on behalf of the Animal Welfare Institute and nineteen other organizations. Letter from Susan Millward, Exec. Dir., Animal Welfare Inst., to Villy Søvndal, Den.'s Minister of Foreign Affairs (Mar. 4, 2013).

[26] In an email, the U.S. Acting IWC Commissioner said the following:

> Denmark/Greenland is now considering issuing catch limits for the years 2013 and 2014 at the same levels that Denmark proposed in Panama. The United States supports catch limits that are consistent with a documented needs statement and that are supported by advice of the IWC Scientific Committee. If Denmark/Greenland were to issue catch limits for 2013 and 2014 at the same levels as their 2012 catch limits, it would likely garner wider support within the IWC and create a more positive

Eskimo Whaling Commission ("AEWC")[28] have supported Greenland's actions, with the AEWC arguing that paragraph 13 of the ICRW Schedule[29] allows Greenland and others to conduct ASW hunts in the absence of an IWC-approved quota. The IWC approved an ASW quota for Greenland at its 2014 meeting[30] that differed from its 2012 proposal by just twelve minke whales.[31] Nonetheless, the controversy has not subsided. At the 2014 meeting, Argentina,

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> atmosphere at IWC65. Further, we support Denmark/Greenland's intention to propose a new schedule amendment to the IWC in 2014 for catch limits through 2018.

E-mail from Ryan Wulff, Acting U.S. IWC Comm'r, to Gitte Hundaul, Den.'s Comm'r to the IWC, and Greenland Deputy Minister Lyberth (Dec. 14, 2012) (on file with author); *see also* U.S. DEP'T OF COMMERCE, NAT'L OCEANIC & ATMOSPHERIC ADMIN., NAT'L MARINE FISHERIES SERV., DRAFT ENVIRONMENTAL IMPACT STATEMENT FOR ISSUING ANNUAL QUOTAS TO THE ALASKA ESKIMO WHALING COMMISSION FOR A SUBSISTENCE HUNT ON BOWHEAD WHALES FOR THE YEARS 2013 THROUGH 2017/2018 7 (2012) ("It is possible that the IWC might not update the catch limit, notwithstanding IWC Scientific Committee management advice that the hunt is sustainable. If so, it should be noted that NOAA is considering issuing annual quotas for the time periods described in the Alternatives under the current IWC Schedule language").

[27] At the IWC's 2012 meeting and as reported in the Chairman's report, St. Lucia noted:

> that the proposed Schedule amendment had not been for a zero quota, but instead was for a specific quota. Given that the previous quota was expired, it commented that what the Commission had actually said to Denmark/Greenland was to go forth and manage their fishery on their own. It considered that whaling would continue despite the outcome of the vote because the outcome effectively meant no quota advice was given.

IWC Annual Report 2012, *supra* note 13, at 36.

[28] Letter from Johnny Aiken, Exec. Dir., Alaska Eskimo Whaling Comm'n, to Douglas P. DeMaster, U.S. IWC Comm'r (Aug. 31, 2012) [hereinafter AEWC Letter]. The AEWC comprises "members of Alaska Eskimo Whaling Commission are the registered whaling captains and their crew members of the eleven whaling communities of the Arctic Alaska coast. *Our Whaling Villages*, ALASKA ESKIMO WHALING COMM'N, http://aewc-alaska.com/Our_Whaling_Villages.html (last visited Jan. 15, 2015).

[29] Schedule, *supra* note 1, ¶ 13.

[30] *Summary of Main Outcomes*, *supra* note 1, at 6 (amending the Schedule to allow aboriginal subsistence whaling). The schedule amendment for Greenland's quota achieved the necessary three-fourths majority with forty-six members voting "yes," eleven members voting "no", and three members abstaining. IWC, *Status of Agenda Items at IWC/65 as of Monday, 15 September 2014*, at 1-2, IWC/65/Status (2014), *available at* https://archive.iwc.int/pages/view.php?ref=3577.

[31] *See* IWC, *Proposed Schedule Amendment (IWC 64)*, at 1, IWC/64/12 (2012) (providing that the number of minke whales struck from the Central stock and West Greenland stock shall not exceed twelve and 178 respectively for the years 2013, 2014, 2015, 2016, 2017, and 2018).

supported by Mexico, Australia, and other IWC members called on the IWC to designate Greenland's whaling as an infraction.[32] If Greenland's ASW for 2013 and 2014 constitutes an infraction, then Denmark, which ratified the ICRW on Greenland's behalf,[33] must punish and prosecute those engaged in the whaling.[34] Denmark has so far resisted these efforts.[35]

Based on the ordinary meaning of paragraph 13 of the Schedule, this article concludes that the ICRW does not establish a right for Greenland (or any other IWC member) to conduct ASW hunts in the absence of an IWC-adopted quota. Moreover, Greenland's subsequent hunt conducted without the required IWC approved ASW quota constitutes an infraction, either as unauthorized ASW or as whaling in violation of the moratorium on commercial whaling. As the International Court of Justice noted in *Whaling in the Antarctic*,[36] only three types of whaling exist: scientific research whaling,

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[32] IWC, *Report of the Infractions Sub-Committee*, at 2, IWC/65/Rep04 (Sept. 11, 2014), *available at* https://archive.iwc.int/pages/view.php?ref=3580 [hereinafter *IWC Report of the Infractions Sub-Committee*].

[33] Greenland is an autonomous territory within Denmark. When Denmark ratified the ICRW, it did so implicitly on behalf of Greenland. Denmark's instrument of ratification does not explicitly state that Denmark is ratifying on behalf of Greenland. *See* Email from Francis J. Holleran, Depositary Officer, U.S. Department of State, to Chris Wold, Assoc. Professor of Law, Lewis & Clark Law School (Sept. 15, 2006) (on file with author) (providing the English translation of the Declaration of the Kingdom of Denmark of Accession to the International Convention on the Regulation of Whaling). However, Lord McNair, a renowned international law scholar, has stated that when a treaty does not include a territorial application clause, "the treaty applies to all the territory of the Contracting Party, whether metropolitan or not" unless a government expressly indicates otherwise. LORD MCNAIR, THE LAW OF TREATIES 117 (1961). This rule was codified in the Vienna Convention, which states that "unless a different intention appears from the treaty or is otherwise established, the application of a treaty extends to the entire territory of each party." Vienna Convention on the Law of Treaties art. 29, May 23, 1969, 1155 U.N.T.S. 331 (entered into force Jan. 27, 1980) [hereinafter Vienna Convention]. As the ICRW does not include any provisions for applying the convention to territories, the general rule applies.

[34] ICRW, *supra* note 1, art. IX (requiring prosecution over infractions by the "government having jurisdiction over the offense" and a requirement to report infractions and actions taken to the IWC).

[35] *See IWC Report of the Infractions Sub-Committee*, *supra* note 32, at 2 (detailing Denmark's view that Greenland's infraction is not exceptional enough to warrant investigation and punishment, but that a balance struck between the ICRW requirements and Greenland's ASW needs should be struck).

[36] 2014 I.C.J. 148 (Mar. 31).

commercial whaling, and aboriginal subsistence whaling.[37] Since Japan's whaling did not constitute scientific research whaling, it constituted commercial whaling,[38] as it was not for aboriginal subsistence. Similarly, since Greenland has not hunted consistently with paragraph 13 of the Schedule (and its whaling cannot be considered to be for purposes of scientific research), then its whaling must be either commercial in violation of paragraph 10(e) of the Schedule or unauthorized ASW in violation of paragraph 13 of the Schedule. Consequently, it should be recorded as an infraction by the IWC and Denmark must take action, pursuant to article IX of the ICRW, to punish and prosecute those involved in Greenland's ASW.

Although paragraph 13 of the Schedule provides that ASW quotas "shall be established" and states that taking of whales for ASW "is permitted,"[39] it also establishes clearly articulated conditions that must be met prior to approval of an ASW quota. In addition, the long-standing practice of the relevant States and the IWC supports the position that IWC-approved quotas are necessary to conduct ASW hunts. Indeed, since the IWC adopted the current language and structure of paragraph 13, no IWC member has ever allowed ASW in the absence of an IWC-approved quota—until Greenland did so in 2013 and 2014. The reasons are obvious; if governments were able to set their own quotas under national legislation, they would undermine the IWC's management scheme.

Finally, rules of logic support the view that paragraph 13 requires the IWC to approve an ASW quota only after it has determined that all the relevant conditions of paragraph 13 have been met. If paragraph 13 establishes a right to ASW, then the role of the IWC would only be to limit ASW quotas of IWC members rather than to authorize ASW quotas. Under these circumstances, it is illogical that an IWC member would need to submit an application to limit its ASW based on subsistence need. Instead, the long-standing practice of the IWC has been to require members to submit an application that demonstrates the subsistence need for an ASW quota, which the

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[37] *See id.* at 148, ¶¶ 229-30 (finding that the Schedule does not allow for definitions of whaling outside of the definitions provided in article VIII of the ICRW).

[38] *Id.* ¶ 231.

[39] AEWC Letter, *supra* note 28.

IWC then accepts based on consensus or votes to either approve or reject.

Section II of this article begins by briefly introducing the ICRW. Section III provides a history of ASW in the IWC and parses the provisions of the Schedule relating to ASW. Section IV applies rules of treaty interpretation found in the Vienna Convention on the Law of Treaties to specific arguments made by those supporting the right of Greenland to establish ASW quotas unilaterally. Section V assesses a range of other evidence, including the practice of relevant IWC members that supports the conclusion that the IWC must approve ASW quotas and that IWC members may not unilaterally establish such quotas. Section VI explains that Greenland's unauthorized ASW in 2013 and 2014 constitutes an infraction. Section VII concludes that Denmark, by virtue of its relationship with Greenland, has acted inconsistently with the ICRW and its Schedule by allowing Greenland to conduct ASW in 2013 and 2014 in the absence of an IWC-approved quota and by failing to report Greenland's hunt as an infraction.

II. SHORT INTRODUCTION TO THE ICRW

The ICRW establishes two objectives: the conservation of whales and the orderly development of a whaling industry.[40] The ICRW itself establishes few rules to achieve those goals. Instead, it creates a commission, the IWC,[41] with the authority to adopt binding regulations "with respect to the conservation and utilization of whale resources."[42] These regulations may relate to a wide variety of matters, including protected and unprotected species; open and closed seasons; open and closed waters; size limits; and time, methods, and intensity of whaling.[43] These regulations, which must be adopted by a three-fourths majority of IWC members,[44] are included in the ICRW's Schedule. The IWC's Scientific Committee provides scientific and technical advice to the IWC.[45]

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[40] ICRW, *supra* note 1, pmbl.

[41] *Id.* art. III(1).

[42] *Id.* art. V(1).

[43] *Id.*

[44] *Id.* art. III(2).

[45] Greg Donovan & Phil Hammond, *Scientific Committee Handbook*, INT'L WHALING COMM'N (2014), http://iwc.int/scientific-committee-handbook (stating

IWC members may opt out of regulations through an objection[46] or reservation.[47] The ICRW expressly allows objections, provided that an IWC member does so within ninety days of receiving notification of the amendment to the Schedule.[48] The ICRW does not explicitly allow reservations when ratifying or acceding to the convention, but it does not preclude them.[49] IWC members have only sparingly taken objections and reservations, although when they do they have been controversial. For example, despite the moratorium on commercial whaling,[50] Norway hunts whales commercially pursuant to an objection,[51] killing at least 729 minke whales in 2014.[52] Iceland hunts whales pursuant to a reservation.[53] Iceland, although it voted against the moratorium, did not file an objection to the decision, eventually ceased whaling, and withdrew from the

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that the IWC established the Scientific Committee in 1950).

[46] Under the ICRW, an amendment "shall not become effective with respect to any Government which has so objected until such date as the objection is withdrawn." ICRW, *supra* note 1, art. V(3).

[47] A reservation is "a unilateral statement, however phrased or named, made by a State, when signing, ratifying, accepting, approving or acceding to a treaty, whereby it purports to exclude or to modify the legal effect of certain provisions of the treaty in their application to that State." Vienna Convention, *supra* note 33, arts. 2(1)(d), 19.

[48] ICRW, *supra* note 1, art. V(3).

[49] The Vienna Convention provides:

> A State may, when signing, ratifying, accepting, approving or acceding to a treaty, formulate a reservation unless:
>
> (a) the reservation is prohibited by the treaty;
>
> (b) the treaty provides that only specified reservations, which do not include the reservation in question, may be made; or
>
> (c) in cases not failing under subparagraphs (a) and (b), the reservation is incompatible with the object and purpose of the treaty.

Vienna Convention, *supra* note 33, art. 19.

[50] Schedule, *supra* note 1, art. III, ¶ 10(e).

[51] *Id.* art. III, ¶ 10(e) n.* (providing that the "[g]overnments of Japan, Norway, Peru and the Union of Soviet Socialist Republics lodged objection[s]" to art. III, ¶ 10(e) of the Schedule).

[52] Barbro Andersen & Sigurd Steinum, *729 Hval Skutt Under den Beste Sesongen Siden 1993*, NORDLAND JOUNALIST (Aug. 20, 2014), http://www.nrk.no/nordland/arets-gode-hvalsesong-er-over-1.11887970.

[53] Schedule, *supra* note 1, art. III, ¶ 10(e) n.• (referring to Iceland's instrument of adherence deposited on October 10, 2002 that states Iceland "adheres to the aforesaid Convention and Protocol with a reservation with respect to paragraph 10(e) of the Schedule attached to the Convention").

ICRW in 1992.[54] It acceded to the ICRW and rejoined the IWC in 2002.[55] Because the ninety-day period for entering objections had expired, Iceland filed a reservation to the commercial ban, which many consider to be invalid.[56] Iceland then resumed full-scale commercial whaling in 2006.[57] Japan hunts whales pursuant to the ICRW's provision for scientific research whaling.[58]

Over time, the IWC has established an array of binding regulations. These include, for example, the creation of the Southern Ocean Sanctuary,[59] catch limits,[60] size limits,[61] restrictions on the types of harpoons that can be used,[62] and aboriginal subsistence whaling.[63] Paragraph 10 of the Schedule classifies whale stocks into three categories and sets quotas based on the maximum sustained yield ("MSY") target for that category.[64] Since the 1985/1986 whaling season, catch limits for all stocks for commercial purposes have been set to zero, unless otherwise specified in the tables of

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[54] *Iceland and Commercial Whaling*, INT'L WHALING COMM'N (2014), http://iwc.int/iceland.

[55] *Id.*

[56] Iceland's reservation has been particularly controversial, with several IWC members lodging objections to it. Schedule, *supra* note 1, art. III, ¶ 10(e) n.# (reporting objections to Iceland's reservation by Argentina, Australia, Brazil, Chile, Finland, France, Germany, Italy, Mexico, Monaco, the Netherlands, New Zealand, Peru, San Marino, Spain, Sweden, the United Kingdom, and the United States). One reason that Iceland's reservation is so controversial is that Iceland cast the decisive vote to approve it, a decision that many regard as fundamentally flawed. *See* Chris Wold, *Implementation of Reservations Law in International Environmental Treaties: The Cases of Cuba and Iceland*, 14 COLO. J. INT'L ENVTL. L. & POL'Y 53, 91 (2003).

[57] *See Catches Taken: Under Observation or Under Reservation*, *supra* note 9 (revealing that Iceland caught seven fin whales and one minke that year).

[58] *See* ICRW, *supra* note 1, art. VIII (allowing governments to provide scientific research permits to nationals for whaling and providing reporting requirements for said permits).

[59] Schedule, *supra* note 1, art. III ¶ 7(b) (designating coordinates for the perimeter of the "Southern Ocean Sanctuary").

[60] *Id.* ¶ 10(e) (setting the catch limits for commercial purposes to zero).

[61] *Id.* ¶¶ 15, 18 (establishing size limits that protect smaller, younger whales for several species).

[62] *Id.* ¶ 6 (forbidding use of the "cold grenade harpoon" for many commercial whaling purposes).

[63] *Id.* ¶ 13 (creating standards for ASW whaling based on aboriginal needs and maximum sustainable yields).

[64] *Id.* ¶¶ 10(a)-(c) (outlining the following categories: Sustained Management Stock, Initial Management Stock, and Protection Stock).

paragraph 10 of the Schedule.[65] The only whale stock that has a catch limit listed in the tables is the West Greenland stock of fin whales, which sets sixteen animals as the maximum number that may be struck.[66] The footnotes indicate that this number is available to be struck by aborigines pursuant to paragraph 13(b)(3),[67] which includes the provisions for Greenlanders to hunt these whales for aboriginal subsistence.

III. THE ICRW'S PROVISIONS RELATING TO ASW

As with other aspects of whaling, the ICRW itself does not include provisions relating to ASW. However, concerns relating to ASW formed an important part of the negotiations relating to the ICRW, concerns which continue to form a critical part of the ongoing work of the IWC.

A. ASW IN THE ICRW'S EARLY YEARS

During the final negotiations of the ICRW in 1946, negotiators from Canada and the Soviet Union objected that the ICRW did not include an exception for ASW.[68] They also made clear that restricting aborigines to "traditional" methods, such as hunting in canoes without firearms, was unacceptable due to challenging Arctic conditions.[69]

Negotiators responded by including a formal statement in the ICRW's Final Act that declares support for the continued taking of gray whales in the Bering and Chukchi Seas, provided that the meat and other products were used "exclusively for local consumption by the aborigines of the Chokotsk and Korjaksk areas."[70] They also included a provision in the initial Schedule exempting the killing of gray and right (also known as bowhead) whales from a whaling ban,

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[65] *Id.* ¶ 10(e).

[66] *Id.* ¶ 1(C) (defining "strike" as "to penetrate with a weapon used for whaling").

[67] *Id.* at 6 n.2.

[68] *See generally* Michael F. Tillman, *The International Management of Aboriginal Whaling*, 16 REVIEWS IN FISHERIES SCI. 437, 438 (2008) (providing an excellent overview of the early years of ASW).

[69] *Id.*

[70] *See id.* at 438-39 (quoting from the Final Act of the Washington Conference at which negotiating States adopted the ICRW).

provided that the meat and other products were used exclusively for local consumption by aborigines.[71] From its inception, the ICRW recognized the important role that whale products play in the nutritional and cultural life of some native peoples.[72] At the same time, by limiting the purposes for and areas in which ASW could occur, the ICRW also affirmed that the IWC could and would regulate such whaling.

From 1948 to 1961, ASW occurred under these basic provisions. When the IWC started limiting the killing of humpback whales, it included a new ASW exception in 1961 to permit Greenlanders to continue killing up to ten humpback whales annually.[73] In 1964, the IWC amended the Schedule to allow a government to kill gray and right whales on behalf of aborigines, provided that the meat and other whale products were used "exclusively for local consumption by the aborigines."[74]

B. ASW IN THE 1970S AND 1980S

ASW changed dramatically in the 1970s when the Scientific Committee became concerned about the rising number of bowhead whales killed by Alaskan Eskimos, as well as an alarming increase in those whales struck by harpoons but lost (known as "struck and lost" in IWC jargon). Whereas the average number of bowheads killed by Alaskan Eskimos had averaged ten between 1945 and 1969, it averaged thirty between 1970 and 1977.[75] Moreover, the number of whales struck and lost rose from ten in 1973 to eighty-two in 1977.[76] Meanwhile, the Scientific Committee estimated that the bowhead population had declined from a historic level between 11,700 and 18,000 to 1,300 in 1977.[77] As a consequence, the Scientific

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[71] *Id.* at 439.

[72] *Bowhead Whale, Qeqertarsuaq, Greenland*, INT'L WHALING COMM'N (2014), http://iwc.int/aboriginal (noting the two major objectives of IWC regulation of ASW is to maintain healthy populations of whale and to allow aboriginal groups to maintain cultural practices of whaling).

[73] *See* IWC, *Twelfth Report of the Commission*, at 31 (1961) (finding nothing wrong with a proposal to allow the killing of ten humpback whales for local consumption in Greenland).

[74] IWC, *Sixteenth Report of the Commission*, at 20-21 (1966).

[75] Tillman, *supra* note 68, at 439.

[76] *Id.*

[77] *Id.* (estimating that the population of bowhead whales dropped to seven to

Committee recommended that ASW of bowheads by Alaskan Eskimos should cease.[78] The IWC agreed, amending the Schedule by deleting the exception for killing right whales (i.e., bowheads) by aborigines.[79]

In the late 1970s and early 1980s, the IWC began exploring a more systematic way of regulating ASW. For example, in 1979, the IWC asked the United States to demonstrate the nutritional, cultural, and subsistence needs of Alaskan Eskimos for bowhead whales,[80] and the next year extended that requirement to all aboriginal hunts.[81] Although these requests were found in non-binding resolutions, the United States and other IWC members complied with the requests.[82] As discussed below, demonstrating need later became a requirement included in the Schedule.

The IWC also created a working group to define subsistence use and objectives for managing whales subject to ASW.[83] That working

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eleven percent of its original size by 1977). Subsequent population estimates showed the bowhead population to be "much larger." Randall R. Reeves, *The Origins and Character of "Aboriginal Subsistence" Whaling: A Global Review*, 32 MAMMAL REV. 71, 72 (2002).

[78] IWC, *Twenty-Eighth Report of the International Whaling Commission*, at 22 (1978) (expressing concern for both killed and "struck but lost" bowheads likely as a result from adoption of shoulder guns instead of dart guns for hunting).

[79] *Id.*

[80] IWC, *Thirtieth Report of the International Whaling Commission*, at 35 (1980) (stating that the IWC would review and make a determination based on the information provided by the United States).

[81] IWC, *Thirty-First Report of the International Whaling Commission*, at 29 (1981) ("[A]ll Contracting Governments under whose jurisdiction aboriginal/ subsistence whaling operations conducted under paragraph 12 of the Schedule shall document annually for the information of the Commission: the utilization of the meat and products of any whales taken for aboriginal/subsistence purposes.").

[82] *See, e.g.*, *id.* at 18 (discussing the interim report submitted by the United States in fulfillment of the resolution on the cultural, nutritional, and subsistence needs of Eskimo populations).

[83] *See id.* at 17 (stating that the working group would "develop appropriate management principles and guidelines for subsistence catches").

group recommended the following definitions to help frame aboriginal subsistence whaling:

> *Aboriginal subsistence whaling* means whaling for purposes of local consumption carried out by or on behalf of aboriginal, indigenous, or native peoples who share strong community, familial, social, and cultural ties related to a continuing traditional dependence on whaling and on the use of whales.
>
> *Local aboriginal consumption* means the traditional uses of whale products by local aboriginal, indigenous, or native communities in meeting their nutritional, subsistence, and cultural requirements. The term includes trade in items which are by-products of subsistence catches.
>
> *Subsistence catches* are catches of whales by aboriginal subsistence whaling operations.[84]

The working group's report also noted that the use of modern technologies to hunt whales is not inconsistent with these definitions.[85] In fact, the use of modern technologies could be more humane by reducing the length of time it takes for whales to die (known as "time to death" in IWC jargon) and could have conservation benefits by reducing the number of animals struck and lost. The report thus recognized that cultures evolve and that the IWC is not trying to "lock in" aboriginal cultures to some distant point in the past. The IWC accepted the report of the working group in a 1982 resolution,[86] but it did not include the definitions in the Schedule.

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[84] IWC, *Aboriginal/Subsistence Whaling (with Special Reference to the Alaska and Greenland Fisheries)*, at 83 (1982) [hereinafter *Aboriginal/Subsistence Whaling*].

[85] *See id.* at 82 (agreeing that hunting techniques be "as humane as possible").

[86] IWC, *Chairman's Report of the Thirty-Fourth Annual Meeting*, at 38 (1983) [hereinafter *IWC 1982 Report*].

In the same 1982 resolution, the IWC also adopted the working group's recommended principles for ASW:

> To ensure that the risks of extinction to individual stocks are not seriously increased by subsistence whaling;
>
> To enable aboriginal people, to harvest whales in perpetuity at levels appropriate to their cultural and nutritional requirements, subject to the other objectives;
>
> To maintain the status of whale stocks at or above the level giving the highest net recruitment and to ensure that stocks below that level are moved towards it so far as the environment permits.[87]

Unlike the definitions, the IWC formalized these principles in paragraph 13 of the Schedule, marking the first time that the IWC imposed scientific requirements for ASW. At the same time, these principles allowed ASW to increase the risks of extinction to a species, so long as that increase is not "serious." The IWC's willingness to accept this conservation risk reflects a recognition of the cultural and nutritional needs of aboriginal peoples, as well as the historically low numbers of whales killed in ASW relative to commercial operations and ASW's lack of a profit motive.[88]

While one author has called the conceptual distinction between commercial whaling and ASW "crude and ambiguous,"[89] the legal distinction is clear: ASW occurs pursuant to paragraph 13 of the Schedule and commercial whaling occurs pursuant to the other provisions of the Schedule, particularly paragraph 10. In fact, while the moratorium on commercial whaling has been in place since 1986, the IWC has continued to review and, in most circumstances, allow limited taking of whales for aboriginal subsistence purposes.[90]

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[87] *Aboriginal/Subsistence Whaling*, *supra* note 84, at 84.

[88] Tillman, *supra* note 68, at 441 (stating that the willingness of the IWC to accept additional risks associated with ASW "apparently arises from a commonly shared belief that, whereas commercial operations are driven by market forces to maximize catches, aboriginal hunts tend to be self-limiting in that they only take what is necessary to satisfy basic human needs").

[89] Reeves, *supra* note 77, at 77, 96-99 (reviewing various interpretations of "aboriginal subsistence").

[90] *See* Schedule, *supra* note 1, art. III, ¶¶ 10, 13. Much more could certainly be said concerning the history of ASW. The IWC has adopted numerous resolutions concerning ASW for specific whale populations. ASW quotas have

C. ASW TODAY

By incorporating the three principles for ASW in the Schedule, the IWC seeks to ensure that ASW does not seriously increase risks of extinction to individual whale stocks and that aboriginal people are able to hunt whales at levels appropriate to cultural and nutritional requirements "in perpetuity."[91] National governments, on behalf of an aboriginal group, must submit a "Needs Statement" that provides evidence of the cultural, subsistence, and nutritional aspects of the hunt, products, and distribution.[92] The IWC's Scientific Committee provides advice on the sustainability of proposed hunts and safe catch limits. The IWC then considers that advice along with the Needs Statement.[93]

More specifically, paragraph 13 establishes two sets of conditions for ASW. Paragraph 13(a) provides the first set of conditions, which apply to ASW quotas for *any* stock. Paragraph 13(a) permits ASW quotas "notwithstanding" the provisions of paragraph 10, provided that several conditions are met. Paragraph 13(a) begins by providing that a quota shall be established, but only (i) to satisfy the aboriginal subsistence need, (ii) for each whaling season, and (iii) in accordance with five additional principles.[94] These five principles relate to the conservation status of the stock, the prohibition against striking or killing calves or suckling calves (depending on the situation), and the need for national legislation that accords with paragraph 13. For example, ASW quotas must be established for those stocks at or above MSY if removals do not exceed ninety percent of MSY; if a stock is below MSY, then quotas are permissible if the quotas allow the stock to move towards MSY.[95]

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fluctuated over the years as well. In addition, the IWC now maintains an Aboriginal Subsistence Whaling Working Group. For more on these issues, see generally *IWC Annual Report 2012*, *supra* note 13.

[91] *See Aboriginal/Subsistence Whaling*, *supra* note 84, at 84.

[92] *See* Schedule, *supra* note 1, art. III, ¶ 13 (establishing whaling ASW quotas based on data submitted by national governments on aboriginal subsistence needs).

[93] *See id.* (balancing maximum sustainable yields with aboriginal needs).

[94] *Id.* ¶ 13(a).

[95] *Id.* ¶ 13(a)(1)-(5).

Paragraph 13(b) provides the second set of conditions. These conditions apply to ASW quotas for *specific* stocks. The chapeau of paragraph 13(b) states that "catch limits for [ASW] are as follows."[96] Paragraphs 13(b)(1)–(4) then set out the conditions under which ASW hunts may occur for specific whale stocks in specific years in specific geographical regions.[97] For each stock, whale meat and other whale products must be used solely for local consumption.[98]

In addition, paragraph 13(b) establishes specific, numerical quotas for each stock. For example, the ASW quota for bowhead whales in the Bering-Chukchi-Beaufort Seas may not exceed 336 for the years 2013-2018; [99] the ASW quota for gray whales from the Eastern stock in the North Pacific may not exceed 140 over the same period.[100] Notably, after the 2012 IWC annual meeting, the ASW quotas applicable to Greenland (e.g., Western Greenland stock of minke whales) did not include quotas for the 2013-2018 period. Instead, the Schedule continued to refer to quotas applicable to the years 2010, 2011, and 2012.[101] Of course, this changed as a result of the IWC's 2014 decision approving Greenland's ASW quotas.[102]

However, not all of the specific provisions for ASW are drafted the same in paragraph 13(b). Paragraph 13(b)(1) is the most clearly drafted. It states that taking of bowhead whales from the Bering-Chukchi-Beaufort Seas stock is permitted "*but only when*" the whale products are used for local consumption by aborigines and "*further provided that*" several additional conditions are met.[103] One of these

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[96] *Id.* ¶ 13(b).

[97] *Id.* ¶ 13(b)(1)-(4).

[98] *Id.*

[99] *Id.* ¶ 13(b)(1)(i).

[100] *Id.* ¶ 13(b)(2)(i).

[101] *Id.* ¶ 13(b)(3).

[102] *See Summary of Main Outcomes*, *supra* note 1, at 6.

[103] Schedule, *supra* note 1, art. III, ¶ 13(b)(1) (emphasis added). The Schedule also states:

> The taking of bowhead whales from the Bering-Chukchi-Beaufort Seas stock by aborigines is permitted, but only when the meat and products of such whales are to be used exclusively for local consumption by the aborigines and further provided that:
>
> (i) For the years *2013, 2014, 2015, 2016, 2017* and *2018*, the number of bowhead whales landed shall not exceed *336*. For each of these years the number of bowhead whales struck shall not exceed 67, except that any unused portion of a strike quota from any year (including 15 unused strikes from the *2008-2012* quota) shall be carried forward and added to the strike quotas of any subsequent years, provided that no more

additional conditions requires a quota to be granted for a specific year;[104] another requires an annual review by the IWC in light of evidence from the Scientific Committee.[105]

Paragraph 13(b)(3) states that taking by aborigines from certain stocks in the waters around Greenland is permitted "*and then only when*" the meat is used for local consumption. Unlike paragraph 13(b)(1), however, it does not end with the phrase "and further provided that." Instead, paragraph 13(b)(3), as well as paragraph (b)(2) for ASW of gray whales, comes to a full stop before adding quotas for individual whale stocks in sub-paragraphs 13(b)(3)(i)-(v).[106] Notably, the number of fin whales from the West Greenland stock included in paragraph 13(b)(3) is sixteen,[107] consistent with

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> than 15 strikes shall be added to the strike quota for any one year.
>
> (ii) This provision shall be reviewed annually by the Commission in light of the advice of the Scientific Committee.

Id.

[104] *Id.* ¶ 13(b)(1)(i).

[105] *Id.* ¶ 13(b)(1)(ii).

[106] Section 13(b)(2) states that:

> The taking of gray whales from the Eastern stock in the North Pacific is permitted, but only by aborigines or a Contracting Government on behalf of aborigines, and then only when the meat and products of such whales are to be used exclusively for local consumption by the aborigines.
>
> (i) For the years *2013, 2014, 2015, 2016, 2017* and *2018*, the number of gray whales taken in accordance with this sub-paragraph shall not exceed *744*, provided that the number of gray whales taken in any one of the years *2013, 2014, 2015, 2016, 2017* and *2018* shall not exceed 140.
>
> (ii)This provision shall be reviewed annually by the Commission in light of the advice of the Scientific Committee.

Id. ¶ 13(b)(2).

In contrast, section 13(b)(3) states that:

The taking by aborigines of minke whales from the West Greenland and Central stocks and fin whales from the West Greenland stock and bowhead whales from the West Greenland feeding aggregation and humpback whales from the West Greenland feeding aggregation is permitted and then only when the meat and products are to be used exclusively for local consumption.

> (i) The number of fin whales struck from the West Greenland stock
> (ii) The number of minke whales struck from the Central stock
> (iii) The number of minke whales struck from the West Greenland stock
> (iv) The number of bowhead whales struck off West Greenland
> (v)The number of humpback whales struck off West Greenland

Id. ¶ 13(b)(3).

[107] *Id.* ¶ 13(b)(3) (including the catch limit for the West Greenland stock of fin whales in both Table 1 and in paragraph 13(b)(3) is redundant, particularly since all other ASW catch limits have been removed from Table 1).

Table 1 in paragraph 10. No other stocks for which quotas are set in paragraph 13(b) have catch or strike limits set out in Table 1. Finally, paragraph 13(b)(4) comprises just two sentences allowing humpback quotas for the Bequians of St. Vincent and the Grenadines in specific years for local consumption.[108]

Structurally, the differences between these paragraphs are merely cosmetic, the result of drafting these provisions over a wide span of time,[109] and, unfortunately, bad drafting. In fact, subparagraphs 13(b)(1), (b)(2), and (b)(3) are structurally identical, except for the use of "further provided that" in subparagraph 13(b)(1). These similarities, especially when comparing the nearly identical language in the paragraphs, are quite plain when one examines the texts word-by-word.[110] Functionally, these subparagraphs serve the same purpose: to impose additional conditions for the establishment of quotas described in the chapeau of paragraph 13(b).[111]

IV.THE VIENNA CONVENTION AND THE ORDINARY MEANING OF THE ASW PROVISIONS

Although the language of the ASW provisions is inconsistent, the meaning of these provisions can be identified by resorting to the rules of treaty interpretation found in the Vienna Convention on the Law of Treaties ("Vienna Convention").[112] The Vienna Convention requires as a general rule that a treaty be interpreted "in good faith in accordance with the ordinary meaning to be given to the terms of the treaty in their context and in the light of its object and purpose."[113]

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[108] *Id.* ¶ 13(b)(4) ("For the seasons *2013-2018* the number of humpback whales to be taken by the Bequians of St. Vincent and The Grenadines shall not exceed *24*. The meat and products of such whales are to be used exclusively for local consumption in St. Vincent and The Grenadines.").

[109] *See* IWC, *Report of the Aboriginal Subsistence Whaling Working Group*, at 14, IWC/64/ASW5 Rev1 (May 28, 2012) (providing an historical overview of ASW in the IWC).

[110] *Compare Summary of Main Outcomes*, *supra* note 1, ¶ 13(b)(3), *and id.* ¶ 13(b), *with id.* ¶ 13(b)(2)(i), *and id.* ¶¶ 13(b)(1)-(4).

[111] *See infra* Part III.A.

[112] Vienna Convention, *supra* note 33, art. 31.

[113] *Id.* art. 31(1). This textual approach to interpretation, which focuses on the ordinary meaning of terms, has attained the status of customary international law. Territorial Dispute Case (Libyan Arab Jamahiriya/Chad), 1994 I.C.J. 6, ¶ 41 (Feb. 3) ("[I]n accordance with customary international law, reflected in Article 31 of the 1969 Vienna Convention on the Law of Treaties, a treaty must be interpreted in

The context can include, *inter alia*, any subsequent practice that establishes the agreement of the parties as to the interpretation or application of the treaty.[114] The Schedule, as amended, is an integral part of the ICRW[115] and is therefore subject to the rules of treaty interpretation described in the Vienna Convention.[116] As a consequence, the Schedule must be interpreted according to the ordinary meaning of the language, taken in context of the object and purpose of the treaty, and in light of practical application.

As described in the following sub-sections, the ordinary meaning of the ASW provisions, in light of the ICRW's context, object, and purpose, supports the conclusion that the IWC must approve ASW quotas and that individual IWC members are not authorized to conduct ASW unilaterally. This analysis provides a good-faith interpretation of the treaty based on its recognized purpose "to provide for the proper conservation of whale stocks and thus make possible the orderly development of the whaling industry."[117] The inclusion of both conservation and use goals in the preamble suggests the need for management, and thus the ICRW should be recognized as a treaty designed to manage whale stocks by the IWC.

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good faith in accordance with the ordinary meaning to be given to its terms in their context and in the light of its object and purpose. Interpretation must be based above al1 upon the text of the treaty."); Competence of the General Assembly for the Admission of a State to the United Nations, Advisory Opinion, 1950 I.C.J. 4, 8 (Mar. 3) ("[T]he first duty of a tribunal which is called upon to interpret and apply the provisions of a treaty, is to endeavour to give effect to them in their natural and ordinary meaning in the context in which they occur. If the relevant words in their natural and ordinary meaning make sense in their context, that is an end of the matter."); *see also* 1 OPPENHEIM'S INTERNATIONAL LAW 1271-75 (Robert Jennings & Arthur Watts eds., 9th ed. 2002).

[114] *Id.* art. 31(3)(b).

[115] ICRW, *supra* note 1, art. I, ¶ 1 ("The Schedule attached thereto which forms an integral part thereof").

[116] Vienna Convention, *supra* note 33, art. 5 (stating that the Convention applies to any treaty that is a constituent instrument of an international organization). Although the ICRW pre-dates the Vienna Convention, the Vienna Convention's basic rules on treaty interpretation, including article 31, are considered customary international law. IAN BROWNLIE, PRINCIPLES OF PUBLIC INTERNATIONAL LAW 608 (5th ed. 1998) (stating that "a good number" although not all, of the provisions of the Vienna Convention express general international law, and those that do not "constitute presumptive evidence of emergent rules of general international law"); IAN M. SINCLAIR, VIENNA CONVENTION ON THE LAW OF TREATIES 5-21 (2d ed. 1984).

[117] ICRW, *supra* note 1, pmbl.

The Schedule is the mechanism by which the ICRW and IWC establish rules for managing individual whale stocks, and the Schedule's provisions must be interpreted in light of this purpose. Any interpretation must be careful not to undercut the ability of the IWC to manage whale stocks according to all provisions of the ICRW.

As described below, the ordinary meaning of the terms and provisions used in the Schedule indicate that paragraph 13(a) establishes a number of conditions that must be met before an ASW quota may be approved. Moreover, the ordinary meaning supports the conclusion that the IWC must determine whether the conditions have been met and must establish ASW quotas. Paragraph 13 does not create a right for an IWC member to conduct ASW hunts.

A. THE USE OF "NOTWITHSTANDING" IN PARAGRAPH 13 IDENTIFIES ASW AS AN EXCEPTION TO THE RULES OF PARAGRAPH 10

Paragraph 13(a) of the Schedule begins with the phrase "notwithstanding the provisions of paragraph 10." The word "notwithstanding" is widely recognized as indicating an exception to a rule. The ordinary meaning of "notwithstanding," defined as "in spite of,"[118] makes that clear: "In spite of" the catch limits and other provisions included in paragraph 10, the IWC may authorize ASW quotas; the ASW quotas are the exception to the primary rules established in paragraph 10. As such, paragraph 13 does not establish an absolute right to ASW, as some have suggested.[119]

The World Trade Organization ("WTO")'s Appellate Body has interpreted "notwithstanding" in the same manner. In a trade dispute unrelated to the ICRW, the WTO Appellate Body concluded that use of the term "notwithstanding" creates an exception to a general rule.[120] It further recognized that a State could use the exception to

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[118] *Notwithstanding Definition*, OXFORD ENGLISH DICTIONARY ONLINE, http://www.oed.com/view/Entry/128667?redirectedFrom=notwithstanding#eid (last visited Jan. 22, 2015).

[119] *See, e.g.*, AEWC Letter, *supra* note 28, at 2-3 (stating that the United States "is *required* to issue aboriginal subsistence catch limits under the plain language of paragraph 13 of the Schedule").

[120] The Appellate Body stated:

deviate from the general rule only if the conditions set out in the exception are met.[121]

The structure of paragraph 13(a) and its "notwithstanding" language closely mirror the language analyzed by the WTO Appellate Body. In the Schedule, the general rules are provided in paragraph 10 and paragraph 13(a) creates an exception to the general rules. Further, the exception is triggered only when all of the conditions set forth in paragraph 13 are met. If the conditions have not been met, then the exception is not triggered.

Paragraph 10 reinforces this interpretation. Paragraph 10 sets out the catch limits for each whale stock in Table 1, which are all set at zero except for West Greenland fin whales. Although Table 1 includes a catch limit for West Greenland fin whales, that does not suggest that ASW may take place for that stock in the absence of an IWC-approved ASW quota because footnote 2 of Table 1 makes catch limits for West Greenland fin whales "subject to paragraph 13(b)(3)." Thus, footnote 2 creates an express link between the catch limits established in Table 1 and the ASW quotas established in paragraph 13(b)(3). Consequently, the catch limit in Table 1 must meet the same conditions under paragraph 13(a) and paragraph 13(b) as any other ASW hunt. Even if the catch limit for fin whales remains in Table 1, a specific quota must be granted for "each" year under paragraph 13. Thus, without a specific ASW quota, no ASW for West Greenland fin whales may occur. Because the IWC did not grant a quota for West Greenland fin whales in 2013 and 2014, Greenland was not allowed to conduct ASW unilaterally in those years, consistent with the ICRW and the Schedule.

> By using the word "notwithstanding", paragraph 1 of the Enabling Clause permits Members to provide "differential and more favourable treatment" to developing countries "in spite of" the MFN obligation of Article I:1. Such treatment would otherwise be inconsistent with Article I:1 because that treatment is not extended to all Members of the WTO "immediately and unconditionally". Paragraph 1 thus excepts Members from complying with the obligation contained in Article I:1 for the purpose of providing differential and more favourable treatment to developing countries, provided that such treatment is in accordance with the conditions set out in the Enabling Clause. As such, the Enabling Clause operates as an "exception" to Article I:1.

Appellate Body Report, *European Communities – Conditions for the Granting of Tariff Preferences to Developing Countries*, ¶ 90,WT/DSB246/AB/R (Apr. 7, 2004) (adopted Apr. 20, 2004).

[121] *Id.*

B. THE IWC MUST INSCRIBE AN ASW QUOTA IN PARAGRAPH 13(b) BASED ON THE PRINCIPLES AND CONDITIONS INCLUDED IN PARAGRAPH 13(a)

The AEWC argues that paragraph 13(a) can be read in isolation of paragraph 13(b). As a result, AEWC concludes that an IWC-approved quota is not needed and that an IWC member may conduct ASW in the absence of an IWC-approved ASW quota.[122] It achieves this result by claiming that the subparagraphs in paragraph 13(b), including the quotas for specified years identified in each clause (i), are "independent of the rest" of paragraph 13(b).[123]

This reading of paragraph 13 is anything but ordinary. Paragraphs 13(a) and 13(b) must be read in conjunction with each other; neither composes the entire ASW management scheme in isolation. Paragraph 13(a) refers to quotas with the language "*catch limits for aboriginal subsistence whaling* . . . shall be established."[124] Paragraph 13(b) mirrors this language by providing that "*[c]atch limits for aboriginal subsistence whaling* are as follows."[125] In other words, paragraph 13(a) establishes general conditions applicable to all ASW quotas and paragraph 13(b) establishes specific conditions for specific whale stocks. These paragraphs complement each other. The use of identical language in paragraphs 13(a) and 13(b)—"*[c]atch limits for aboriginal subsistence whaling*"—further supports the conclusion that paragraphs 13(a) and 13(b) must be read as one comprehensive management scheme and that specific catch quotas, based on the principles in paragraph 13(a), are to be inscribed in paragraph 13(b).

Paragraph 13(a) also specifies that the conditions for establishing ASW quotas included in paragraph 13 must be met in "each whaling season." This language is straightforward: in each year, a quota must meet all the requirements of paragraph 13 and the IWC alone inscribes ASW quotas for "each whaling season" in paragraph 13(b).

Without an ASW quota from the IWC for the 2013 and 2014 seasons, Greenland did not meet the conditions in paragraph 13(a) of the Schedule that a "catch limit shall be established . . . [for] each

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[122] AEWC Letter, *supra* note 28, at 8, 10.

[123] *Id.*

[124] Schedule, *supra* note 1, art. III, ¶ 13(a) (emphasis added).

[125] *Id.* ¶ 13(b) (emphasis added).

whaling season." The IWC refused to set a quota for the Greenlandic ASW hunt. The language in paragraph 13(a) requires that a quota "be established," which is an affirmative act by some entity. This mirrors the requirement in paragraph 13(a)(2) that the quota is "set at levels." As noted previously in this section, that quota must be inscribed in paragraph 13(b). The only way a quota may be inscribed in paragraph 13(b) is upon a three-fourths majority vote of IWC members. In other words, while the sentence is written in passive voice, the unnamed entity is the IWC, because only the IWC can adopt amendments to paragraph 13(b).

C. THE GENERAL STRUCTURE OF PARAGRAPHS 13(b)(1)-(4) SUPPORTS AN INTERPRETATION OF PARAGRAPH 13 THAT IDENTIFIES THE IWC AS THE ENTITY TO APPROVE ASW QUOTAS

The general structure of paragraphs 13(b)(1)-(4) creates a management scheme that requires the IWC to set quotas before ASW may occur. The drafting of paragraph 13(b)(1) illustrates this conclusion. The phrase "further provided that" underscores the link between the conditions set out in paragraph 13(b)(1) and the additional conditions set out in sub-sections 13(b)(1)(i)-(ii). The phrase indicates that any request for ASW quotas must meet the requirements of these sub-sections before ASW is permitted. The Oxford English Dictionary defines "further" as "going beyond what already exists or has been dealt with; additional, more."[126] The Oxford Dictionary also defines "provided that" as "with the provision or condition (that)."[127] Taken together, the phrase "further provided that" is clearly designed to create conditions in *addition* to those included in the rest of the paragraph. Those additional conditions appear in paragraphs 13(b)(1)(i)-(ii) and include quotas established in specific years. When the IWC has not issued a quota by amending 13(b)(1)(i) of the Schedule, then the conditions of paragraph 13(b)(1) are not met and no ASW hunts may occur.

The AEWC has argued that deleting the numeric ASW quotas in 1977 for specific years in paragraph 13(b)(1)(i) for bowhead whales

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[126] *Further Definition*, OXFORD ENGLISH DICTIONARY, http://www.oed.com/view/Entry/75715?rskey=hgPrmg&result=2&isAdvanced=false#eid (last visited Jan. 22, 2015).

[127] *Provided Definition*, OXFORD ENGLISH DICTIONARY, http://www.oed.com/view/Entry/153449?redirectedFrom=provided#eid (last visited Jan. 22, 2015).

would not have resulted in a zero quota. Instead, it would have resulted in no numeric quota being set, thereby allowing a limitless ASW hunt for bowheads.[128] By extension, the AEWC argues that the failure of the IWC to adopt an ASW quota has the same effect. AEWC reaches this conclusion "since clause (i) is a 'further provided' clause *that is independent of the rest of paragraph 13(b)(1)*."[129] The AEWC's argument is completely without merit. As noted in the previous paragraph, the phrase "further provided that" establishes a link between two elements; it does not sever the link. In the case of paragraph 13(b), it links the conditions in paragraph 13(b)(1) to the conditions in sub-paragraphs (i)–(v). The AEWC is, in fact, interpreting the phrase opposite of the phrase's ordinary meaning.

While paragraph 13(b)(3) forms the basis for Greenland's ASW quota, paragraph 13(b)(1) helps frame paragraph 13(b)(3). As noted in Section III(C) above, the structure of each exception in paragraph 13(b) is the same. While differences in language are generally read as intentional, that is not the case here; to treat sub-paragraphs (i)–(ii) of paragraph 13(b)(1) as additional conditions while treating sub-paragraphs (i)–(iv) of paragraph 13(b)(3) as independent provisions would lead to absurd results. In that scenario, the IWC would need to approve ASW quotas for bowheads in the Bering-Chukchi-Beaufort Seas but not for any of the other stocks subject to ASW. That is exactly the kind of absurd result that treaty interpreters must avoid.[130]

Similarly, paragraph 13(b)(3) cannot be read independently of the overall structure of paragraph 13(b). It could be argued that the full stop at the end of paragraph 13(b)(3) permits ASW of the stocks listed so long as the meat and products are used exclusively for local consumption. This would mean that paragraph 13(b)(3) is read as granting permission to conduct ASW unless the sub-paragraphs 13(b)(3)(i)-(iv) contain a quota limiting the hunt. However, this argument is inconsistent with the overall structure of paragraph

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[128] AEWC Letter, *supra* note 28, at 10.

[129] *Id.* (emphasis added).

[130] *See, e.g.,* Polish Postal Service in Danzig, Advisory Opinion, 1925 P.C.I.J. (ser. B) No. 11, at 39 (May 16) ("[I]t is a cardinal principal of interpretation that words must be interpreted in the sense which they would normally have in their context, unless such interpretation would lead to something unreasonable or absurd.").

13(b), which begins, in the chapeau, with the phrase "catch limits are as follows." It does not logically follow that if the purpose of paragraph 13(b) is to set catch limits, then the subsidiary paragraph sets no limit unless qualified. The quotas set in sub-paragraphs 13(b)(3)(i)-(iv) are a limitation on paragraph 13(b)(3), similar to the way paragraph 13(b)(1)(i) limits paragraph 13(b)(1). To read this section otherwise would render the phrase "catch limits are as follows" superfluous.

The interpretation that paragraph 13(b)(3) is designed to serve the same purpose as paragraph 13(b)(1) fits better with the structure of both paragraph 13(b) and paragraph 13 as a whole. Based on logic and practical application, paragraphs 13(b)(1)-(4) are designed to serve the same purpose, despite their different drafting.

The conclusions in this section and in section IV(D) below are supported by the underlying objectives for managing ASW. In 1982, the IWC agreed on the following objectives for ASW:

> (1) To ensure that the risks of extinction to individual stocks are not seriously increased by subsistence whaling;
>
> (2) To enable aboriginal people, to harvest whales in perpetuity at levels appropriate to their cultural and nutritional requirements, subject to the other objectives; and
>
> (3) To maintain the status of whale stocks at or above the level giving the highest net recruitment and to ensure that stocks below that level are moved towards it so far as the environment permits.[131]

While allowing aboriginal people to meet their cultural and nutritional requirements is an important objective, that objective is *subject to the other objectives* of preventing risks of extinction and maintaining stocks at the highest level of recruitment. In fact, "the highest priority shall be accorded to the objective of ensuring that the

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[131] *Aboriginal/Subsistence Whaling*, *supra* note 84, at 84.

risks of extinction to individual stocks are not seriously increased by subsistence hunting."[132]

Reading paragraph 13(a) in conjunction with paragraph 13(b) best fulfills these objectives. Paragraph 13(a) includes the conditions for ensuring that stocks are not threatened by extinction and maintaining high levels of recruitment. Paragraph 13(b) ensures that meat is actually used to meet cultural and nutritional requirements. It further helps meet the biological goals by ensuring that a quota consistent with all conditions in paragraphs 13(a) and (b) is approved by the IWC and inscribed in paragraph 13(b).

D. THE PHRASES "SHALL BE ESTABLISHED" AND "SHALL BE PERMITTED" DO *NOT* INDICATE THAT EITHER THE IWC OR AN IWC MEMBER IS REQUIRED TO ADOPT AN ASW QUOTA

Paragraph 13(a) provides that ASW quotas "shall be established" and "shall be permitted." However, these phrases do not create a requirement that members issue quotas when the IWC fails to do so, as the AEWC asserts.[133] Rather, the phrase providing that ASW quotas "shall be established" relates to the phrase at the end of the same paragraph: "in accordance with the following principles." Similarly, the phrase "shall be permitted" relates to the phrase "so long as total removals do not exceed 90 percent of MSY." In both cases, the use of "shall" is linked to the requirement to meet specified conditions. The AEWC has conveniently ignored the phrases "in accordance with the following principles" and "so long as" which link the directive to set quotas with meeting the specified conditions.

Again, this is consistent with the ordinary meaning of "shall," which the Oxford English Dictionary defines, in relation to stating a necessary condition, as something that "must" happen "if something else is to happen."[134] That is, a quota must be established, provided

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[132] IWC, *45th Annual Report of the International Whaling Commission*, at 42-43 (1995).

[133] AEWC Letter, *supra* note 28, at 13 ("To comply with the plain language of the Schedule and the [Whaling Convention Act (WCA)], the Secretary [of Commerce] *must* permit aboriginal subsistence whaling and establish numeric catch limits under the WCA if none are provided in the Schedule.").

[134] *Shall Definition*, OXFORD ENGLISH DICTIONARY, http://www.oed.com/view/Entry/177350?rskey=nWMzoy&result=2&isAdvanced=false#eid (last visited

that the relevant conditions are met. Taken together, these phrases demonstrate that the principles enshrined in paragraphs 13(a)(1)-(5) are necessary to meet the general conditions of paragraph 13(a). It does not create an independent requirement for members to issue quotas.

However, the use of "shall" is not superfluous. The IWC must—it "shall"—establish ASW quotas, provided that such quotas are consistent with the principles and conditions established in paragraphs 13(a) and 13(b). If the conditions are met, the IWC may not refuse to establish a quota.

E. THE USE OF PASSIVE VOICE DOES NOT INDICATE THAT EITHER THE IWC OR AN IWC MEMBER MAY IMPLEMENT A PROVISION OF THE ICRW OR THE SCHEDULE

The use of the passive-voice phrase "catch limits . . . shall be established" does not suggest that either the IWC or an IWC member may establish an ASW quota, as the AEWC asserts.[135] Specifically, the AEWC argues that the IWC specifies in the Schedule when it wants the IWC to undertake an activity by using active voice ("[t]he Commission shall") or expressly identifying the Commission as the body to undertake the activity ("[t]his provision shall be reviewed by the Commission."). As a result, according to the AEWC, when the Schedule does not specifically identify the actor, the Commission intended either the IWC or an IWC member to implement the activity. Since paragraph 13 uses passive voice, the AEWC claims that either the IWC or an IWC member may establish ASW quotas.[136]

However, even a casual read of the Schedule shows the fallacy of this argument. Paragraph 10, for example, provides that "[a]ll stocks of whales shall be classified in one of three categories": Sustained Management Stock, Initial Management Stock, and Protection Stock,[137] without identifying who will classify stocks into these categories. In addition, paragraph 10(e) establishes a moratorium on commercial whaling. It is perhaps the most important current

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Jan. 22, 2015).

[135] AEWC Letter, *supra* note 28, at 8, 9.

[136] *Id.*

[137] Schedule, *supra* note 1, art. III, ¶ 10.

provision in the Schedule. Yet, while it provides that the moratorium "will be kept under review," it does not identify which entity will conduct the review.

If the views of the AEWC are accepted, each IWC member could identify whale stocks as falling within one of the three categories. In this scenario, some members could identify a stock as a Protection Stock while others could designate it as a Sustained Management Stock subject to commercial whaling. If the commercial whaling moratorium is removed, individual IWC members would have authority to set independent catch limits for all whale stocks except for the most highly protected category, and could unilaterally reclassify whales as a Sustained Management Stock (lowest level of protection). Similarly, either the IWC or each individual IWC member could review the moratorium, a result that would be nonsensical. Both of these actions would result in complete chaos and would negate the purposes of the ICRW to conserve whales and develop a whaling industry in an orderly manner.

F. THE REQUIREMENT TO ADOPT NATIONAL LEGISLATION IN PARAGRAPH 13(a)(5) DOES NOT INDICATE THAT ASW QUOTAS MAY BE UNILATERALLY ADOPTED

Paragraph 13(a)(5) provides that ASW "shall be conducted under national legislation that accords with this paragraph." This language does not suggest that IWC members may conduct ASW unilaterally without an IWC-approved quota, as the AEWC believes.[138] Rather, the provision simply states that national legislation is required as part of the overall ASW management scheme; the IWC may not approve an ASW quota and an IWC member may not conduct ASW in the absence of national legislation conforming to paragraph 13.

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[138] The AEWC argues the following:

> Absent a numeric catch limit in the Schedule, it is simply not possible for a Contracting Government to comply with paragraph 13(a) without establishing a catch limit through its own national legislation, which of course is precisely what paragraph 13(a)(5) of the Schedule instructs Contracting Governments to do. Without a numeric catch limit set either at need or at the applicable level to safeguard whale stocks, how does a Contracting Government meet its obligation to ensure compliance with the requirements of paragraph 13(a)?

AEWC, *supra* note 28, at 12.

Interpreting paragraph 13(a)(5) as a prerequisite to the IWC approving ASW quotas is consistent with the ordinary meaning of the provisions in light of its purpose and context. Allowing individual IWC members to set their own quotas would create compliance problems with the MSY provisions in 13(a)(1)-(2) by creating the conditions for a tragedy of the commons where no one member bears responsibility if its particular quota causes a stock to slip below MSY levels. Paragraph 13(a) is a comprehensive section that up to this point has managed all ASW activity. The alternative interpretation would likely result in failure of any sort of management scheme.

V. OTHER EVIDENCE SUPPORTING IWC-APPROVED QUOTAS AS A PREREQUISITE TO ASW HUNTS

Other evidence further suggests agreement and practice among IWC members and within certain governments that the IWC must approve ASW quotas before a member may conduct ASW hunts. Article 31(3)(c) of the Vienna Convention allows treaties to be interpreted in light of subsequent agreement and subsequent practice of the parties.[139] The prevailing view in international law, however, is that subsequent agreement or subsequent practice may be used to interpret a treaty only when *all* parties to the relevant treaty have subsequently agreed or acted in a particular way.[140] For example, a WTO panel established in the *EC-Biotech*[141] dispute concluded that it

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[139] *See* Vienna Convention, *supra* note 33, art. 31(3)(c). Article 31 provides:

> 3. There shall be taken into account, together with context:
>
> (a) any subsequent agreement between the parties regarding the interpretation of the treaty or the application of its provisions;
>
> (b) any subsequent practice in the application of the treaty which establishes the agreement of the parties regarding its interpretation;
>
> (c) any relevant rules of international law applicable in the relations between the parties.

Id.

[140] *See* John H. Knox, *The Judicial Resolution of Conflicts Between Trade and the Environment*, 28 HARV. ENVTL. L. REV. 1, 67-69 (2004) (noting that scholars and tribunals have stated that "parties" under article 31 of the Vienna Convention means all parties bound by a treaty, and thus an act by a single party or even a group of parties is insufficient to establish subsequent agreement or practice for purposes of treaty interpretation).

[141] Panel Reports, *European Communities – Measures Affecting the Approval*

was not required to take into account the Biosafety Protocol to interpret the WTO's Agreement on the Application of Sanitary and Phytosanitary Measures ("SPS Agreement") because Argentina, Canada, and the United States are not parties to the Biosafety Protocol but are parties to the SPS Agreement.[142] Nonetheless, the panel stated that it could use the Biosafety Protocol to interpret the SPS Agreement if it found it informative.[143]

Viewed in this light, the evidence described below, including previous reactions to the IWC's failure to approve an ASW quota, likely does not rise to the level of state agreement or state practice

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and Marketing of Biotech Products, ¶ 4.543, WT/DS291/R, WT/DS292/R, WT/DS293/R (Sept. 29, 2006) (adopted Nov. 21, 2006).

[142] *Id.* ¶¶ 7.70–.71, 7.75. Paragraph 7.70 provides the panel's core conclusion and reasoning. Paragraphs 7.70 and 7.71 state:

> Taking account of the fact that Article 31(3)(c) mandates consideration of other applicable rules of international law, and that such consideration may prompt a treaty interpreter to adopt one interpretation rather than another, we think it makes sense to interpret Article 31(3)(c) as requiring consideration of those rules of international law which are applicable in the relations between all parties to the treaty which is being interpreted. Requiring that a treaty be interpreted in the light of other rules of international law which bind the States parties to the treaty ensures or enhances the consistency of the rules of international law applicable to these States and thus contributes to avoiding conflicts between the relevant rules . . . .
>
> [I]t is not apparent why a sovereign State would agree to a mandatory rule of treaty interpretation which could have as a consequence that the interpretation of a treaty to which that State is a party is affected by other rules of international law which that State has decided not to accept.

Id. ¶¶ 7.70-.71.

[143] *Id.* ¶¶ 7.92–.93. The International Law Commission has criticized the panel's analysis:

> [The *EC–Biotech* Panel] interpreted article 31(3)(c) so that the treaty to be taken account of must be one to which all parties to the relevant WTO treaty are parties. This latter contention makes it practically impossible ever to find a multilateral context where reference to other multilateral treaties as aids to interpretation under article 31(3)(c) would be allowed. The panel buys what it calls the "consistency" of its interpretation of the WTO Treaty at the cost of the consistency of the multilateral treaty system as a whole. It aims to mitigate this consequence by accepting that other treaties may nevertheless be taken into account as facts elucidating the ordinary meaning of certain terms in the relevant WTO treaty. This is of course always possible and, as pointed out above, has been done in the past as well. However, taking "other treaties" into account as evidence of "ordinary meaning" appears a rather contrived way of preventing the "clinical isolation" as emphasized by the Appellate Body.

Int'l Law Comm'n, *Fragmentation of International Law: Difficulties Arising from the Diversification and Expansion of International Law*, ¶ 450, U.N. Doc. A/CN.4/L.682 (Apr. 8, 2006).

that must be considered. Nonetheless, the evidence is informative, which a treaty interpreter could use to help determine the ordinary meaning of a treaty provision. Further, it can be used to illustrate how the IWC members have gravitated towards the ordinary meaning of paragraph 13 discussed in section IV as the most reasonable interpretation of the ICRW and the Schedule. In addition to the reactions to past quota rejections, U.S. Department of State documents, the circumstances surrounding the denial of Greenland's quota (including Denmark's indication that it had to withdraw from the IWC as a result Greenland's unauthorized ASW hunt), IWC resolutions and terms of reference, Greenland's national legislation scheme, and U.S court decisions all support interpreting paragraph 13 as requiring the IWC to adopt ASW quotas before ASW may occur.

A. PAST REJECTIONS OF ASW QUOTAS SUPPORT THE CONCLUSION THAT IWC-APPROVED ASW QUOTAS ARE REQUIRED

The actions of the United States and other IWC members after the IWC rejected ASW quotas indicate that they believe the IWC must approve ASW quotas prior to conducting ASW. For example, in 1977, the IWC suspended the ASW quota for bowhead whales taken by native people of Alaska (United States) and Chukotka (Russia) in the Bering-Chukchi-Beaufort Seas over concerns about the size of the hunt and its impact on populations, and inadequate surveillance and enforcement measures to ensure that ASW hunts on bowheads were in compliance with the ICRW.[144] Rather than engage in ASW by self-allocating a quota in the absence of an IWC-approved quota, the United States called a special meeting of the IWC in December 1977 seeking IWC adoption of a quota.[145] Fifteen of the seventeen IWC members attended the special meeting in 1977, and a vote for a reduced quota passed with ten in favor, three against, and two abstaining.[146] Significantly, no IWC members stated that the special meeting was irrelevant because the United States and Russia could impose their own quota. To the contrary, all IWC members took their responsibility to evaluate proposals for ASW quotas seriously,

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[144] IWC, *Chairman's Report of the Twenty-Ninth Meeting*, at 22 (1978) (noting that five recognized stocks should retain their Protection Stock status).

[145] *See* IWC, *Chairman's Report of the Thirtieth Meeting*, at 26 (1979).

[146] *See id.* at 23.

attended the meeting, and ultimately approved the quota.

Similarly, when the IWC rejected an ASW quota for bowheads taken by native people of Alaska and Chukotka in the Bering-Chukchi-Beaufort Seas in 2002,[147] the United States and Russia did not unilaterally authorize an aboriginal subsistence hunt. Instead, the United States again called for a special meeting, held in October 2002, at which time the IWC approved a quota.[148]

The IWC denied Greenland's ASW quota request for humpback whales in 2007[149] and 2008[150] and deferred a decision on the matter in 2009.[151] That quota was later revisited and approved in 2010.[152] As with the United States, Greenland did not authorize hunts for humpback whales between 2007 and 2010.

In both instances when the IWC rejected the bowhead ASW quota, the United States proceeded by calling a special session of the IWC and neither the United States nor Russia authorized ASW hunts. This suggests that, at least as far the bowhead whale stock of the Bering-Chukchi-Beaufort Seas was concerned, the United States and Russia recognized that a quota adopted by the IWC was necessary before ASW hunts could occur.[153] Greenland did not call a special session, but instead complied with the IWC's decision by not conducting any ASW hunts on humpback whales before the IWC approved an ASW quota at a later meeting. This suggests a common understanding that

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[147] *See generally* IWC, *Chair's Report of the 54th Annual Meeting*, at 19-22 (2002).

[148] *See* IWC, *Chair's Report of the 55th Annual Meeting*, at 14 (2003).

[149] *See generally* IWC, *Chair's Report of the 59th Annual Meeting*, at 19-22 (2007) (explaining that Denmark withdrew its request for a quota for humpback whales because of increasing negative pressure).

[150] IWC, *Chair's Report of the 60th Annual Meeting*, at 23 (2008) (reporting that the proposed amendment did not pass because it received twenty-nine votes in favor, thirty-six against, and two abstentions).

[151] *Annual Report of the International Whaling Commission 2010*, *supra* note 14, at 22-23 (finding, however, that the IWC Commission deferred the decision to an intersessional meeting, that intersessional meeting was not quorate, and the IWC could not take a decision on the matter); IWC, *Chair's Report of the 61st Annual Meeting*, at 23 (2009).

[152] *Annual Report of the International Whaling Commission 2010*, *supra* note 14, at 22-23.

[153] *See Chair's Report of the 59th Annual Meeting*, *supra* note 149, at 21 (noting that the United States could not support the requested takes of bowhead and humpback whales).

ASW hunts require an IWC-approved quota before they may proceed.

B. U.S. ACTIONS SUPPORT THE CONCLUSION THAT IWC-APPROVED ASW QUOTAS ARE REQUIRED

The actions of the United States also support the interpretation that the IWC must approve ASW quotas before ASW may occur. After the IWC denied the U.S. request for a bowhead quota in 2002, the U.S. IWC Commissioner Rollie Schmitten told the press that:

> In [fifty-six] years of history in the IWC . . . that was the most unjust, unkind, unfair vote that was ever taken. That vote literally denied people (the ability) to feed their families . . . . We will leave no stone unturned. It is so critical that we want to see if we can revive it today . . . . Governments can play games, but you can't play with families.[154]

Similarly, a State Department spokesperson stated the following after the IWC failed to approve the bowhead ASW quota:

> So we'd like to see the Commission's decision reconsidered internally or inter-sessionally, now that the meeting has ended. The International Whaling Commission could hold a special meeting to reconsider the quota. It also has procedures, I understand, whereby they could conduct a postal ballot. So we'll be looking into options there to try to see that this quota be approved as it has been for so many years.[155]

Clearly, these statements indicate that the United States understood that the IWC's rejection of the bowhead quota prevented ASW on bowheads.

The U.S. view is highlighted in a description of the process for establishing ASW quotas under U.S. law, in which the United States writes, "[o]nce the IWC approves a request for an aboriginal subsistence whaling quota . . . and sets catch limits for each whale stock in five-year increments, the [U.S. Whaling Convention Act] provides the mechanism for the U.S. to implement these quotas."[156]

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[154] Mick Corliss, *IWC Meeting Ends in a Bitter Divide*, JAPAN TIMES (May 25, 2002), http://www.japantimes.co.jp/text/nn20020525a3.html.

[155] Philip T. Reeker, Deputy Spokesman, Remarks at the State Department Briefing (May 24, 2002), *available at* http://www.usembassyisrael.org.il/publish/peace/archives/2002/may/052504.html.

[156] U.S. DEP'T OF COMMERCE, NAT'L OCEANIC & ATMOSPHERIC ADMIN.,

The position of the United States is clear: the IWC first approves and sets quotas and then the United States implements those quotas through domestic legislation.

In addition, the U.S. Department of State issued a fact sheet explaining the position of the U.S. government on ASW quotas. In this statement, the Department of State expressed U.S. support for quotas for the Alaska Eskimo Whale Commission and the Makah Indian Tribe of Washington State.[157] The State Department also explained that the IWC sets quotas by geographical stock, rather than by country.[158] Management based on regional stocks takes into account the specific biological needs of the stock and the aggregate effects of hunts.[159] Management must be able to promote the endurance of the stock across its entire geographic distribution, and, to that end, ICRW Contracting Governments have given management authority to the IWC because it is better positioned to manage shared resources than individual nations. For this reason, the IWC does not set quotas on a country-by-country basis, and it is inappropriate for countries to set quotas of any kind on a unilateral basis. The U.S. State Department supported this view when it explained that "[t]he [United States] and Russia allocate the IWC quotas among the native hunters, so that the limits are not exceeded."[160] This language shows that the United States (and implicitly Russia) understood that they had no right to hunt without a quota set by the IWC and that IWC members allocate ASW quotas only after the IWC adopts them. The fact that the U.S. State

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NAT'L MARINE FISHERIES SERV., FINAL ENVIRONMENTAL IMPACT STATEMENT FOR ISSUING ANNUAL QUOTAS TO THE ALASKA ESKIMO WHALING COMMISSION FOR A SUBSISTENCE HUNT ON BOWHEAD WHALES FOR THE YEARS 2008 THROUGH 2012 6 (2008).

[157] *Aboriginal Subsistence Whaling*, U.S. DEP'T OF STATE (May 15, 2002), http://2001-2009.state.gov/p/eur/rls/fs/10224.htm [hereinafter *Aboriginal Subsistence Whaling-U.S. Dep't of State*].

[158] *Id.*

[159] Starting in 1972, proposals began to move Aboriginal Whaling and the ICRW towards a more ecological approach. This coincided with abandoning the Blue Whale Unit and introducing species quotas for the Antarctic. In addition, concern arose that nonmembers operating outside of IWC regulations undermined effectiveness. *See* PATRICIA W. BIRNIE, INTERNATIONAL REGULATION OF WHALING: FROM CONSERVATION OF WHALING TO CONSERVATION OF WHALES AND REGULATION OF WHALE WATCHING 425-30 (1985).

[160] *Aboriginal Subsistence Whaling-U.S. Dep't of State, supra* note 157.

Department raised this issue in conjunction with support for a renewed ASW quota suggests that the United States viewed denial of the quota as restricting its ability to issue a unilateral quota.

Moreover, the circumstances under which the IWC denied Greenland's quota in 2012 illustrate the reasons for not allowing IWC members to set ASW quotas unilaterally. Greenland/Denmark came to the IWC asking for an ASW quota larger than its quota in previous seasons.[161] It would frustrate IWC management measures and conservation of whale stocks if the IWC's rejection of a proposed increase in a quota allowed the proponent IWC member to conduct unlimited whaling. If one accepted that argument, then the IWC would not vote to approve a quota, but rather to limit ASW or, if it rejected a quota, to remove the quota so that members could engage in unlimited ASW on that whale stock. Such an interpretation is absurd. The IWC denied Greenland's quota request because some IWC members believed that the proposed quota included an unacceptable degree of commercialization and was higher than necessary to meet subsistence needs.[162] These reasons for denying the quota suggest that the members that voted against the quota understood that their vote would restrict Greenland's hunting activities rather than allow Greenland to hunt unchecked.

C. IWC RESOLUTIONS SUPPORT THE CONCLUSION THAT IWC-APPROVED ASW QUOTAS ARE REQUIRED

IWC resolutions and terms of reference for IWC committees over an extended period of time support the conclusion that the IWC has sole authority to set ASW quotas. For example, when the IWC approved the quota for bowheads in the Bering-Chukchi-Beaufort Seas at the special meeting in 1977, it also passed a resolution that welcomed improved surveillance and enforcement measures by the United States that would help "ensure that the number of whales struck does not exceed the *limit* established by the [IWC]."[163] By

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[161] *See generally Proposed Schedule Amendment (IWC 64)*, *supra* note 31.

[162] *See* IWC, U.K. Comm'r Report, *64th Annual Meeting of the International Whaling Commission*, at 3 (2012), *available at* http://archive.defra.gov.uk/wildlife-pets/wildlife/protect/whales/documents/iwc64-uk-commissioners-report.pdf (discussing concerns about the need for the increased quotas given that many investigations that revealed the whale meat was being served to tourists).

[163] IWC, *Chairman's Report of the Special Meeting, Tokyo, December 1977*,

focusing the resolution on ensuring U.S. compliance with the IWC-approved limit on ASW, the IWC itself indicated its belief that the IWC must approve ASW quotas. If the quotas were mere recommendations, it is unlikely that the IWC would adopt a resolution focused on "ensuring" that the United States does not exceed a limit established by the IWC. The language suggests a broad understanding among IWC members that members must comply with the IWC-approved ASW quotas. The IWC's rejection of a quota is not a license to hunt freely. It naturally follows that rejection of a requested quota sets the quota at zero, rather than resulting in no numeric limit on ASW hunts.

At its thirty-fourth meeting in 1982, the IWC passed a resolution highlighting the importance of cooperation with aboriginal peoples in ASW management. The resolution stated that "[t]he [IWC] agrees to manage aboriginal subsistence whaling in accordance with management principles to be set forth in the Schedule."[164] This resolution contains two important points. First, the IWC has agreed to manage ASW. It seems clear from this language that IWC members anticipated that the IWC would have sole authority with regard to ASW. The resolution does not mention individual IWC members having independent management authority over ASW as an alternative to IWC management. Unilateral action by IWC members to adopt and manage ASW quotas unilaterally runs counter to the purpose of delegating authority to the IWC and undermines the IWC's management measures. Just as in the 1977 resolution concerning ASW for bowheads, the 1982 resolution mentions IWC management of ASW. This adds strength to the argument that members have a general understanding that the IWC is the primary body with authority to manage ASW. Second, the resolution states that management must be in accordance with the principles set forth in the Schedule. This recognizes the Schedule as the mechanism for managing ASW. Taken together, these clauses show that IWC members understood that the IWC has sole authority to manage ASW, and that the Schedule is the mechanism by which the IWC manages ASW. This supports the conclusions reached in Section IV that the Schedule comprises a comprehensive management scheme

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at 4 (1977).

[164] *IWC 1982 Report*, *supra* note 86, at 39, Appendix 3.

requiring the IWC to approve ASW quotas, and that IWC members do not have the authority to set ASW quotas unilaterally.

At its forty-eighth meeting in 1996, the IWC established the current terms of reference for the IWC's Aboriginal Subsistence Whaling Sub-Committee that support the interpretation that the IWC has primary authority for management of ASW. The terms of reference state that this Sub-Committee shall consider nutritional, cultural, and subsistence needs to provide advice to the IWC for "its consideration *and determination of appropriate management measures*."[165] In this resolution, the IWC acknowledges that it determines the appropriate ASW management measures. This shows further recognition of the IWC's role in setting ASW management, particularly in setting ASW quotas.

The two resolutions, adopted by consensus,[166] and these terms of reference constitute multiple declarations over a twenty-year period in which IWC members have articulated essentially the same thing: that the IWC is the body that has authority to set ASW quotas. These statements by the IWC help shed light on the meaning of the language in the Schedule and help interpret the ICRW. In fact, the International Court of Justice commented that resolutions, while non-binding, "may be relevant for the interpretation of the Convention or its Schedule" when adopted by consensus or unanimous vote[167] and that parties to a treaty have an obligation to give "due regard" to such resolutions.[168]

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[165] IWC, *Chairman's Report of the Fiftieth Annual Meeting*, at 31 (1998) (emphasis added).

[166] Whether the 1977 resolution relating to bowheads was adopted by consensus is less clear. The chairman's report notes that the IWC voted on the "proposal" to amend the Schedule to include an ASW quota for bowheads. It further states that the IWC agreed to an additional paragraph to the resolution. It is not clear whether the "proposal" on which the IWC voted included the resolution or whether IWC adopted the resolution separately. *See IWC 1982 Report*, *supra* note 86, at 29. Resolutions are adopted by a simple majority and Schedule amendments by a three-fourths majority, suggesting separate votes for the two items. However, it is clear that the Schedule amendment and resolution were part of a package, suggesting that the vote was taken as a single item. *Chairman's Report of the Special Meeting*, *supra* note 163, at 4.

[167] Whaling in the Antarctic (Austl. v. Japan), 2014 I.C.J. 148, ¶ 46 (Mar. 31).

[168] *Id.* ¶¶ 83, 144 (concluding that Japan's expanded use of lethal methods in its new Antarctic whaling program, as compared to its previous program, was "difficult to reconcile with Japan's obligation to give due regard to IWC

D. GREENLAND'S NATIONAL LEGISLATION SUPPORTS THE CONCLUSION THAT IWC-APPROVED ASW QUOTAS ARE REQUIRED

As discussed in Section IV(F), IWC members are required under paragraph 13(a)(5) to implement the requirements of the ICRW through national legislation. Greenland implements the ICRW through an executive order of the Greenland Home Rule Government. The English translation of the original executive order provided to the IWC suggests that Greenland recognizes the necessity of acquiring an ASW quota from the IWC prior to allowing ASW hunts. The relevant provision requires the government to consult with the municipal governments and the hunter's organization to decide the number of whales that can be taken from each municipality.[169] It further requires that "[t]he allocated IWC quotas are the basis of the annual quota."[170] While this language is not explicit that the IWC quota restricts Greenland's hunts, a contrary interpretation does not make sense: without an allocated IWC quota, Greenland has nothing on which to base its annual quota. Greenland's own implementing legislation is thus consistent with the view that the IWC must first adopt ASW quotas before an ASW hunt may be authorized.

E. U.S. COURT CASES SUPPORT THE CONCLUSION THAT IWC-APPROVED ASW QUOTAS ARE REQUIRED

Two U.S. judicial opinions also support the view that only the IWC may approve ASW quotas. In the wake of the 1977 quota denial for the Bering-Chukchi-Beaufort Seas bowhead whale stock, two lawsuits in U.S. federal courts challenged government decisions relating to the IWC's removal of the quota. These cases provide an independent legal analysis of the obligations of the United States and insight into how U.S. courts may deal with these issues if the quotas are ever revoked in the future.

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resolutions and Guidelines and its statement that JARPA II uses lethal methods only to the extent necessary to meet its scientific objectives").

[169] *See* IWC, *White Paper on Management and Utilization of Large Whales in Greenland*, at 76, IWC/64/ASW 7 (June 18, 2012).

[170] *Id.*

The first case, *Hopson v. Kreps*,[171] was brought on behalf of Alaskan Eskimos challenging regulations adopted by the U.S. government pursuant to the ICRW. Plaintiffs claimed that the IWC had exceeded its jurisdiction under the ICRW by removing the ASW provisions and that the Secretary of Commerce had acted illegally by promulgating the regulations.[172] The Ninth Circuit recognized that "a major purpose of the Convention was the creation of an international commission with power to fix [seasonal quotas for the taking of whales]."[173] The Ninth Circuit also explained that an IWC member may avoid application of the Schedule by lodging an objection within ninety days.[174] The court recognized that not only does the IWC have the power to set quotas, but also that IWC members are obligated to comply with the Schedule unless they object.

The second case, *Adams v. Vance*,[175] was a challenge by the Inupiat Eskimos to the decision of the Secretary of State not to file an objection to the IWC amendments to the Schedule that removed the Bering-Chukchi-Beaufort Seas bowheads from ASW hunts.[176] The D.C. Circuit noted that the United States could avoid application of the Schedule by making an objection to the decision, but that the United States chose not to object.[177] The D.C. Circuit recognized that modification of the Schedule by the IWC amounted to a ban on whaling that possibly could cause irreparable injury to the Eskimos.[178] The court is clear that the removal of a quota is a ban on ASW.

These cases taken together indicate that U.S. federal courts believed that the United States acted consistently with its legal obligations under the ICRW by promulgating regulations that halted

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171. 622 F.2d 1375 (9th Cir. 1980).

172. *Id.* at 1377 ("Since Congress enacted the Whaling Convention Act of 1949 solely to implement the Convention, the Commerce Department was not authorized to adopt Commission regulations that exceeded the scope of the Commission's jurisdiction").

173. *Id.* at 1376 (citing Hopson v. Kreps, 462 F. Supp. 1374, 1375 (D. Alaska 1979)).

174. *Id.* at 1377.

175. 570 F.2d. 950 (D.C. Cir. 1987).

176. *Id.* at 952.

177. *Id.*

178. *Id.* at 953 (noting that hunts of bowhead after the ban carried with it the potential for criminal prosecution).

ASW hunts, and that the United States could avoid these obligations only by lodging an objection to the Schedule within ninety days. Further, the courts recognize that the power to set quotas lies with the IWC and that removal of a quota is equal to a ban. The analysis of these U.S. federal courts is consistent with and further supports the ordinary meaning interpretation that only the IWC may approve ASW quotas.

These two U.S. federal court cases indicate that in 1977, when the IWC removed the ASW quota for bowheads, the United States government had the option to object to the amendment to the Schedule within ninety days. In this situation, the IWC was actually deleting the reference in the Schedule to aboriginal whaling for bowhead whales (called right whales at the time).

Whether an IWC member may object to the IWC's rejection of an ASW quota depends on whether the Schedule is amended by deleting the relevant paragraphs of the Schedule. In the case of Greenland's quota, the IWC retained paragraph 13(b)(3) with the expired dates, presuming apparently that Greenland would seek renewal of its quota at a future IWC meeting. Under these circumstances, Denmark, on behalf of Greenland, would not have an opportunity to object because there is no Schedule amendment to object to. If the IWC had amended the Schedule by deleting paragraph 13(b)(3), then Denmark would have had the opportunity to object. The objection, however, would have no practical effect because the IWC must still approve Greenland's quota subject to the conditions of paragraphs 13(a) and (b) of the Schedule. Under either scenario, Greenland would not be allowed to conduct ASW.

The inability of Denmark to object to the IWC's rejection of Greenland's proposal raises no questions of unfairness because Denmark and other IWC members had the opportunity to object when the ASW provisions were adopted. If an IWC member had wanted to object to the IWC's authority to approve ASW quotas, then it should have lodged an objection at that time. When States enter into international agreements, they exercise their national sovereignty in ways that may limit their regulatory options. This is a well-recognized concept in international law.[179] In the case of ASW,

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[179] Customary law or the State's consent to be bound by a treaty may restrict that State's use of a power within its reserved domain; "no subject is irrevocably

the ICRW contracting parties have limited their ability to object now by agreeing to the ASW management scheme found in paragraph 13 and failing to object to it. It is now well established that the IWC has authority to regulate ASW and, as part of that management scheme, approve ASW quotas.

This situation is not unique to the ICRW. For example, the parties to the Convention on International Trade of Endangered Species of Wild Fauna and Flora ("CITES")[180] have developed a regime for approving sales of African elephant ivory to specific countries.[181] If the parties reject a proposal to allow trade to a specific country, that country has no means to make a formal reservation to that decision. The CITES parties had an opportunity to make a reservation when the parties amended the CITES Appendices to establish the rules for trade in African elephant ivory.

VI. THE CONSEQUENCES OF GREENLAND'S UNAUTHORIZED WHALING

As noted previously, in 2012, the IWC rejected Greenland's request for an ASW quota starting with the 2013 season for a number of reasons.[182] Greenland's proposal failed to get a three-fourths majority because some IWC members expressed concerns over the size of the quota, Greenland's conversion factors used to calculate the yield of meat from each whale, and the commercial aspects of the hunt, including the sale of whale meat in restaurants.[183]

Greenland responded first by sending a letter to IWC members seeking comment on its proposal to establish a unilateral ASW quota.[184] Members raised several objections to Greenland's proposal,

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fixed within the reserved domain." BROWNLIE, *supra* note 116, at 293; *see also* BENEDETTO CONFORTI, INTERNATIONAL LAW AND THE ROLE OF DOMESTIC LEGAL SYSTEMS 133 (René Provost trans., 1993) (providing that international law, whether custom or treaty, acts to restrict the power of sovereign States).

[180] *See generally* Convention on International Trade in Endangered Species of Wild Fauna and Flora, Mar. 3, 1973, 27 U.S.T. 1087, 993 U.N.T.S. 243 (entered into force July 1, 1975).

[181] *See id.* Appendices I-III.

[182] Press Release, *supra* note 16.

[183] *See IWC Annual Report 2012*, *supra* note 13, at 21.

[184] PS, *supra* note 21 (reporting that "[t]he Danish government argues that by setting its own independent quota, Greenland is contravening IWC regulations."); Letter from Jens K. Lyberth, Greenland Deputy Minister, Ministry of Fisheries,

stating, for example, that any ASW quota required approval by the IWC and that Denmark, on Greenland's behalf, could submit a new proposal, which the IWC could vote on by postal vote.[185]

Nonetheless, Greenland unilaterally established an ASW quota for the 2013 and 2014 seasons[186] and allowed the hunt to occur, with Greenland hunters killing 198 whales in 2013.[187] Greenland's unilateral killing of whales set off the next round of legal debate, with the coalition of countries known as the Buenos Aires Group arguing that Denmark's failure to report Greenland's ASW as commercial whaling constituted an infraction.[188] Argentina, supported by Chile, Mexico, and Australia, made the following statement in the IWC's Infractions Sub-Committee:

> [T]he IWC recognises aboriginal subsistence catches but that a quota for aboriginal subsistence catches in Greenland for the period 2013 to 2018 was not agreed at IWC64. Therefore it considered that the catches in East and West Greenland . . . took place without the authorisation of the IWC and should be reported as infractions according to Article IX of the Convention.[189]

Denmark responded by stating that the catches had been reported as aboriginal catches, and that "portraying its aboriginal take as an infraction does not reflect the exceptional circumstances faced by Denmark, Greenland and the IWC following the last meeting."[190]

Hunting, and Agric., to IWC Comm'rs, Regarding Greenland Quotas on Large Whales (Dec. 6, 2012) (on file with author).

[185] Note Verbale from the Embassy of Brazil in the United Kingdom on behalf of the Governments of Argentina, Chile, Colombia, Costa Rica, Dominican Republic, Mexico and Panama (Dec. 21, 2012), *available at* http://iwc.int/private/downloads/37bq3ttg9voks0gso0kgkkwgc/IWCCCG1038.pdf; Letter from Donna Petrachenko to Gitte Hundahl, *supra* note 22 (objecting to Greenland's proposal).

[186] *Whaling in Greenland: Re. Greenland Aboriginal Subsistence Whaling*, GOV'T OF GREENLAND, http://naalakkersuisut.gl/en/About-government-of-greenland/Whaling-in-Greenland (last visited Jan. 19, 2015); *see also* Letter from Lyberth to IWC Comm'rs, *supra* note 184.

[187] *Catches Taken: ASW*, *supra* note 7 (reporting 192 whales killed in East Greenland and six in West Greenland 2013 and noting that the data for 2014 is not yet available).

[188] *See 2014 IWC 65 Meeting in Slovenia*, *supra* note 24.

[189] *IWC Report of the Infractions Sub-Committee*, *supra* note 32, at 2.

[190] *Id.*

Denmark further remarked that portraying Greenland's whaling as an infraction:

> fails to note that all Greenlandic catches are strictly regulated and follow the advice of the Scientific Committee. Furthermore it does not address the comprehensive efforts made by Denmark, Greenland to resolve the issue to be able to continue its work within the IWC nor does it recognise the subsistence needs of the indigenous people of Greenland. Denmark is, together with others, working hard to find a carefully balanced solution which addresses concerns on all sides for the future and is grateful to those who have participated in the process.[191]

Unable to resolve the issue, the Infractions Sub-Committee forwarded the issue to the IWC. However, the IWC could not resolve the issue either. Instead, after some discussion, the IWC chair characterized the issue as an operational issue—"[a] procedural issue pertaining to Schedule amendments"[192]—and referred it to a Finance and Administrative Committee working group on operational efficiency and cost saving measures.[193]

Labeling Greenland's activities as an infraction is no small matter. The ICRW requires all IWC members to take appropriate measures to punish and prosecute infractions of the Convention.[194] They are also required to submit full details of each infraction and measures taken (such as penalties assessed) to address the infraction to the IWC.[195] If Greenland's ASW constitutes an infraction, then Denmark is required to take action against Greenland's aboriginal whalers and members of Greenland's government who authorized such whaling (neither the IWC nor the Infractions Sub-Committee has the authority to punish infractions).[196] Resolution of this issue seems to

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[191] *Id.*

[192] IWC, Summary of Main Outcomes, Decisions and Required Actions from the 65th Annual Meeting (Initial Draft) (undated) (on file with author).

[193] Summary of Main Outcomes, *supra* note 1.

[194] ICRW, *supra* note 1, art. IX, ¶ (1) (mandating that "Each Contracting Government shall take appropriate measures").

[195] *Id.* ¶ (4).

[196] *IWC Annual Report 2000*, *supra* note 15, at 19 (noting that on one occasion, the Infractions Sub-Committee appeared to support the position that an accidental take, such as the incidental catch of a whale in a fishery or the misidentification of a whale purposefully killed but only after DNA testing found to be a protected species, should be recorded as infractions "but that normally no

be much more than a "procedural issue."

Neither the ICRW nor the IWC has defined "infraction." As a consequence, and as illustrated by the debate over whether Greenland's ASW in 2013 and 2014 constituted an infraction, the members accused of infractions deny that an infraction has occurred or fail to submit relevant information.[197] Some members, such as Japan, have argued that no infraction has occurred when the action is not clearly prohibited by the ICRW or its Schedule.[198] St. Vincent and the Grenadines, which has been granted a small ASW quota for humpback whales that prohibits the taking of calves,[199] has resisted attempts to label the killing of small humpbacks as an infraction, arguing that the definition of "calf" is unclear.[200]

According to one analysis, the accused IWC member recognized alleged infractions as infractions in just ten of forty-six cases from 1991 to 2004.[201] In nineteen cases, the member denied that the incidents constituted infractions, and in twenty-six cases they failed to provide additional information even though the Infractions Sub-Committee requested the information.[202] One long-time IWC observer notes that "[o]ver time, members increasingly showed an unwillingness to cooperate and infractions mostly remained unpunished"[203] and that the IWC's handling of infractions is "weak and ineffective."[204]

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penalties are imposed by national governments").

[197] SANDRA ALTHERR, PRO WILDLIFE & OCEAN CARE, NON-COMPLIANCE WITHIN THE IWC: REQUIREMENTS FOR AN EFFECTIVE IWC COMPLIANCE REVIEW COMMITTEE 4 (2006).

[198] *See, e.g.*, *Chair's Report of the 55th Annual Meeting*, *supra* note 148, at 40.

[199] Schedule, *supra* note 1, art. III, ¶ 13(b)(4).

[200] *See Chair's Report of the 52nd Annual Meeting*, *supra* note 15, at 18; *see also* WHALE & DOLPHIN CONSERVATION SOC'Y, *supra* note 15, at 3-4 (reviewing the history of attempts to label this killing as an infraction).

[201] WHALE & DOLPHIN CONSERVATION SOC'Y, *supra* note 15, at 7; *Chair's Report of the 55th Annual Meeting*, *supra* note 148, at 39 (highlighting that the Republic of Korea reported the illegal, deliberate catch of one minke whale by a Korean national and fined the captain eight million won (about $7,000 US at the time), revoked the vessel owner's fishing license, and confiscated the meat and sold it publicly).

[202] WHALE & DOLPHIN CONSERVATION SOC'Y, *supra* note 15, Annex.

[203] ALTHERR, *supra* note 197, at 4.

[204] *Id.* at 22.

With respect to Greenland, however, the case is relatively straightforward and the conduct should be declared an infraction. Without an IWC-approved quota, Greenland is not authorized to engage in ASW. In the absence of an IWC-approved quota, Greenland's hunt is either commercial whaling in violation of the moratorium on commercial whaling, included in paragraph 10(e) of the Schedule, or unauthorized ASW in violation of paragraph 13 of the Schedule. Whether Denmark reported Greenland's catch as commercial or ASW is immaterial; either way, the catch violated binding provisions of the Schedule and constituted an infraction by Denmark, the relevant IWC member.

VII. CONCLUSION

With Greenland's unilateral establishment of an ASW quota and hunt for the 2013 and 2014 seasons, aboriginal subsistence whaling joined the moratorium on commercial whaling and Japan's whaling for scientific purposes as among the most important and controversial issues facing the IWC. IWC members have disagreed over the legal effect of Greenland's actions. While some argue that only the IWC may approve ASW quotas and that Greenland's subsequent hunt constituted a punishable infraction, others disagree.

Based on an analysis of the ordinary meaning of the ICRW and the Schedule, this article concludes that only the IWC may approve ASW quotas and that IWC members may not conduct ASW in the absence of a quota approved by the IWC. Although paragraph 10 of the Schedule sets out the general prohibition against killing whales, paragraph 13 establishes a narrow exception that is only triggered when all substantive conditions have been met. These conditions require, among other things, that the IWC adopt a quota for each season. Consequently, killing whales pursuant to a unilaterally established ASW quota constitutes an infraction, either for violating the moratorium on commercial whaling in paragraph 10 or as unauthorized ASW.

The overall structure of paragraph 13 and the subsidiary paragraphs create a regulatory scheme that would be undermined if individual IWC members were able to set their own ASW quotas. This ordinary meaning interpretation is supported by the actions of the IWC and its members, Greenland's implementing legislation, U.S. federal court decisions, U.S. Department of State documents, and the circumstances surrounding the denial of Greenland's quota. All of the evidence supports the general understanding among IWC members that an IWC-approved ASW quota is necessary before a member may conduct ASW hunts. This evidence has been consistent over a long period of time and derives from the actions of a number of IWC members, including the actions of Greenland and the United States when the IWC denied their requests for ASW quotas. As such, the IWC's denial of Greenland's request for an ASW quota at its 2012 meeting acted as a bar to any ASW activity by Greenland for the 2013 season and subsequent seasons until the IWC approved an ASW quota for the relevant stocks. Greenland was not allowed to establish ASW quotas for 2013 and 2014 unilaterally, as it did. It was required either to request a special session of the IWC or a postal vote to gain approval for its quota or submit a request for an ASW quota at a future meeting of the IWC, which it did in 2014. However, because it allowed ASW for 2013 and 2014 in the absence of an IWC-approved quota, Denmark, on Greenland's behalf, must report the hunt as an infraction and take appropriate measures to punish and prosecute those involved in the whaling.

Assessment of genetic structure among eastern North Pacific gray whales on their feeding grounds

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Assessment of genetic structure among eastern North Pacific gray whales on their feeding grounds

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ABSTRACT

Although most eastern North Pacific (ENP) gray whales feed in the Bering, Beaufort, and Chukchi Seas during summer and fall, a small number of individuals, referred to as the Pacific Coast Feeding Group (PCFG), show intra- and interseasonal fidelity to feeding areas from northern California through southeastern Alaska. We used both mitochondrial DNA (mtDNA) and 12 microsatellite markers to assess whether stock structure exists among feeding grounds used by ENP gray whales. Significant mtDNA differentiation was found when samples representing the PCFG ($n = 71$) were compared with samples ($n = 103$) collected from animals feeding further north ($F_{ST} = 0.012$, $P = 0.0045$). No significant nuclear differences were

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detected. These results indicate that matrilineal fidelity plays a role in creating structure among feeding grounds but suggests that individuals from different feeding areas may interbreed. Haplotype diversities were similar between strata (h_{PCFG} = 0.945, h_{Northern} = 0.952), which, in combination with the low level of mtDNA differentiation identified, suggested that some immigration into the PCFG could be occurring. These results are important in evaluating the management of ENP gray whales, especially in light of the Makah Tribe's proposal to resume whaling in an area of the Washington coast utilized by both PCFG and migrating whales.

Key words: *Eschrichtius robustus*, gray whale, population structure, mitochondrial DNA, microsatellites, demographic independence.

A single stock of gray whales (*Eschrichtius robustus*) is currently recognized in U.S. waters (Carretta *et al*. 2013). This stock, which is referred to as the eastern North Pacific (ENP) stock, is estimated to contain approximately 19,000 individuals (Laake *et al*. 2009). Most of these whales feed in the Bering, Beaufort, and Chukchi Seas during summer and fall and then migrate south along the coast of North America to overwinter in the lagoons and coastal waters of Baja Mexico. However, a small number of individuals feed in more southern waters from northern California through southeastern Alaska during summer and fall (Gilmore 1960; Pike 1962; Hatler and Darling 1974; Darling 1984; Calambokidis *et al.* 2002, 2012). Photo-identification research, which commenced in the early 1970s and continues to date, has identified a subset of whales that have returned to this southern feeding ground in multiple years and account for the majority of sightings in the area during summer and fall months (Hatler and Darling 1974; Darling 1984; Calambokidis *et al.* 2002, 2012). These whales are referred to as the Pacific Coast Feeding Group (PCFG; IWC 2011*a*). Recent estimates of annual abundance suggest that the PCFG includes approximately 200 animals (Calambokidis *et al.* 2012). Although PCFG whales account for the majority of sightings on this southern feeding ground during summer and fall, the area is also used by whales that are encountered in the region following the migration (*e.g.*, after 1 June) but are seen in only one year (Calambokidis *et al.* 2012). These individuals are generally seen for shorter time periods and in a more limited area than are PCFG whales, and they may represent stragglers from the larger group of animals that migrate through the southern feeding ground on their way to feeding areas further north (Calambokidis *et al*. 2012).

The PCFG includes some animals that were first identified as calves with their mothers on the southern feeding ground and that have returned to feed in the area in subsequent years (Calambokidis *et al.* 2012). This pattern of behavior, which is often called matrilineal fidelity, likely results from calves learning the location of suitable feeding/calving grounds from their mothers. Matrilineal fidelity to feeding and/or calving areas has been documented in other baleen whales (*e.g.*, Gulf of Maine humpback whales, Clapham and Mayo 1987; southern right whales, Valenzuela *et al.* 2009). Understanding patterns of matrilineal fidelity may be important in shaping management decisions, as it is thought that the lack of recovery or repopulation of baleen whales in some areas heavily impacted by commercial whaling is related to the loss of knowledge of where suitable habitat is located (Clapham *et al.* 2008).

Concern for PCFG whales has arisen in part from recent interest in the resumption of whaling by the Makah Tribe in northwest Washington, an area used by virtually all migrating whales as well as by foraging whales considered part of the PCFG. The current proposal by the Makah Tribe includes time/area restrictions designed to reduce the probability of killing a PCFG whale by focusing hunt effort on the much larger group of whales migrating to/from feeding areas further north. However, PCFG whales are present during the migratory season, and it is impossible to ensure that no PCFG whales would be killed. The Makah Tribe also proposes to compare photographs of any whales harvested in the hunt to a photo-identification catalog of known PCFG whales and to suspend the hunt if needed to prevent the number of PCFG whales harvested from exceeding the annual allowable bycatch level for that year (IWC 2011*b*).

Evaluating whether any kills would, over time, have the potential to deplete the PCFG requires an understanding of how individuals are recruited into the group. If recruitment into the area is exclusively internal, such that use of the area is driven by calves learning the location of feeding grounds from their mothers, then a PCFG individual that is removed would not be replaced by immigration. However, if recruitment is largely external, then it is possible that any takes from the PCFG could be offset by immigration into the PCFG by whales that in previous years fed in northern areas. As aforementioned, some PCFG individuals were first identified as calves on the feeding ground and have returned to the area to feed in subsequent years. However, the origin of other individuals is unknown, and "new" (previously unidentified) noncalf whales are identified each year, some of which have returned to the southern feeding ground in subsequent years (Calambokidis *et al.* 2012). Although these whales may be individuals who were "missed" as calves (*e.g.*, not identified as a calf or not photographed that season), they could also represent whales that previously fed further north but now demonstrate fidelity to the PCFG range.

Genetic studies have provided some insight into mechanisms of recruitment into the PCFG. Initial work utilizing a simulation-based approach indicated that if the PCFG originated from a single recent colonization event in the past 40–100 yr, with no external recruitment into the group, detectable mtDNA genetic differentiation would be generated (Ramakrishnan and Taylor 2001). Subsequent empirical analysis, however, failed to detect such a signal when comparing 16 samples collected from PCFG whales using Clayoquot Sound, British Columbia, with samples (n = 41) collected from individuals presumed to feed in more northern areas (Steeves *et al.* 2001). More recently, Frasier *et al.* (2011) used mtDNA to compare samples collected from 40 individuals considered part of the PCFG with published data generated from 105 samples collected from ENP gray whales, most of which stranded along the migratory route (LeDuc *et al.* 2002). All haplotypes identified among the PCFG samples were also found in the larger ENP sample set, and haplotype diversity found in the PCFG ($h = 0.93$) was lower than, but similar to, that found among the samples representing the larger ENP population ($h = 0.95$). However, significant differences in estimates of long-term effective size and mtDNA haplotype frequencies were identified between the two groups. These results suggest that matrilineally directed fidelity plays a role in use of this area, and the authors concluded that the PCFG should be recognized as a distinct management unit (Frasier *et al.* 2011).

One limitation of previous genetic studies on the PCFG is that they utilized samples primarily collected from gray whales that stranded while on the ENP migratory route as representative of the larger ENP population in their comparisons. Although the likelihood that any of these stranded animals were part of the PCFG is low given the large size of the ENP gray whale population, this possibility could not be ruled out based on the location where most of the ENP samples were collected. More importantly, the limited number of samples available from the feeding ground(s) north of the Aleutians precluded previous studies from making a direct comparison between animals utilizing different feeding grounds.

At the end of the feeding season, PCFG whales are thought to join the southbound migration to Mexican waters and have therefore been presumed to interbreed with the larger ENP population (Calambokidis *et al.* 2002, 2012). Earlier genetic studies of the PCFG relied exclusively on mtDNA, however, and the assumption that PCFG whales interbreed with gray whales feeding in other areas was not assessed. Conception in gray whales is thought to occur primarily during a 3 wk period between late November and early December (27 November to 13 December), although if no conception occurs during this first period, a second estrus may occur about 40 d later when whales are on or near their wintering grounds (Rice and Wolman 1971). Rugh *et al.* (2001) estimated that the median (peak) sighting date for the southbound migration is 12 December for Unimak Pass, Alaska, suggesting that many gray whales would be north of the PCFG seasonal range during the first mating period and raising the possibility that some segregation in breeding could occur with respect to feeding ground origin.

Here we contribute to the understanding of stock structure of gray whales by (1) comparing samples collected from gray whales feeding north of the Aleutians with samples collected from PCFG whales to directly address whether structure exists among feeding grounds used by ENP gray whales, and (2) using nuclear markers (n = 12 microsatellites) to test the assumption that PCFG whales interbreed with whales from other feeding grounds. We also increased the number of samples collected from PCFG whales and, for those samples linked to photographed individuals, were able to further refine our representation of the PCFG by incorporating sighting histories of known individuals in the comparisons. Although other scenarios are possible, here we test the following three hypotheses:

(1) No population structure (*e.g.,* panmixia) is present among feeding grounds used by ENP gray whales; individuals move between feeding areas and exhibit random mating. This hypothesis would be supported by a finding of no nuclear or mitochondrial differentiation between samples from PCFG whales and those collected from animals feeding further north.

(2) Utilization of feeding areas is influenced by internal recruitment, with calves following their mothers to feeding grounds and returning in subsequent years. Mating is random with respect to feeding ground affiliation. This hypothesis would be supported by a finding of significant differences in mtDNA haplotype frequencies when comparing samples from PCFG whales with those collected from animals feeding further north, but no significant differences in microsatellite allele frequencies between these groups.

(3) Utilization of feeding areas is influenced by matrilineal fidelity and mating is not random with respect to feeding ground affiliation. This hypothesis would be supported by a finding of significant differences in both mtDNA haplotype and microsatellite allele frequencies.

METHODS

Samples

The initial sample set consisted of 277 samples collected between 1994 and 2010, with collection locations ranging from northern California to Barrow, Alaska and

Chukotka, Russia (Fig. 1, Table S1). Although some samples were collected from individuals taken as part of a subsistence hunt off Chukotka ($n = 75$ samples) or from stranded individuals ($n = 17$), the majority of samples ($n = 185$, including all samples collected between northern California and British Columbia, Canada) were collected as biopsies from free-ranging individuals. During biopsy sample collection, efforts were made to obtain a photograph of each biopsied whale. These photographs were compared to a photo-identification catalog maintained by Cascadia Research Collective and containing photo-identification images primarily collected between 1998 and 2009. This catalog focuses on the PCFG whales but also includes some migrating whales that were photographed in the spring (March through May) during their northward migration.

Linking biopsy samples to photographed whales allowed the sighting history of individuals to be evaluated when determining which samples should be used to represent the PCFG whales. As noted earlier, whales utilizing the PCFG's seasonal range fall into two categories: (1) whales that return frequently and account for the majority of sightings, and (2) apparent stragglers from the migration that are sighted in only one year (Calambokidis *et al.* 2012). To ensure that our PCFG stratum was representative of the first category of whales, samples were screened using two criteria: (1) the sample had to be linked to a photo-identified animal, and (2) the photo-identified

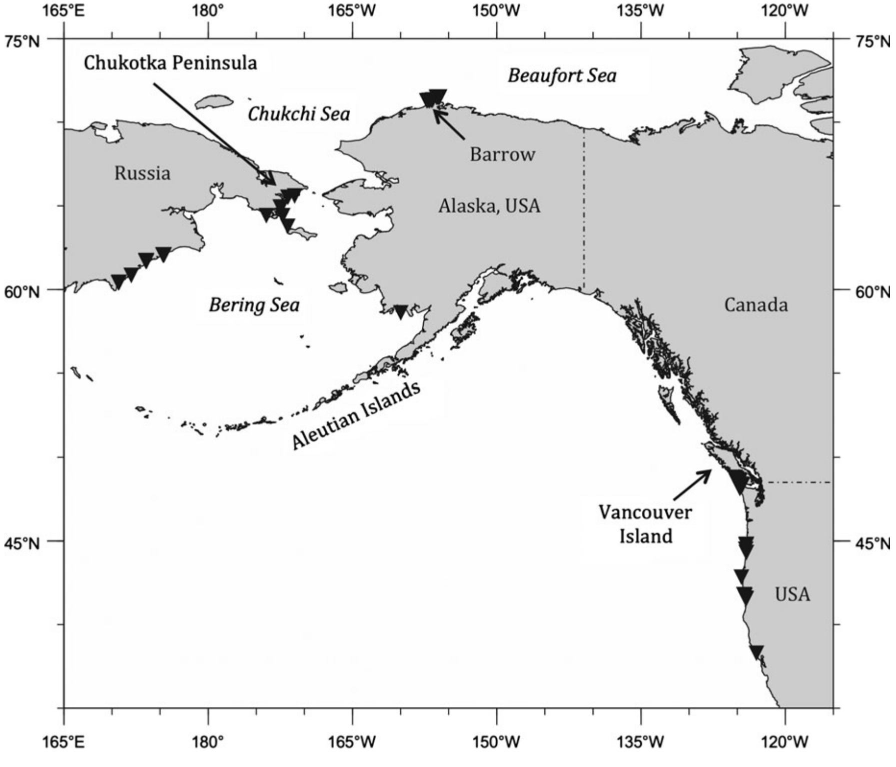

Figure 1. Locations where samples were collected, with key areas mentioned in the text labeled.

animal to which the sample was linked had to have been sighted in two or more years within the defined season (1 June to 30 November) and area (between 41ºN and 52ºN, in concordance with the boundaries used by the International Whaling Commission's Scientific Committee, IWC 2012) representative of PCFG whales. Samples collected on the southern feeding ground but not meeting these criteria (n = 36) were removed prior to data analysis, leaving 113 samples collected from whales considered to represent the PCFG in the sample set.

Samples collected from gray whales on the northern feeding area were stratified in two ways. First, all samples collected from whales that were north of the Aleutian Island chain between June and November were included in a "North" stratum (n = 128). This stratification assumes that whales use the northern feeding area in a relatively uniform manner, such that sampling location within this area does not matter. However, little is known about whether gray whales exhibit fidelity to smaller regions within the northern feeding area. If multiple feeding aggregations exist north of the Aleutians, then sampling location within that larger area is important. Although the original design of the study was to have a stratum representing Chukotka, Russia, and a stratum representing Barrow, Alaska, the sample size for the latter (n = 14 individuals) was insufficient to characterize genetic frequencies from that area. As such, we were unable to directly address hypotheses about whether additional structure exists north of the Aleutian Islands. However, we did include a comparison of the PCFG stratum to the Chukotka stratum (n = 75 samples) to avoid including unrecognized heterogeneity in our representation of animals feeding in the north.

Laboratory Processing

DNA extraction, PCR amplification and sequencing—Genomic DNA was extracted from samples using either sodium chloride protein precipitation (Miller *et al*. 1988) or silica-based filter purification (Qiaxtractor DX reagents, Qiagen, Valencia, CA) following the manufacturers' instructions. Extractions were performed on a JANUS automated work station (Perkin-Elmer, Waltham, MA). MtDNA sequences for eight of these samples had been generated previously for another study (LeDuc *et al*. 2002); however, to provide consistent quality control, these samples were resequenced for our analyses. The 5′ end of the hyper-variable mtDNA control region was amplified from extracted genomic DNA, using the polymerase chain reaction (PCR) and the primers used in the LeDuc *et al*. (2002) study (H00034, Rosel *et al*. 1994; L15812, Chivers *et al*. 2005). DNA was amplified using a 25 μL reaction of ~100 ng DNA, 1× PCR buffer (50 mM KCl, 10 mM Tris-HCl, pH 8.3, and 1.5 mM $MgCl_2$), 0.6 mM dNTPs, 0.3 μM primers, and 0.25 units of Taq DNA polymerase (New England BioLabs, Inc.). The PCR cycling profile consisted of 90°C for 2 min, followed by 35 cycles of 94°C for 50 s, an annealing temperature of 60°C for 50 s, and 72°C for 1 min, then a final extension of 72°C for 5 min. Sequencing of amplified products followed standard techniques (Saiki *et al.* 1988, Palumbi *et al.* 1991), and both strands of the amplified DNA product were sequenced independently on an Applied Biosystems, Inc. (ABI) model 3730 sequencer. If a sample was identified as having a mtDNA haplotype that was not found among any of the other samples, mtDNA amplification and sequencing were replicated to confirm the haplotype identity. All sequences were aligned using Sequencher v4.8 (Gene Codes Corp. 2000), resulting in final sequences that were 523 base pairs long.

Nuclear DNA processing—Twelve microsatellite loci isolated from other cetacean species were used to genotype the samples (see Table S2): EV14, EV37, and EV94

(Valsecchi and Amos 1996); Gata028, Gata098, Gata417, and Gt023 (Palsbøll *et al.* 1997); RW31 and RW48 (Waldick *et al.* 1999); and SW10, SW13, and SW19 (Richard *et al.* 1996). For all reverse primers except those amplifying Gata098 and EV37 (which failed to amplify with modified primers), the primer sequence was modified from the original design by placing the sequence GTTTCTT on the $5'$ end to facilitate complete adenylation and thus more consistent scoring (Brownstein *et al.* 1996). Forward primers were fluorescently labeled. Extracted DNA was amplified using a 25 μL reaction of ~100 ng of DNA, 1× PCR buffer (50 mM KCl, 10 mM Tris-HCl, pH 8.3, and 1.5 mM $MgCl_2$), 0.6 mM dNTPs, 0.3 μM primers, and 0.5 units of Taq DNA polymerase (New England BioLabs, Inc.). The PCR cycling profile included 90°C for 2.5 min, followed by 35 cycles of 94°C for 45 s, 1 min at the optimal annealing temperature (see Table S2), and 72°C for 1.5 min, then a final extension of 72°C for 5 min. Only one locus was amplified per reaction, and each PCR product was assessed electrophoretically on a 2% agarose gel for size and quality before loading onto an ABI 3730 Genetic Analyzer. ABI GeneMapper software (version 4.0) was used along with an internal size standard (GeneScan-500 ROX, ABI) to determine allele fragment size. Two positive control samples were included on each plate to ensure consistent sizing between runs.

Sex determination—Samples were genetically sexed by amplification and Real-Time PCR (MX3000p, Stratagene Inc.) of the zinc finger (ZFX and ZFY) genes. Samples from one male and one female for which sex had been determined *via* examination of a stranded animal were included as positive controls in all amplifications. Sex was determined by the amplification pattern: males had two products and females had one (Morin *et al.* 2005).

Analysis

Data review—Quality control and sample tracking procedures, as detailed in Morin *et al.* (2010), were implemented during data generation. A randomly chosen set of samples, representing 13% of all samples processed, was sequenced, sexed, and genotyped a second time, and these records were reviewed for consistency. For the microsatellite data, replicate and original genotypes were compared, and a per-allele error rate was calculated by determining the number of discrepant allele calls divided by the total number of allele calls compared across all loci. In addition, all microsatellite genotypes were scored independently by two experienced genotypers. The allele calls from each genotyper were compared, and calls that did not match were reviewed jointly by both genotypers. Inconsistencies that could not be resolved upon review were treated as missing data.

After genotyping of samples was complete for eight of the twelve loci (EV14, EV94, Gata028, Gata417, Gt023, RW31, SW13, and SW19), the program GENECAP (Wilberg and Dreher 2004) was used to calculate the probability that two randomly chosen individuals would share the same multilocus genotype under both the assumption of Hardy-Weinberg equilibrium (PID_{HW}, Paetkau and Strobeck 1994) and under the more conservative assumption that full siblings may be present within the data set (PID_{SIB}, Waits *et al.* 2001). Samples with identical genotypes, indicating that they may have been collected from the same animal, were flagged for further review. These sample pairs were checked to see if they also shared the same mtDNA haplotype and sex, and, when possible, photo-identification records were used to confirm the genetic match. For all samples that shared identical mtDNA haplotypes, sexes, and nuclear genotypes at the eight loci, one sample from each pair was removed and then the remaining samples were genotyped at the additional four loci prior to further analysis.

After genotyping at all 12 microsatellite loci was complete, the data set was reviewed to identify samples that were missing data for ≥25% of the markers; these samples were considered to be of poor quality and were removed prior to further analysis. The program MSTOOLS (Park 2001) was used to identify any additional samples whose genotypes matched at eight or more loci (using the full 12 microsatellite data set) and thus might represent duplicate samples that were not detected in the earlier analysis. Deviations from Hardy-Weinberg equilibrium (HWE) were assessed for each locus using Genepop (version 4.0.11, Rousset 2008). Both the probability test (Guo and Thompson 1992) and the test for heterozygote deficiency (Rousset and Raymond 1995) were conducted using the program defaults for the Markov chain parameters (10,000 dememorization steps, 20 batches, 5,000 iterations/batch). Genepop was also used to test for linkage disequilibrium (LD) for each pair of loci. All tests were run for the combined data set as well as for each stratum. The false discovery rate (FDR) adjustment (Benjamini and Hochberg 1995) was used to control for multiple testing when the results of the HWE and LD analyses were assessed.

Genetic diversity—For the mtDNA data, nucleotide (π) and haplotype (h) diversities (Nei 1987) were calculated using Arlequin 3.1 (Excoffier *et al.* 2005). To look for phylogeographic patterns among the mtDNA data, the software package Network 4.5.1.0 (available at http://www.fluxus-engineering.com/sharenet.htm) was used to generate a median-joining network of haplotypes using the algorithm of Bandelt *et al.* (1999). For the microsatellite data, the number of alleles per locus and observed and expected heterozygosities (Nei and Roychoudhury 1974) were calculated using custom code (eiaGenetics[2]) written in the statistical programming language R (R Core Development Team 2009).

Genetic structure—Pairwise estimates of genetic divergence were calculated using both F_{ST} (Weir and Cockerham 1984) and the AMOVA Φ_{ST} (Excoffier *et al.* 1992) for the mtDNA data using Arlequin v3.1 (Excoffier *et al.* 2005). For the Φ_{ST} pairwise distance calculations, the program jModelTest v2.1.4 (Guindon and Gascuel 2003, Posada 2008, Darriba *et al.* 2012) was used to select the best nucleotide substitution model based on the Akaike Information Criterion (AIC). Statistical significance was assessed using 10,000 permutations. Fisher's exact test (Raymond and Rousset 1995) was also used to test for mtDNA differentiation between strata using Arlequin 3.1 (Excoffier *et al.* 2005); 10,000 replications were used to test for significance. For the microsatellite data, F_{ST} (Weir and Cockerham 1984), F'_{ST} (Hedrick 2005, Meirmans 2006), and a χ^2 test were used to assess genetic differentiation using custom R-code (eiaGenetics). Statistical significance was determined from 5,000 permutations of each data set.

RESULTS

Data Review

Fourteen samples (including 11 samples collected from stranded whales) did not produce useable mtDNA sequence data and also failed to amplify at >4 microsatellite

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[2] Available on request from E. Archer at eric.archer@noaa.gov.

loci; these samples (identified as "poor quality" samples) were removed from all subsequent analyses and data review (Table S1, S3).

Based on the genotypes of the remaining samples (*n* = 227) at the initial eight loci, the probability of two individuals possessing the same multilocus genotype was 9.08×10^{-9} for unrelated individuals (PID_{HW}) and was 6.97×10^{-4} for full siblings (PID_{SIB}), indicating that the microsatellite loci were adequate for identifying unique individuals. These samples were screened for duplicates (*i.e.*, samples considered to be from the same animal) after genotyping of the first eight loci was complete. Fifty samples had microsatellite genotypes that were identical to at least one other sample in the data set. In all cases, the mtDNA haplotypes and sexes of each pair also matched. Forty-two of the duplicate samples were identified in the PCFG stratum; 74% of these (*n* = 31) were confirmed to be the same animal using photo-identification records. All 50 duplicate samples were removed from further analysis. No movements of animals between regions representing different strata were identified based on genetic matches (*i.e.*, all samples sharing identical genetic profiles were part of the same stratum). The number of unique individuals (*n* = 177) remaining after removal of duplicates is shown in Table S3.

The proportion of missing genotypes at each locus was ≤2% for all loci (Table S2). Using the samples randomly selected for replication, a per-allele error rate of 0.11% was detected for the full microsatellite data set. After controlling for the FDR, no loci demonstrated significant deviations from HWE for either the probability test or the test for heterozygote deficiency. One pair of loci (EV94-SW19) showed significant linkage disequilibrium (LD) in the Chukotka and the North strata, while three pairs of loci (EV14-Gt023, EV94-RW48, and EV94-Gata098) demonstrated significant LD in the PCFG stratum. All loci were retained in subsequent analyses.

Further review of the microsatellite data set did not identify any samples that were identical for ≥7 loci. Two samples amplified at ≤8 loci and were removed from the microsatellite analyses, leaving a total of 175 unique individuals for the microsatellite analyses. These samples did produce useable mtDNA sequence data and were thus retained in that data set.

No discrepancies were identified when the replicated and original mtDNA haplotype sequences were compared. The mtDNA haplotype could not be resolved for three of the 177 individuals, and these individuals were removed from the mtDNA data set but retained in the microsatellite data set. Sex was determined for all of the 177 individuals.

Genetic Diversity

Thirty-six mtDNA haplotypes defined by 36 variable sites were identified among the 174 individuals for which mtDNA haplotypes were resolved (Table 1). Thirty-two (NCBI Accession numbers AF326789-326824) of these haplotypes had been previously identified in LeDuc *et al.* (2002). The frequency of each haplotype in the defined strata (including Barrow) is shown in Table 2. Nineteen haplotypes were shared between the North and the PCFG strata, with four haplotypes found only in the PCFG. For all strata, many haplotypes were found in only one individual (*n* = 13 haplotypes in the North, *n* = 12 haplotypes in Chukotka, and *n* = 8 haplotypes in the PCFG, including three of the haplotypes found only in the PCFG). Haplotype diversity (*h*) was high in all strata defined for the analysis (0.945–0.953). Nucleotide diversity (π) was also similar among the three defined strata (0.0144–0.0154). The median-joining network shows the relationship among mtDNA haplotypes and their

Table 1. Number of mtDNA control region haplotypes, haplotype diversity (± SE), and nucleotide diversity (± SE) within each stratum.

Strata	No. of samples	No. of haplotypes	Haplotype diversity (h)	Nucleotide diversity (π)
North[a]	103	32	0.952 (± 0.008)	0.0144 (± 0.008)
Chukotka	69	27	0.953 (± 0.011)	0.0145 (± 0.008)
PCFG	71	23	0.945 (± 0.010)	0.0154 (± 0.008)

[a] Samples from Chukotka are included as part of the North stratum.

Table 2. The mtDNA haplotypes identified in the study, their corresponding NCBI accession numbers, and the number of individuals with each haplotype in each stratum.

MtDNA haplotype ID	NCBI accession number	North[a] (n = 103)	Chukotka (n = 69)	Barrow (n = 14)	PCFG (n = 71)
1	AF326789	10	8	2	7
2	AF326790	3	2	0	4
3	AF326791	14	9	1	1
4	AF326792	5	4	0	6
5	AF326793	1	1	0	1
7	AF326795	7	4	0	6
8	AF326796	1	1	0	2
9	AF326797	1	1	0	0
11	AF326799	3	2	1	3
12	AF326800	5	4	1	3
13	AF326801	5	3	0	9
14	AF326802	1	1	0	7
15	AF326803	3	0	2	0
16	AF326804	1	0	1	0
17	AF326805	1	0	0	0
18	AF326806	3	3	0	2
20	AF326808	6	1	2	2
21	AF326809	2	1	1	3
22	AF326810	1	1	0	0
23	AF326811	5	4	0	0
24	AF326812	2	2	0	3
25	AF326813	6	4	0	1
26	AF326814	2	1	1	0
27	AF326815	0	0	0	4
28	AF326816	2	2	0	2
29	AF326817	2	2	0	0
30	AF326818	0	0	0	1
31	AF326819	1	1	0	0
33	AF326821	5	4	0	1
35	AF326823	1	0	1	0
36	AF326824	1	0	1	1
38	KC917326	1	1	0	0
42	KC917327	1	1	0	0
43	KC917328	1	1	0	0
46	KC917329	0	0	0	1
47	KC917330	0	0	0	1

[a] Samples from Chukotka are included as part of the North stratum.

frequency in each stratum (Fig. 2). MtDNA haplotypes from both Chukotka and the PCFG are dispersed throughout the network, and no phylogeographic pattern was apparent.

A summary of nuclear diversity for each microsatellite locus is shown in Table S2. Measures of nuclear diversity for each stratum after averaging across loci are shown in Table 3. As in the comparisons of mtDNA haplotype and nucleotide diversity, nuclear diversity was similar across all strata. Nine alleles were found only among whales that were part of the North stratum (six of these were from Chukotka), and three alleles were identified only among PCFG whales.

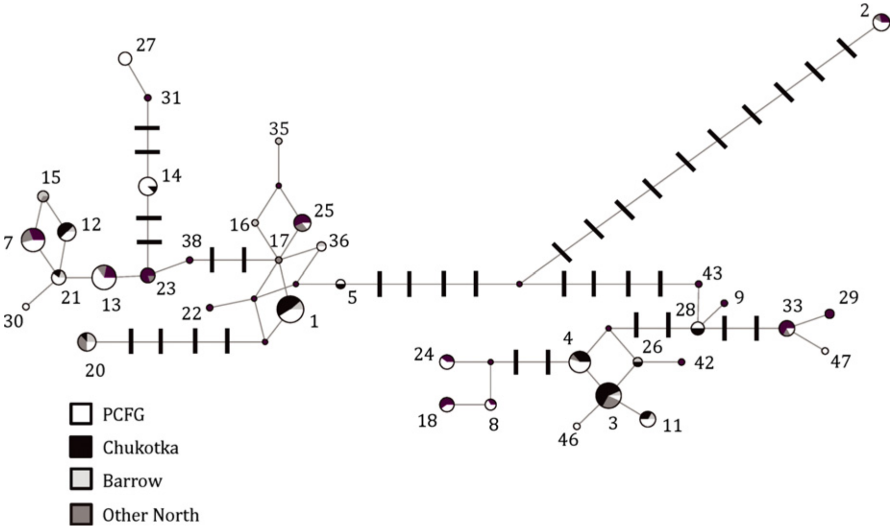

Figure 2. Median-joining network showing relationships among the mtDNA haplotypes. The numbers next to the nodes correspond to the haplotype IDs listed in Table 4. The size of the nodes is proportional to the frequencies of the haplotypes, and each node is shaded to indicate the fraction of individuals with that haplotype from each strata. The small black diamonds (unlabeled) indicate haplotypes that were inferred by the program but were not found among our samples. The length of lines connecting nodes is proportional to the inferred number of mutations separating haplotypes; for all haplotypes separated by more than one mutation, hash marks are used to represent the number of mutational events.

Table 3. Estimates of the number of alleles, observed heterozygosity (H_o), and expected heterozygosity (H_e) averaged across loci within each stratum for the microsatellite data. The genotypes of two samples that were used in the mtDNA analysis were removed because they amplified for ≤8 loci.

Strata	No. of samples	Mean number of alleles	Mean H_o	Mean H_e
North[a]	105	8.75	0.72	0.73
Chukotka	70	8.33	0.73	0.73
PCFG	70	8.00	0.74	0.73

[a] Samples from Chukotka are included as part of the North stratum.

Sex Ratio

All strata were comprised of more females than males, with ratios of 1.4 females per male in each stratum (Table S3). This female bias is similar to that (1.47 females per male) described in Frasier *et al*. (2011). Although the female bias was not significantly different from the expected 1:1 ratio in any of the strata, when all samples were combined the female bias was significantly different from parity ($\chi^2 = 5.43$, $P < 0.05$).

Genetic Structure

The results of the mtDNA comparisons are shown in Table 4a. The Tamura and Nei model of nucleotide substitution (Tamura and Nei 1993) with invariant sites (TrN + I) was selected as the most appropriate model of sequence evolution and was used in calculating $\Phi_{ST.}$ When the PCFG stratum was compared with the North stratum, significant differences in mtDNA haplotype frequencies were detected using F_{ST} and the exact test ($F_{ST} = 0.012$, $P = 0.0045$; Fisher's exact test $P = 0.0067$), but no significant differences were found in the Φ_{ST} comparison ($\Phi_{ST} = 0.012$, $P = 0.0740$). Statistically significant differences were detected in all mtDNA comparisons of the PCFG stratum with the Chukotka stratum ($\Phi_{ST} = 0.020$, $P = 0.0386$; $F_{ST} = 0.010$, $P = 0.0348$; Fisher's exact test $P = 0.0254$). None of the comparisons across strata utilizing the microsatellite data were significant (Table 4b).

DISCUSSION

Given that PCFG whales share the same migratory routes and wintering grounds used by other ENP whales, it has generally been thought that PCFG whales interbreed with whales that feed further north (*e.g.,* Calambokidis *et al*. 2002, 2012). Here we were able to test that assumption directly by using microsatellite markers to compare PCFG whales with whales feeding north of the Aleutians. No significant nuclear differences between the two groups were identified, indicating that gray whales feeding in these areas likely represent a single interbreeding population. Significant differences in mtDNA haplotype frequencies were identified between the PCFG and northern feeding whales, however, suggesting that some structure exists among

Table 4. Results of pairwise comparisons across strata using (a) mtDNA and (b) 12 microsatellites. Comparisons that are statistically significant are shown in bold.

Pairwise comparison	Φ_{ST}	*P*-value	F_{ST}	*P*-value	Fisher exact test *P*-value
(a)					
North[a] (103) *vs*. PCFG (71)	0.012	0.0740	0.012	**0.0045**	**0.0067**
Chukotka (69) *vs*. PCFG (71)	0.020	**0.0386**	0.010	**0.0349**	**0.0254**

Pairwise comparison	F_{ST}	*P*-value	F_{ST}'	*P*-value	χ^2 *P*-value
(b)					
North[a] (105) *vs*. PCFG (70)	0.000	0.5269	0.000	0.5271	0.3491
Chukotka (70) *vs*. PCFG (70)	0.001	0.2539	0.003	0.2539	0.3503

[a] Samples from Chukotka are included as part of the North stratum.

feeding grounds used by ENP gray whales. Within the PCFG, this finding is concordant with photo-identification records that indicate that many animals first identified as calves return to the PCFG feeding area in subsequent years (Calambokidis *et al.* 2012). When combined, these findings are consistent with the second proposed hypothesis, and suggest that while mating is random with respect to feeding ground affiliation, utilization of feeding areas is influenced by internal recruitment.

The results of our mtDNA comparisons are similar to those presented in Frasier *et al.* (2011), who also found evidence of maternally driven structure when comparing samples from whales that were considered to represent the PCFG with a sample set comprised primarily of animals that stranded along the migratory route in the ENP. All of the samples utilized in the Frasier *et al.* (2011) study to represent the PCFG were collected from whales in Clayoquot Sound, which is located off the central west coast of Vancouver Island, British Columbia. In contrast, 89% of the samples representing the PCFG in this study were collected from animals in the waters off northern California, Oregon, and Washington, with only 12 samples (11%) collected off southern Vancouver Island. While the majority of PCFG whales photographed off southern Vancouver Island (52%) and northern Washington (60%) have also been sighted off western Vancouver Island, interchange between more distant areas (*e.g.*, comparison of northern California and western Vancouver Island) has been documented less frequently (Calambokidis *et al.* 2012). In addition, while some whales are known to move throughout the range of the PCFG, sightings of other whales are concentrated within subareas (Calambokidis *et al.* 2012), suggesting that individual gray whales may not use the range of the PCFG randomly. Thus while there is likely overlap among the individuals sampled in Frasier *et al.* (2011) and the current study, neither represents random sampling across the range of the PCFG. In the future, the collection of additional samples from whales in the northern portion of the PCFG range and/or integration of our sample set with that utilized by Frasier *et al.* (2011) would provide more evenly distributed sample coverage throughout the range of the PCFG and could provide insight into whether additional substructuring within the PCFG exists.

Despite the fact that the estimated abundance of the PCFG is roughly 1% of that of the ENP population as a whole, the haplotype diversity identified in the PCFG is similar to that found among strata representing the larger ENP population. This high haplotype diversity seems inconsistent with what might be expected if the PCFG was founded by a small number of individuals and has remained isolated (*e.g.*, all recruitment into the group is internal) for many generations. Under such a scenario, the mtDNA haplotypes carried by founders that were males or nonreproducing females would be lost over time, while haplotypes found in successfully reproducing females and their returning offspring would build to higher frequencies, resulting in reduced haplotype diversity in the group. However, the mtDNA haplotype diversity found within the PCFG, as well as the significant but relatively low level of mtDNA differences identified between the PCFG and northern feeding whales, could suggest that colonization of the PCFG range occurred relatively recently. Under this scenario, strong mtDNA differences between PCFG whales and individuals feeding further north may have had insufficient time to develop, and the number and distribution of haplotypes in the PCFG would not have been strongly affected by genetic drift. Little is known about the history and origin of the PCFG. Gray whales have been recorded feeding in the southern portion of the PCFG range as early as 1926, when a single gray whale, which was reported to have been feeding with four other whales, was taken by the Trinidad whaling station off the entrance to the Crescent City Harbor in July (Howell and Huey 1930). Additional sightings of whales within the PCFG range during summer and fall were reported in the 1940s, 50s, and 60s (Gilmore 1960, Pike and MacKaskie 1969, Rice and Wolman 1971). The repeated return of individual whales to the area was first documented starting in the 1970s (Hatler and Darling 1974, Darling 1984). This time period marked the beginning of photo-identification studies for gray whales, and thus it is unknown if fidelity to the PCFG area occurred prior to this time or if the sightings recorded earlier were of animals that only visited the area during a single feeding season.

It is unclear what oceanographic conditions would have been present during the last century that would have precipitated use of the PCFG feeding area. Pyenson and Lindberg (2011) reconstructed the carrying capacity of gray whales over the past 120,000 yr by quantifying what feeding habitats would have been available during that time. They hypothesized that gray whales survived glacial fluctuations during the Pleistocene by employing generalist filter-feeding strategies that allowed them to take advantage of alternative food sources and feeding areas, similar to foraging strategies and areas used by PCFG whales today (*e.g.*, Darling *et al.* 1998, Dunham and Duffus 2001). More recently, access to the Bering Sea feeding areas would have been limited by heavy ice during parts of the "Little Ice Age" (*ca.* 1450–1850). Even if the PCFG seasonal range was colonized prior to the start of commercial whaling, this group of animals may have been greatly depleted or eliminated prior to the end of commercial whaling. Thus, it is plausible that the PCFG range may have been colonized multiple times in the past as a response to environmental changes and/or to depletion due to whaling.

The low level of mtDNA differentiation and high diversity are also consistent with a scenario in which matrilineal fidelity plays a role in determining use of the PCFG area but in which external recruitment also occurs. Given that the migratory route for whales traveling to the northern feeding ground(s) passes through the PCFG range, such recruitment could take place if migrating whales encounter a productive source of food within the PCFG range, remain in the area for the remainder of the season, and return in subsequent years (Calambokidis *et al.* 2002, 2012). External recruitment would slow the accumulation of genetic differences between PCFG whales and individuals feeding further north. Also, external recruits (at least initially) would likely carry haplotypes not previously identified among PCFG individuals, increasing the number and diversity of haplotypes found as well as the proportion of haplotypes currently shared between the PCFG and the animals feeding north of the Aleutians. Examination of the photo-identification data provides some information relevant to evaluating whether external recruitment into the PCFG could be occurring. Although photo-identification studies of the PCFG started in the early 1970s (Hatler and Darling 1977, Darling 1984), consistent efforts covering a larger portion of the PCFG seasonal range did not begin until 1998 (Calambokidis *et al.* 2012). Between 1998 and 2010, "new" (*i.e.*, previously unidentified) noncalf whales continued to be identified in the PCFG area each year, and many of these whales returned to the area in subsequent years (mean = 11 whales per year, 2002–2009, northern California to northern British Columbia; Calambokidis *et al.* 2012). It is unknown what proportion of these new whales could be immigrants into the group (*e.g.,* external recruits) and what proportion may be animals that were internally recruited but were not identified as calves during their first year (*e.g.*, "missed calves"). Although the number of calves identified on the PCFG range each year is low (mean = 3 calves per year, range 0–9, 2002–2009, northern California to northern British Columbia), calves may wean from their mothers as early as June or July, making them difficult to identify as calves (*vs*. yearlings or young animals) and leading to underestimates of the number of calves present (Calambokidis *et al*. 2012). Indices of gray whale calf production based on estimates of the number of northbound calves past Piedras Blancas, California, are highly variable and averaged 4.3% (calf estimate/total population estimate, range 1.55%–6.8%) between 1994 and 2000 (Perryman *et al*. 2002). These estimates are likely high relative to the total number of gray whale calves that survive the full migration, as mortality of calves due to killer whale predation is known to occur in areas north of Piedras Blancas, including Monterey Bay, California (see summaries in Jefferson *et al.* 1991, Ford and Reeves 2008), an area that both PCFG and ENP whales traverse while migrating. While it is unknown how these estimates relate to calf production among PCFG whales, applying these indices to a group of 200 animals would result in a mean of 9 calves per year (range 3–13 calves per year).

In addition, comparison of nine whales photographed off Barrow, Alaska in 2006 and 2010 with the photo-identification catalog of animals identified within the PCFG range resulted in two matches (Calambokidis *et al*. 2012). One of these animals was photographed off Vancouver Island during March on a single occasion and thus may have been migrating through the area and would not be considered part of the PCFG. The second animal, however, had previously been sighted in multiple years during summer/fall in the PCFG area. While the significance of this match is difficult to interpret given the limited photo-identification data available from Barrow, it does indicate that at least this one individual has utilized more than one feeding ground during its lifespan.

Based on the genetic results presented here, it is not possible to determine the extent of immigration into the PCFG that could occur while still allowing mtDNA differences to be detected. While dispersal can be indirectly estimated from F_{ST} values (Wright 1931), the assumptions (*e.g.*, equal population sizes, equilibrium) of the underlying model are unlikely to be valid in wild populations (Whitlock and McCauley 1999). In addition, if the PCFG was isolated from the rest of the ENP population in the past, then the underlying level of genetic divergence would be related to the length of time the two groups had been separated and their effective sizes (Nei and Chakravarti 1977). As the underlying level of genetic divergence increases, the amount of recent immigration that could occur without obscuring the signal of mtDNA differentiation also increases. This highlights the fact that there are multiple scenarios (*e.g.,* colonization histories, number of founders, and immigration rates) that could lead to the pattern of mtDNA differentiation seen in the comparisons of the PCFG and the ENP samples. Given the information that is currently available, we are not able to discriminate among these possibilities.

A remaining question is whether additional structure exists within the northern feeding area. If there is no structure on the feeding grounds north of the Aleutians, then the northern strata (both "North" and "Chukotka") could be considered representative of the genetic diversity of whales feeding throughout the northern feeding area and the mtDNA differences observed here would be driven by fidelity of individuals to the PCFG seasonal range. However, if structuring is present among northern feeding areas, then the differences demonstrated here may be influenced by fidelity of individuals in either or both areas (PCFG and Chukotka). While the results of photo-identification studies of the PCFG are consistent with the occurrence of some internal recruitment, the collection of additional samples from northern feeding areas would be valuable in further elucidating the mechanisms creating the observed differences and in evaluating whether structuring is present among whales utilizing the northern feeding grounds.

Implications for Management

Understanding recruitment into the PCFG is relevant to management under the Marine Mammal Protection Act (MMPA). The goal of the MMPA is to maintain population stocks as functioning elements of their ecosystem. The National Marine Fisheries Service (2005) considers stocks to be demographically independent units, such that the population dynamics of the affected group is more a consequence of births and deaths within the group (internal dynamics) rather than of immigration or emigration (external dynamics). This definition is similar to that described for management units by Palsbøll *et al.* (2007) and for a population under the ecological paradigm by Waples and Gaggiotti (2006).

Traditionally, the most commonly used approach to evaluate demographic independence using genetic data has been null hypothesis testing, in which significant divergence of allele frequencies between groups is considered evidence supporting the delineation of separate management units (Moritz 1994). This approach assumes that if the migration rate is large enough to lead to demographic dependence, then genetic comparisons will not be able to reject the null hypothesis. Under this criterion, our findings support recognition of the PCFG of gray whales as demographically independent based on the significant differences in mtDNA between the PCFG and whales feeding further north.

Critical to our understanding of whether two groups are demographically independent, however, is the rate of dispersal between them. As noted in Waples and Gaggiotti (2006), there is no general framework for determining at what dispersal rate populations become demographically correlated, although it has been suggested that demographic correlation occurs when the proportion of immigrants in a group is greater than 10% (Hastings 1993). However, simulations have shown that, at least in cases where multiple microsatellite loci are used, it may be possible to reject panmixia even when dispersal rates are higher than this level (Palsbøll *et al.* 2006, Waples and Gaggiotti 2006). These results suggest that while genetic comparisons like those conducted here can provide insight into demographic connectivity, they should be interpreted carefully and integrated with other available information on the demography of the groups being considered (Lowe and Allendorf 2010).

When the significant mtDNA differences identified between the PCFG and the northern feeding strata are put into context with the other available evidence, questions arise about the balance between internal recruitment and external immigration. The significant mtDNA differences, as well as the observations of animals first identified as calves returning to the PCFG (Calambokidis *et al.* 2012), indicate that internal recruitment into the group occurs. However, the low level of mtDNA differences identified, the similarity in haplotype diversities between the PCFG and other groups thought to represent the larger ENP population, and the continued identification of "new" whales each year (Calambokidis *et al.* 2012) suggest that external immigration into the group may also be taking place. While other explanations (*e.g.*, recent colonization and a high rate of "missed" calves) exist that could be consistent with demographic independence of the PCFG, discriminating between these explanations is not currently possible.

Although uncertainty remains, our results indicate that it is plausible that the PCFG represents a demographically independent group and suggest that caution should be used when evaluating the potential impacts of the proposed Makah harvest on this group of animals. Continued monitoring of the PCFG, including the collection of additional photographs and genetic samples, is warranted. Future work should focus on estimating dispersal rates and levels of internal recruitment in the PCFG. The lack of differentiation in nuclear markers identified in our study limits the use of some approaches (*e.g.*, assignment tests) commonly used to estimate dispersal. However, with the collection of additional samples from PCFG whales, a parentage-based approach, similar to that used by Peery *et al.* (2008), may be valuable in documenting internal recruitment into the group and thus in assessing the demographic independence of the PCFG.

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SUPPORTING INFORMATION

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Table S1. Samples used in the study, including the SWFSC accession number, GeneticID, collection method (B = biopsy, H = harvest, S = stranding), date of collection, location of collection, strata, and whether the sample was retained in the final analysis. Samples were removed because they were considered duplicates (code 1), due to poor quality (code 2), or because they could not be assigned to a stratum (code 3, which includes whales that were sampled in the PCFG range but did not meet the criteria for being included in the PCFG stratum). GeneticID represents a unique identifier for individuals, such that samples that were considered to be from the same individual were assigned the same GeneticID. The strata specified include: North, CHK (Chukotka), PCFG, and South. Samples considered part of the CHK stratum were also included in the North stratum in the analyses. The South stratum includes samples collected from whales within the PCFG seasonal range but which did not meet the criteria for being classified as PCFG whales (see text for further explanation).

Table S2. Characteristics of the microsatellite loci used in the study, including the species for which primers were initially designed, the size of repeats, the annealing temperature used in the study (Ta), the reference listing primer sequences, the number of alleles per locus, the proportion of missing genotypes, the expected heterozygosity (He), the observed heterozygosity (Ho), and the results of the test for heterozygote deficiency (HWE; Rousset and Raymond 1995).

Table S3. The total number of samples in each stratum, the number of samples removed from the study due to poor quality (see criteria described in text), the number of duplicate samples removed, and the number of individuals remaining in each stratum for each analysis. Duplicate samples (*i.e.*, samples from the same individual) were identified based on genotyping of eight microsatellite loci. Samples collected on the southern feeding ground but not considered to represent the PCFG (n = 36) are not included in the table.

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An Age-Structured Model or Exploring the Conceptual Models Developed for Gray Whales in the North Pacific

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INTERNATIONAL
WHALING COMMISSION

An Age-Structured Model or Exploring the Conceptual Models Developed for Gray Whales in the North Pacific

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ABSTRACT

A sex- and age-structured population dynamics model which can represent the stock hypotheses developed during the April 2014 rangewide review of population structure and status of North Pacific gray whales is outlined. The model allows for multiple stocks, each of which can have sub-stocks, multiple feeding and wintering grounds, as well as migratory corridors. Animals can move between sub-stocks in a pulse or diffusively. The values for the parameters of the model can be estimated by fitting it to data on trends in relative and absolute abundance, in addition to mixing proportions based on telemetry and mark-resight data. The model is generic, but the specifications in this document include choices made when an operating model was developed to evaluate alternative *SLA*s for the Pacific Coast Feeding Group (PCFG) for the eastern north Pacific gray whales. An example application of the model is provided.

INTRODUCTION

The workshop on the rangewide review of the population structure and status of North Pacific gray whales (IWC, 2014) developed several conceptual models for gray whales in the North Pacific. These hypotheses differed in terms of the number of stocks and how those stocks are divided into sub-stocks and how they are distributed across the North Pacific. The Workshop recommended that a framework based on an age- and sex-structured population dynamics model be developed to explore whether the conceptual models are consistent with the available data and whether the existing data are sufficient to enable most of the parameters of the model to be estimated.

This paper provides the mathematical specifications for a strawman sex- and age-structured model, outlines how this model could be used to implement one of the conceptual models developed by IWC (2014) [Fig. 1], and provides some preliminary results.

MODEL STRUCTURE

The model distinguishes ‘stocks’ and ‘sub-stocks’. Stocks are demographically and genetically independent whereas sub-stocks are linked through dispersal of individuals[1], though perhaps at very low rates for some combinations of sub-stocks.

Each stock / sub-stock is found in a set of sub-areas, each of which may have catches (commercial, aboriginal or incidental), proportions of stocks / sub-stocks mixing[2] in those sub-areas, and indices of relative or absolute abundance. Catches may be specified to sets of months during the year if the various sub-stocks are not equally vulnerable to catches throughout the year.

Commented [JS1]: The definition in the footnote is a little too narrow. We are also considering sub-stocks in the mixing so the groups do interbreed. Also, we have mixing during migration as well as on the feeding grounds (I assume you meant grounds instead of groups).

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[1] The term ‘dispersal’ is used here in the sense of ‘effective dispersal’, and refers to permanent movement of individuals among stocks. Such individuals become part of the population to which they move and contribute to future reproduction.

[2] Mixing is defined here as two stocks which overlap at some time on the feeding groups, but do not interbreed.

Basic Population Dynamics

The population dynamics are based on the standard age-structured model used by the IWC Scientific Committee and which has formed the basis for the evaluation of *SLA*s for the Eastern North Pacific gray whales, i.e.:

$$\begin{array}{ll}
N^{m/f,i,j}_{t+1,0} = 0.5B^{i,j}_{t+1} & a = 0 \\
N^{m/f,i,j}_{t+1,a} = ((N^{m/f,i,j}_{t,a-1} - C^{m/f,i,j}_{t,a-1})\, S_{a-1} + I^{m/f,i,j}_{t,a-1})\tilde{S}^{i,j}_{t} & 1 \le a \le x-1 \quad (1.1) \\
N^{m/f,i,j}_{t+1,x} = ((N^{m/f,i,j}_{t,x} - C^{m/f,i,j}_{t,x})S_x + (N^{m/f,i,j}_{t,x-1} - C^{m/f,i,j}_{t,x-1})\, S_{x-1} + I^{m/f,i,j}_{t,x} + I^{m/f,i,j}_{t,x-1})\, \tilde{S}^{i,j}_{t} & a = x
\end{array}$$

where $N^{m/f,i,f}_{t,a}$ is the number of males / females of age *a* in sub-stock *j* of stock *i* at the start of year *t*; $C^{m/f,i,f}_{t,a}$ is the catch of males / females of age *a* in sub-stock *j* of stock *i* during year *t* (whaling is assumed to take place in a pulse at the start of each year); S_a is the annual survival rate of animals of age *a* in the absence of catastrophic mortality events (assumed to be the same for males and females):

$$S_a = \begin{cases} S_0 & \text{if } a = 0 \\ S_{1+} & \text{if } 1 < a \end{cases} \tag{1.2}$$

S_0 is the calf survival rate for animals; S_{1+} is the survival rate for animals aged 1 and older; $\tilde{S}^{i,j}_{t}$ is the amount of catastrophic mortality (represented in the form of a survival rate) for sub-stock *j* of stock *i* during year *t* (catastrophic events are assumed to occur at the end of the year after mortality due to whaling and non-catastrophic natural causes and dispersal; in general $\tilde{S}^{i,j}_{t}$ =1, i.e. there is no catastrophic mortality); $B^{i,j}_{t+1}$ is the number of births to sub-stock *j* of stock *i* during year *t*; $I^{s,m/f}_{t,a}$ is the net dispersal of female/male animals of age *a* into sub-stock *j* of stock *i* during year *t*; and *x* is the maximum (lumped) age-class (all animals in this and the *x*-1 class are assumed to be recruited and to have reached the age of first parturition). *x* is taken to be 15[3].

Births and density-dependence

Density-dependence is assumed to be a function of numbers of animals ages 1 and older by feeding ground relative to the carrying capacity by feeding ground. The density-dependence component of sub-stock *j* of stock *i* is the sum of the density-dependence components by feeding group weighted by the proportion of animals from sub-stock *j* of stock *i* which are found on each feeding ground, i.e.:

$$F(i,j,t) = \sum_A \left(X^{A,i,j} (N^{1+,A}_t / K^{1+,A})^z \right) / \sum_A X^{A,i,j} \tag{2.1}$$

where z is the degree of compensation; N^{1+A}_t is the number of 1+ animals on feeding ground *A* at the start of year *t*:

$$N^{1+,A}_t = \sum_i \sum_j X^{A,i,j} \sum_{a=1}^{x} (N^{m,i,j}_{t,a} + N^{f,i,j}_{t,a}) \tag{2.2}$$

K^{1+A}_t is the carrying capacity for feeding ground *A*:

---

[3] The results would be identical to those reported here if x was set to the maximum of the age-at-recruitment and the age-at-maturity.

$$K^{1+,A} = \sum_i \sum_j X^{A,i,j} \sum_{a=1}^{x} (N^{m,i,j}_{-\infty,a} + N^{f,i,j}_{-\infty,a}) \tag{2.3}$$

$X^{A,i,j}$ is the proportion of animals of sub-stock *j* of stock *i* which is in feeding ground *A*.[4]

The number of births at the start of year *t* for sub-stock *j* of stock *i*, $B_t^{i,j}$, is given by:

$$B_t^{i,j} = b_t^{i,j}\, N_t^{f,i,j} \tag{2.4}$$

where $N_t^{f,i}$ is the number of mature females in sub-stock *j* of stock *i* at the start of year *t*:

$$N_t^{f,i,j} = \sum_{a=a_m}^{x} N_{t,a}^{f} \tag{2.5}$$

a_m is the age-at-maturity (the convention of referring to the mature population is used here, although this actually refers to animals that have reached the age of first parturition); $b_t^{i,j}$ is the probability of birth/calf survival for mature females:

$$b_t^{i,j} = \max(0, b_K\{1 + A^{i,j}(1 - F(I, j, t))\}) \tag{2.6}$$

b_K is the average number of live births per year per mature female at carrying capacity; and $A^{i,j}$ is the resilience parameter for substock *j* of stock *i*.

Immigration (dispersal)

The numbers dispersing into sub-stock *j* of stock *i*, include contributions from pulse migration as well as diffusive dispersal:

$$\begin{aligned} I_{t,a}^{s,j,i} = {} & \sum_k \delta^{k,j,i} \tilde{N}_{t,a}^{s,i,k} - \sum_k \delta^{j,k,i} \tilde{N}_{t,a}^{s,i,j} + \\ & \sum_{k \neq j} \Omega_y^{k,j,i} \frac{\tilde{N}_{t,a}^{s,i,k}}{\sum_{a=1}^{x} (\tilde{N}_{t,a}^{m,i,k} + \tilde{N}_{t,a}^{f,i,k})} - \sum_{k \neq j} \Omega_y^{j,k,i} \frac{\tilde{N}_{t,a}^{s,i,j}}{\sum_{a=1}^{x} (\tilde{N}_{t,a}^{m,i,j} + \tilde{N}_{t,a}^{f,i,j})} - \end{aligned} \tag{3.1}$$

where $\delta^{k,j,i}$ is the rate of dispersal from sub-stock *k* to sub-stock *j* of stock *i*; $\Omega_y^{k,j,i}$ is the number of animals which disperse in year *y* from sub-stock *k* to sub-stock *j* of stock *i* in a pulse; and $\tilde{N}_{t,a}^{s,i,k} = (N_{t,a}^{s,i,k} - C_{t,a}^{s,i,k})\, S_a$.

Anthropogenic~~genetic~~ removals

The catch by stock / sub-stock is generally determined by apportioning the catches by fleet[5], taking account of mixing (i.e. exposure to harvesting) matrices, according to:

$$C_{t,a}^{m/f,i,j} = \sum_k C_t^{m/f,k} \frac{\alpha_a^k X^{A_k,i,j} N_{t,a}^{m/f,i,j}}{\sum_{i,j,a} \alpha_a^k X^{A_k,i,j} N_{t,a}^{m/f,i,j}} \tag{4.1}$$

---

[4] It is usually the case that $\sum X^{A,i,j} = 1$. However, for the gray whales, this is not necessarily the case because catches can take place in the various sub-areas at different times. What is then important is the relative values of the $X^{A,i,j}$ among stocks and sub-stocks for a given feeding ground.

[5] A fleet is the combination of a fishery sector (commercial / aboriginal) and the sub-area in which the catch is taken.

where $C_t^{m/f,k}$ is the catch of males/females caught by fleet *k* during year *t*; A_k is the sub-area in which fleet *k* operates; and α_a^k is the relative vulnerability of animals of age *a* to harvest to the fleets which operate in sub-area *k*.

The incidental catches by sub-area are computed using the equation:

$$C_y^{\mathrm{I},A} = \begin{cases} \left\{1-\tfrac{0.5}{69}[1999-y]\right\}\bar{C}^{I.A} & \text{if } y \le 1999 \\ \bar{C}^{I,A} N_y^{1+,A} / N_{1999}^{1+,A} & \text{otherwise} \end{cases} \tag{4.2}$$

where $C_y^{\mathrm{I}/s,A}$ is the incidental catch of animals of sex *s* in sub-area *A* during year *y*; and $\bar{C}^{I.A}$ is the mean catch in sub-area *A* (see Table 1). The incidental catches are allocated to stock using the formula:

Commented [JS2]: Table 1 has a couple of errors. First it lumps all SE whale mortality together instead of separating by season and then later we see that all of the mortality is assigned the summer rate.

The other error is that California mortalities are flip-flopped for migratory and feeding season.

$$C_{t,a}^{I,m/f,i,j} = \sum_A C_t^{I,A} \frac{\tilde{\alpha}_a X^{A,i,j} N_{t,a}^{m/f,i,j}}{\sum\limits_{i,j,a} \tilde{\alpha}_a X^{A,i,j} N_{t,a}^{m/f,i,j}} \tag{4.3}$$

where the selectivity pattern for incidental catches $\tilde{\alpha}_a$ is 1 for all ages (Weller *et al.*, 2008).

Initializing the parameter vector

The numbers at age in the pristine population are given by:

$$\begin{aligned} N_{-\infty,a}^{m/f,i,j} &= 0.5\, N_{-\infty,0}^{i,j} \prod_{a'=0}^{a-1} S_{a'} && \text{if } a < x \\ N_{-\infty,x}^{m/f,i,j} &= 0.5\, N_{-\infty,0}^{i,j} \prod_{a'=0}^{x-1} S_{a'} / (1-S_x) && \text{if } a = x \end{aligned} \tag{5.1}$$

The value for $N_{-\infty,0}^{i,j}$ is determined from the value for the pre-exploitation size of the 1+ component of sub-stock *j* of stock *i* using the equation:

$$N_{-\infty,0}^{m,i,j} = K^{1+,i,j} / \left(\sum_{a=1}^{x-1} \left(\prod_{a'=0}^{a-1} S_{a'} \right) + \frac{1}{1-S_x} \prod_{a'=0}^{x-1} S_{a'} \right) \tag{5.2}$$

where $K^{1+,i,j}$ is the carrying capacity (in terms of the 1+ population size size) for sub-stock *j* of stock *i*:

$$K_t^{1+,i,j} = \sum_{a=1}^{x} (N_{-\infty,a}^{m,i,j} + N_{-\infty,a}^{f,i,j}) \tag{5.3}$$

$N_{-\infty,a}^{m/f,i,j}$ is the number of animals of age *a* that would be in sub-stock *j* of stock *i* in the pristine population.

The model is based on the assumption that the age-structure at the start of year τ is stable rather than that the population was at its pre-exploitation equilibrium size at some much earlier year. The determination of the age-structure at the start of year τ involves specifying the effective 'rate of increase', γ, that applies to each age-class. There are two components contributing to γ, one relating to the overall population rate of increase (γ^+) and the other to the exploitation rate. Under the assumption of knife-edge recruitment to the fishery at age a_r, only the γ^+ component (assumed to be zero following Punt and Butterworth [2002]) applies to ages

a of a_r or less. The number of animals of age a at the start of year τ relative to the number of calves at that time, $N^*_{\tau,a}$, is therefore given by the equation:

$$N^*_{\tau,a} = \begin{cases} 1 & \text{if } a = 0 \\ N^*_{\tau,a-1} S_{a-1} & \text{if } a \le a_r \\ N^*_{\tau,a-1} S_{a-1}(1-\gamma) & \text{if } a_r < a < x \\ N^*_{\tau,x-1} S_{x-1}(1-\gamma)/(1-S_x(1-\gamma)) & \text{if } a = x \end{cases} \tag{5.4}$$

where B_τ is the number of calves in year τ and is derived directly from equations 2.1 and 2.6.

$$B_\tau = \left(1 - \left[1/(N^f_\tau b_K) - 1\right]/A\right)^{1/z} \frac{K^{1+}}{N^{1+,*}_\tau} \tag{5.5}$$

The effective rate of increase, γ, is selected so that if the population dynamics model is projected from year τ to a year Ψ, the size of the 1+ component of the population in a reference year Ψ equals a value, P_Ψ.

Likelihood function

Under the assumption that the estimates of abundance for a sub-area are log-normally distributed, the negative of the logarithm of the likelihood function is given by:

$$-\ell nL = \ell n\sqrt{\text{Det}[V]} + 0.5\sum_k (\ell\,\text{n}\,\underline{N}^{A,obs} - \ell\,\text{n}\,\underline{N}^{A})[V^{-1}](\ell\,\text{n}\,\underline{N}^{A,obs} - \ell\,\text{n}\,\underline{N}^{A})^T \tag{6.1}$$

where $N_t^{A,\text{obs}}$ is survey estimate of abundance for sub-area A during year t; and V is the sum of the variance-covariance matrix for the abundance estimates plus an additional variance term (assumed to be independent of year).

The data on the proportion of each stock in each sub-area is modelled under the assumption that the proportions are normally distributed, i.e.:

$$-\ell nL = \sum_i \sum_A \sum_t \tfrac{1}{2(\tau_t^{i,A})^2}(p_t^{i,A} - p_t^{i,A,\text{obs}})^2 \tag{6.2}$$

where $p_t^{i,A}$ is the model-estimate of the proportion of the animals in sub-area A which are from stock i; $p_t^{i,A,\text{obs}}$ is the observed proportion of animals in in sub-area A which are from stock I; and $\tau_t^{i,A}$ is the standard error of $p_t^{i,A,\text{obs}}$.

Quantification of uncertainty

Uncertainty can be quantified in various ways. For the purposes of the analyses of this report, the uncertainty of the model predictions for a scenario (choices for the stock structure hypothesis, MSYR, etc.) is quantified by bootstrapping. This involved generating pseudo abundance estimates from distributions with means given by the actual data and variance-covariance matrix V (with the values for the additional variance parameters set to those obtained by fitting the model to the actual estimates of abundance).

EXAMPLE APPLICATION

Stocks and spatial structure

The example application is based on the conceptual model of gray whales outlined in Fig. 1. There are two stocks (‘Asian’ and ‘Eastern’) for the example application, with the ‘eastern’ stock divided into three sub-stocks (‘Sakhalin’, ‘North’ and ‘PCFG’). There are eight feeding grounds (‘West of Kamchatka’, ‘Sakhalin’, ‘Kamchatka-East’, ‘Northern Bering Sea / South Chukchi’, ‘North Chukchi’, ‘Gulf of Alaska’, and ‘PCFG’), there are three migration corridors (Japan, Korea and California), and there are two wintering grounds (Asia and Mexico). The feeding grounds, migration corridors, and wintering grounds are the sub-areas for the model.

For this hypothesis, the ‘Northern Bering Sea / South Chukchi’ and ‘North Chukchi’ feeding grounds are combined into a single feeding ground (sub-area), denoted the ‘North’ feeding ground, while the Japanese and Korean migration corridors are also merged into a single ‘Japan/Korea/China’ migration corridor. Two of the feeding grounds ‘PCFG’ and ‘California’ are divided seasonally [Jun-Dec; Jan – May] because of differences in rates of incidental catch, combined with differences of the relative vulnerability of the various stocks and sub-stocks at this time. There are two fleets in the ‘North’ feeding ground to allow for historical commercial and aboriginal catches. An extra sub-area (Calif-3) is added to the model to enable it to be fitted to the estimates of absolute abundance under the assumption that all animals passing through California are subject to being counted with equal probability.

Commented [JS3]: I know it adds another parameter, but I think it would be good to separate SE Alaska mortality in the migratory and feeding season since they are different rates.

Parameterization

Catastrophic mortality is assumed to be zero (i.e., $\tilde{S}_t^{i,j}$ =1) except for the North sub-stock for 1999 and 2000 when it is assumed to be equal to the parameter $\tilde{S}$ (IWC, 2013). This assumption reflects the large number of dead gray whales observed stranded along the coasts of Oregon and Washington during 1999 and 2000 relative to the number stranded there in other years with data (Brownell *et al.*, 2007; Gulland *et al.*, 2005). The catastrophic mortality in 1999 and 2000 is assumed to have only impacted the North sub-stock because the abundance estimates for the PCFG and Sakhalin sub-stocks increased when the catastrophic mortality occurred, in contrast to those for the North sub-stock which declined substantially. Immigration occurs only between the North sub-stock and the PCFG sub-stock, and only animals aged 1+ immigrate. Allowance is also made for a pulse dispersal of 20 animals from the North sub-stock to the PCFG sub-stock in each of the years 1999 and 2000 (IWC, 2013).

Commented [JS4]: Your assumption here reads that females with calves would not use a different feeding area and that calves after they have weaned will not explore into a new feeding area during their first summer feeding season. I don’t know if this is true. In Calambokidis et al 2012 they note the observations of PCFG females with calves at the Channel Islands and the fact that neither the female or her calves were seen again in the PCFG that year. We also know that the phase II migration is last and females with calves are observed in the PCFG migrating slowly up the coast in early June. If they find good feeding what prevents them from recruiting into the PCFG?

The parameters of the population dynamics model are the carrying capacities of each stock, the proportion which each stock is at the start of the first year considered in the model (τ=1930), the intrinsic rate of growth of each stock, the survival rates for the North sub-stock in 1999 and 2000 (assumed to be the same), the dispersal rate between the North and PCFG sub-stocks, the relative vulnerability of PCFG as compared to other ~~whales~~sub-stocks in Southeast Alaska, the PCFG area in Dec-May (the migratory period)[6], and in California, and the additional variance parameters for each time-series of abundance estimates. There are in total 17 estimable parameters.

Commented [JS5]:

The value for the degree of compensation parameter is set to 2.39 (which corresponds approximately to MSYL occurring at 60% of carrying capacity) and MSYR is assumed to be 3.5%. For ease of parameterization, the numbers of animals dispersing from the ‘north’ and PCFG sub-stocks to the ‘Sakhalin’ sub-stock is assumed to be zero.

Two scenarios regarding the proportion of Sakhalin animals found in the Japan/Korea/China area are considered (0.2 and 0.1).

Data utilized

Table 3 (available as a spreadsheet) lists the historical catch data by sex, year, and area based on IWC (2011, 2013), Bradford (2003) and input from members of the Steering Group. Table 4 lists the abundance estimates for the Sakhalin, California and PCFG feeding grounds. The

Commented [JS6]: Table 2 is not referenced in text. It would be helpful if it were referenced to help reader understand it.

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[6] All PCFG sub-area catches during June-November are assumed to be from the PCFG sub-stock. See table 2 for the catch mixing matrices.

1998 estimate for the PCFG feeding ground is considered to be biased and is consequently ignored. Table 5 summarizes the mixing proportion data on which the analyses are based.

RESULTS AND DISCUSSION

Results of preliminary analyses

Figures 2 and 3 show the fits of the model to the abundance estimates. The model is able to capture the trends in abundance adequately when the mixing proportion of Sakhalin animals in the Japan/Korea/China migration corridor is assumed to be 0.2 (Fig. 3), but the fit to the abundance estimates for the PCFG feeding ground are misspecified when this mixing proportion is 0.1. The extent of additional variation (expressed as standard errors of logs) obtained by fitting the operating model to the actual data (the base model) is 0.054/0.052 (Sakhalin series), 0.088/0.081 (Southern California series), and < 0.02 (PCFG series) for the two choices for the mixing rates of Sakhalin animals in the Japan/Korea/China area. The model predicted proportions in the Japan/Korea/China area are 0.55 and 0.44 (0.2 mixing proportion for Sakhalin whales in the Japan/Korea/China area) and 0.68 and 0.31 (0.1 mixing proportion for Sakhalin whales in the Japan/Korea/China area) for observed proportions of 1 and 0 Sakhalin animals. The base model predictions of the proportion of PCFG whales in southeast Alaska, the PCFG sub-area (Dec-May), and California (June-Nov, Dec-May) is 0.57, 0.30, 0.27, and 0.19 respectively (0.2 mixing proportion) and 0.55, 0.27, 0.25 and 0.15 respectively (0.1 mixing proportion). These values match the data used for conditioning (0.57, 0.36, 0.30 and 0.09) adequately give the assumed standard deviation of 0.1 (Table 5).

Commented [JS7]: I cannot understand the mechanics of the model. Why would PCFG abundance series change if mixing in the Japan Corridor changes from 0.1 to 0.2. I had thought that this would be coming from either ENP whales or Sakhalin whales based on the proportions but would have no influence on PCFG. Does the mixing proportion used also affect the migration rate of ENP and PCFG whales?

The time-trajectories of abundance by stock are sometimes sensitive to the value of the mixing proportion of Sakhalin whales in the Japan-Korea area (Figs 4 and 5). Specifically, the Asian stock is a higher fraction of its initial size if the probability of the Sahkalin sub-stock being in Japan / Korea is 0.2. However, the fits to the Sakhalin abundance series is clearly mis-specified. This mis-specification can be addressed by increasing the MSY rate from 3.5%, but in the interests of simplicity, the results of this paper are based on a common MSY rate across stocks.

The stocks are estimated to be well below their (current) carrying capacities when the mixing proportion for Sakhalin whales in the Japan/Korea/China area is 0.2, with the Asian and Sakhalin stocks approximately 10% of their carrying capacities and the North and PCFG sub-stocks approximately half of theirs (Fig. 5). Note that the model does not have direct information on carrying capacity for the Sakhalin and North sub-stocks because neither of the associated abundance time-series provide strong evidence for a reduction in growth rate over time. The abundance data for the PCFG sub-area is stable. However, the model (which includes dispersal from the North to PCFG sub-stocks) suggests an increasing trend. In principle, model runs could be conducted in which the carrying capacity of the PCFG stock is set to approximately 200 1+ animals.

In contrast to the outcomes from the model in which the mixing proportion for Sakhalin whales in the Japan/Korea/China area is 0.2, setting the mixing rate to 0.1 leads to unrealistic estimates of the trend in abundance in the PCFG feeding ground. This may be due to convergence to a local minimum of the objective and hence requires further investigation.

Next steps

Several of the data inputs are preliminary. Specifically, it is necessary to finalize the catch series, update the survey estimates of abundance to include the variance covariance matrices for the abundance estimates for the Sakhalin feeding ground and the recent surveys off California. The mixing proportions should be updated to reflect ~~telemetry~~ photo-identification data and other catches of known stock animals off Asia. The underlying data on mixing should be reanalysed to provide appropriate values for standard errors.

Once the data have been finalized, allowance should be made for uncertainty regarding the mixing proportions when constructing the bootstrap data sets, and the model applied to all of the stock structure hypotheses. Finally, scenarios should be developed to examine the impact of anthropogenic impacts of gray whales across their range.

ACKNOWLEDGEMENTS

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Table 1

Average historical ~~western~~ ENP incidental catches 2008-2012 (J. Scordino, pers. commn).

Stratum	Average incidental catch
North	0.15
Southeast Alaska	0.70
PCFG [Dec – May]	1.10
PCFG [Jun – Nov]	1.55
California [Dec – May]	1.20
California [Jun – Nov]	3.65

Commented [JS8]: Why not put (Scordino et al. 2014)?

Commented [JS9]: The average incidental catch for SE AK was 0.55 June-Nov and 0.15 Dec-May. Availability in SE AK was 0.57 June-Nov and could not be calculated during migration but could be informed by relative proportion of populations.

Commented [JS10]: You have your incidental catch switched by season for California. It should be 3.65 Dec-May and 1.20 Jun-Nov. This is enough difference in mortality that it may affect the performance of model if it is also backwards in the code.

Table 2

The catch mixing matrices for the example application. Allocation to sub-stocks is pre-specified, and depends for the PCFG sub-area on time of the year. The γs denote the estimable parameters of the catch mixing matrix. Note that the ‘Calif-3’ area is included so that the surveys cover all of the PCFG, Sakhalin and north stocks.

Stock /	Sub-area / season												
Sub-stock	Asia	Japan-Korea-China	Kamchatka-West	Sakhalin	Kamchatka-East	North	Southeast Alaska	PCFG (June – Nov)	PCFG (Dec– May)	California (June – Nov)	California (Dec – May)	Calif-3	Mexico
Western	1	1	1										
Eastern													
Sakhalin		0.1 /0.2[a]		1	1				1	1	1	1	1
North					1	1	1		1	1	1	1	1
PCFG							γ_1	1	γ_2	γ_3	γ_4	1	1

a – meant to capture the “occasional” migration to Japan / Korea/China

Commented [JS11]: This table is not referenced in the text to give reader perspective on what stages of the analysis the matrix is used.

Commented [JS12]: This looks like you are assuming whales in Japan are always either WNP or Sakhalin whales. Weren’t we also evaluating that the whales seen south of Japan in Asia are ‘wondering’ ENP whales like the whales in the Atlantic? The schematic in fig 1 shows wondering whales.

Table 4a

Indices of 1+ abundance for the Sakhalin sub-area [From Cooke, to come] (J.G. Cooke, pers. comm.~~n~~)

Year	Estimate	CV
1995	64	0.041
1996	66.9	0.035
1997	72.9	0.024
1998	76.4	0.017
1999	84.4	0.011
2000	85.8	0.009
2001	91.4	0.006
2002	96.8	0.005
2003	104.3	0.005
2004	114	0.006
2005	119.2	0.006
2006	125.2	0.007
2007	126.8	0.008
2008	128.4	0.01
2009	128.9	0.011
2010	133.9	0.012
2011	137.8	0.013
2012	149.4	0.019

Table 4b

Estimates of absolute abundance (with associated standard errors) for the eastern North Pacific stock of gray whales based on shore counts (source: 1967/78-2006/07: Laake *et al*, 2012; 2006/07-2010/11: Durban *et al*, 2013).

Year	Estimate	CV	Year	Estimate	CV
1967/68	13426	0.094	1985/86	22921	0.081
1968/69	14548	0.080	1987/88	26916	0.058
1969/70	14553	0.083	1992/93	15762	0.067
1970/71	12771	0.081	1993/94	20103	0.055
1971/72	11079	0.092	1995/96	20944	0.061
1972/73	17365	0.079	1997/98	21135	0.068
1973/74	17375	0.082	2000/01	16369	0.061
1974/75	15290	0.084	2001/02	16033	0.069
1975/76	17564	0.086	2006/07	19126	0.071
1976/77	18377	0.080	2006/07	20750	0.060
1977/78	19538	0.088	2007/08	17820	0.054
1978/79	15384	0.080	2009/10	21210	0.046
1979/80	19763	0.083	2010/11	20990	0.044
1984/85	23499	0.089			

Table 4c

Estimates of absolute abundance (with associated CVs) for 41°-52°N (the PCFG sub-area) (source: J. Laake, pers. commn).

Year	Estimate	CV	Year	Estimate	CV
1998	126	0.086	2006	200	0.106
1999	147	0.102	2007	193	0.133
2000	149	0.101	2008	207	0.088
2001	181	0.077	2009	206	0.098
2002	198	0.064	2010	194	0.094
2003	210	0.086	2011	197	0.080
2004	218	0.078	2012	209	0.073
2005	218	0.120			

Table 5
Data on mixing proportions. The standard errors are assumed (Sources: Japan: Amanda Bradford; others: Jonathan Scordino)

Area	Year	Stock 1	Stock 2	Estimate (SD)
Japan	2007	Sakhalin	Asia	1 (0.1)
Japan	2012	Asia	Sakhalin	1 (0.1)
Southeast Alaska	2012	PCFG	North	0.57 (0.1)
PCFG (Dec-May)	2012	PCFG	North	0.36 (0.1)
California (Jun-Nov)	2012	PCFG	North	0.30 (0.1)
California (Dec-May)	2012	PCFG	North	0.09 (0.1)

Commented [JS13]: Andre, I am betting that it complicates the model a bit, but mortality does occur in SE Alaska during the migratory season. We do not have a known mixing proportion for SE Alaska during the migratory season. In the paper I wrote I set the migratory season as 0.01 PCFG and 0.99 ENP. In the paper I reported 0.75 mortalities during the time period of 2008-2012.

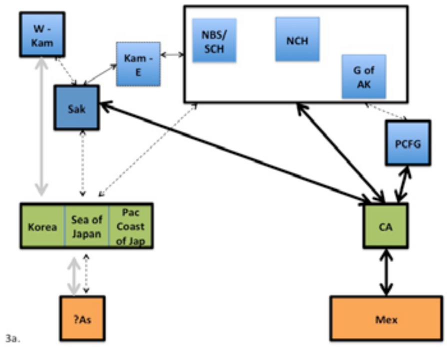

Figure 1. Conceptual overview of the stock-structure hypothesis being modelled (Model 3a of IWC [2014], “Two breeding stocks (Asia and Mexico) may exist, although the Asian stock, which included whales that feed west of the Kamchatka Peninsula in the Okhotsk Sea and utilized migratory routes and wintering grounds in the WNP, may have been extirpated. The Mexico stock includes three feeding sub-stocks: PCFG, NBS/SCH-NCH-G of AK, and Sakhalin. The whales that feed off eastern Kamchatka are a mixed-stock aggregation including whales from both the Sakhalin and Northern feeding sub-stocks. Occasional movements of whales occur between 1) Sakhalin and the feeding region (W-Kam), migratory routes, and wintering grounds of the potentially extirpated Asian stock, 2) the Northern feeding area and the Asian migratory routes and wintering grounds, and 3) the PCFG and the Northern feeding region”).

Commented [JS14]: There are two different areas reported here. One is for the Gulf of Alaska in this conceptual model and the above is for Southeast Alaska. Southeast Alaska estimates are not informed by surveys around Kodiak Island which I assume the Gulf of Alaska would be. Would it be best to make an availability based on SE Alaska and Kodiak surveys together for Alaska south of the Aleutians?

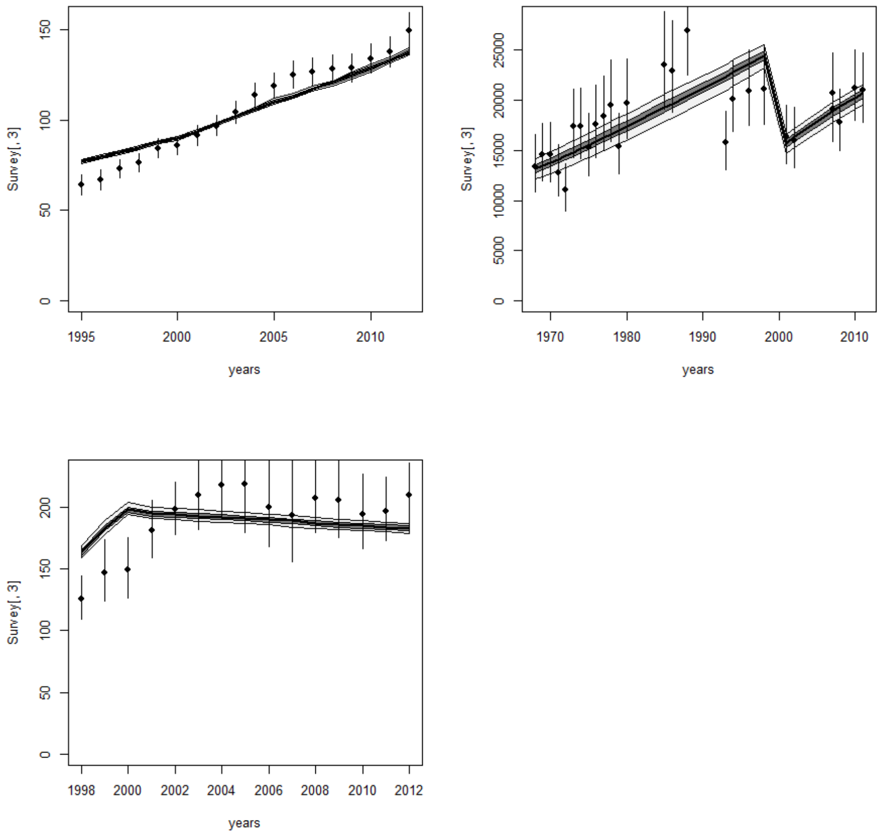

Figure 2. Fit of the population dynamics model to abundance estimate for the case in which the mixing fraction of Sakhalin animals in the Japan/Korea/China sub-area is assumed to be 0.1.

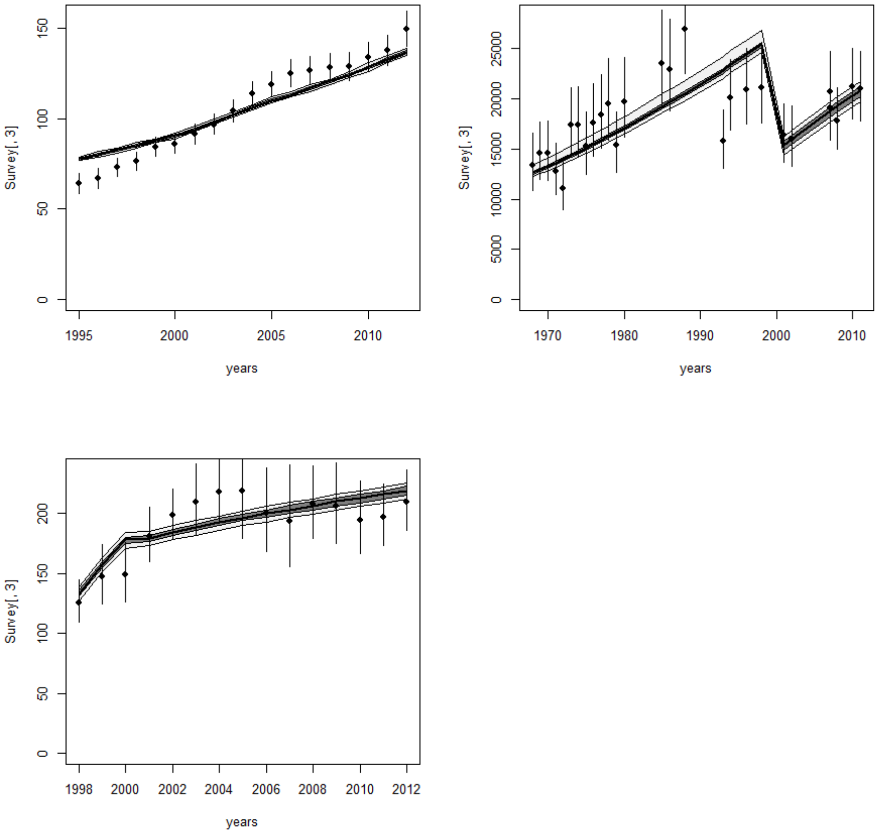

Figure 3. Fit of the population dynamics model to abundance estimate for the case in which the mixing fraction of Sakhalin animals in the Japan/Korea/China sub-area is assumed to be 0.2.

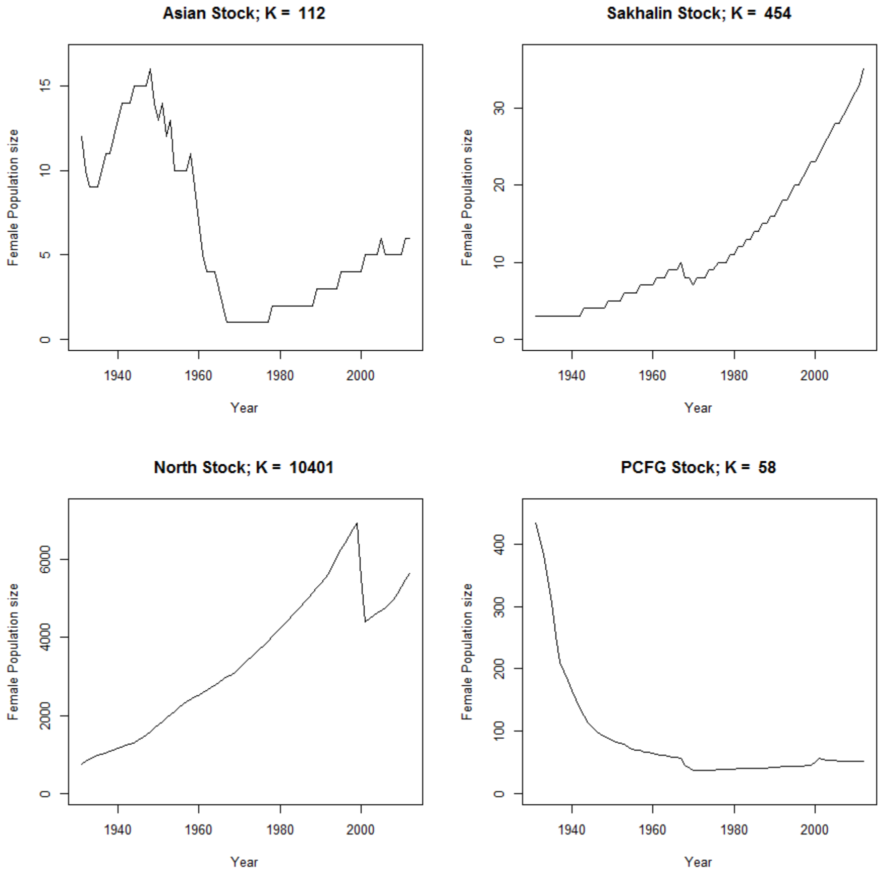

Figure 4. Time-trajectories of number by stock / sub-stock for the case in which the mixing fraction of Sakhalin animals in the Japan/Korea/China sub-area is assumed to be 0.1.

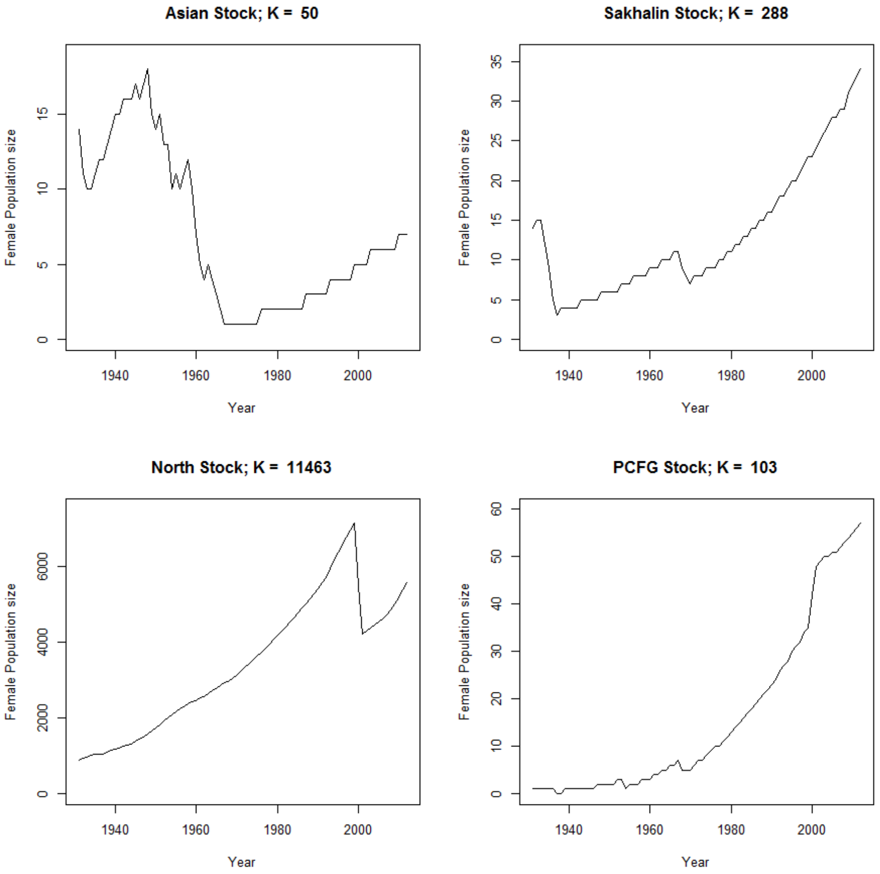

Figure 5. Time-trajectories of number by stock / sub-stock for the case in which the mixing fraction of Sakhalin animals in the Japan/Korea/China sub-area is assumed to be 0.2.

Killing efficiency in the Icelandic fin whale hunt 2014

Report to the Directorate of Fisheries in Iceland, February 19, 2015

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Background and brief summary of results

Survival time (ST), Time to death (TTD) and Instantaneous death rate (IDR) are terms that are used to measure and quantify the killing efficiency or standard of killing methods and practices used in whaling operations (Øen 1995). Sampling and analysis of ST and TTD data in a standardised manner make it possible to compare the killing efficiency of different hunting practices and hunting gears and also measure the impact of developments, changes in hunting practices and training of hunters etc.

A NAMMCO Expert Group Meeting in 2010 to assess TTD data and results from whale hunts (NAMMCO 2010) recommended sampling of TTD data from several hunts, including the Icelandic hunt of fin whales (*Balaneoptera physalus*) with the aim to compare and evaluate the killing efficiency of hunting methods and identify possible improvements and implementation of these in the hunt. NAMMCO recommended that data of TTD should be collected and analysed with covariates (animal size, shooting distance and angle of harpoon cannon shot, hit region and detonation area) like it had been done for more than 5000 minke whales (*Balaenoptera acutorostrata*) in Norway during 1981-2002 (Øen 1995, 2003).

To follow up these recommendations the Directorate of Fisheries in Iceland engaged the author of this report to organize the sampling of TTD data from the Icelandic fin whale hunt in 2014 and also to process and organise the analysis of the data in compliance with the NAMMCO recommendations.

In 2014 TTD data was sampled from 50 fin whales caught from two vessels. The results show that 84% of the whales had died instantly. The whales were killed with 90 mm Kongsberg harpoon canons and Whale Grenade-99 modified with 100 g of pressed penthrite as explosive. Grenade detonation in the thorax (chest), in or at the thoracic spine, neck or brain resulted in 100% instant death. This is superior to the results recorded from hunts using black powder grenades and also for most other hunts of whales where TTD has been recorded. Also the penthrite grenade has shown to be far more reliable in function and safer in use than grenades with black powder as explosive that had been used earlier.

Work to improve the killing efficiency in the Icelandic fin whale hunt 1985-2013

Development work to improve the killing efficiency in the hunt of fin whale in Iceland has been an on going process initiated and financed by the company Hvalur hf since 1985.

The hunt in 2014 was carried out using 90 mm Kongsberg harpoon canon and a new harpoon grenade designed to trigger the detonation of 100 g of the explosive penthrite (PETN) at a depth of 110 cm after penetration into the whale. The development of the grenade, which was concluded in 2013 replaced "The Black Powder Grenade" with 650 g of black powder as explosive, a type of grenade that has been used for large whales for at least 70-80 years.

Fin whale hunting using black powder grenade

Black powder belongs to the so-called primary explosives. These explosives are very sensitive in nature and can be brought to explode by external heat, pressure, friction, mechanical shock or electric sparks. If it gets wet it will misfire. Black powder also contains sulphur, which smells and affects taste and causes waste of meat. The black powder used in whale grenades is packed in a cast iron casing that splits up (fragments) into small and larger pieces upon detonation. The whales are killed of a combination of the blow and the splints from the iron casing. The wounding and killing efficiency of such splints is however unpredictable as it depends on which organs that are hit and if they are fatally wounded.

No systematic sampling of data regarding killing efficiency (TTD) of black powder grenades seems to be carried out except a few data sampled from the fin and sperm whale (*Physeter* macrocephalus) hunt in Iceland. Rowsell (1979) examined 16 sperm whales and three fin whales during butchering. Based on organ damages he concluded that onset of unconsciousness was rapid in eight whales, while onset of unconsciousness was slow in seven whales. Four whales had been reshot with a second harpoon. Lambertsen and Moore (1983) observed the kill and flensing (butchering) of 19 fin whales and estimated a median TTD to three minutes and the mean TTD to five minutes. No whales were recorded instantly dead but six whales were recorded unconscious instantly or within 10 seconds. The median and mean time to unconsciousness were estimated to two minutes and about 3.5 minutes, respectively. The longest survival time recorded was 16 minutes.

Development of the penthrite whale grenade for 90 mm harpoons

Secondary explosives, like penthrite (PETN), are much more stable than black powder and carry greater explosive power. Penthrite is thermally the most stable and least reactive of its category of explosives. High temperatures are needed (4 250 ˚C) to set it off and penthrite detonates even if it has become wet. Penthrite has proven to be very efficient to render whales unconscious and/or dead almost instantly by producing pulses of "shock" and pressure waves that travel spherical (in all directions) at hypersonic speed causing severe damage to vital organs. Massive lacerations, bleedings and cuts, usually occur at the detonation site, and injuries and bleeding are often found in the brain, heart, lungs and other vital organs (Øen EO, 1995; Knudsen and Øen, 2003). Consequently, there is no need for a casing that produces splints at the detonation. In addition penthrite does not affect the usefulness or taste of the meat because it does not dissolve in water, and upon detonation it breaks down into natural gases and water.

1985-1989

Experiments on 90 mm harpoon grenade technology started in Iceland in 1985 and continued to 1989 in conjunction with the Icelandic program of whale research. The experiments showed that it was possible to instantly kill a fin whale and safely use the contemporary Norwegian minke whale grenade with a charge of 22 g of penthrite fuse on 90 mm harpoons.

A prototype penthrite grenade was made using the core of the contemporary Norwegian minke whale grenade in 1986. The prototype was equipped with a casing of steel large enough to accommodate 100 g of penthrite fuse. After shooting tests at artificial targets the grenade was used for the hunt of several fin and sei whales (*Balaenoptera borealis*) from 1986 to 1989 and a few fin whales in 2006. In 1986 one member of the flensing crew sampled data on TTD for 10 fin and 16 sei whales. Based on information from the gunner on behaviour of the whales after being hit and observations at the flensing the IDR was estimated to approx. 70-80%. However, no systematic necropsy of the whales or statistical analysis of the data had been undertaken. The only firm conclusion that can be drawn from these data is that detonation of 100 g of penthrite fuse in the chest or near the spinal column in the chest or neck resulted in instant death (Øen 1986).

2009-2014

When the commercial fin whale hunt in Iceland was restarted in 2009, a new penthrite grenade, Whale Grenade–99 with 30 g of casted/pressed penthrite, had been developed and implemented in the Norwegian minke whale hunt (Øen EO, 2006). This grenade is made of aluminium. The former grenade of steel from the 1980ies that had been modified for fin whale hunt 1986 was no longer produced. The new minke whale grenade had therefore to be modified to accommodate a 100 g penthrite charge and a longer and stronger trigger line. A prototype was made and tried in the fin whale hunt in 2009 and with some minor modifications in 2010. However, in cases where the heavy 90 mm harpoon with the grenade in the tip hit hard bones it misfired due to damage of the aluminium core.

No fin whaling took place in Iceland in 2011 and 2012. Before the hunting season 2013 the prototype from 2009 was re-designed. The aluminium core was replaced with stainless steel and the nylon trigger line was replaced with a 90 cm long Dynex® braid 60 line with knot breaking strength of 425 kg. The trigger hooks were moved from the grenade core and fixed with a metal plate to the serving rope for the harpoon claws. The function of the grenade and trigger line was thoroughly tested on artificial targets before it was implemented in the hunt. Gunners and crews were informed how to safely handle and use the grenade and the gunners were instructed to aim the harpoon at the chest of the whale and from the side. Also the crews at the flensing plan were instructed how the grenade was constructed and how to safely handle grenades that were suspected for misfire (duds).

The new grenade was well received by the hunters. However, inspection of carcasses during flensing showed that the gunners often fired at the whales from a narrow angel from behind instead of from the side. Also two serious incidents of premature detonation of the grenade in front of the harpoon canon were reported. Examination of these incidents revealed that the trigger line was not sufficiently fixed and triggered the detonation when the harpoon accelerated out of the barrel. Except of the flaw with the trigger line, the grenade functioned well and needed no further modification.

Prior to the 2014 hunting season the gunners and crews attended a training course where i.a. the incidents with the trigger line and results from the 2013 trials were discussed in details in addition to issues covering safety and function of the grenade, anatomy of the fin whale with particular emphasis on position of vital organs like the central nervous system (brain, spinal column in chest and neck) and the cardiovascular system (heart, lungs and large vessels in the chest). The gunners were instructed of the importance of aiming the harpoon grenade at the chest and to hold the shot until they could fire at the whale from the side (45°-135° relative to the animal's long axis).

Electronic sights for 90 mm Kongsberg harpoon canon

Harpoon guns are traditionally equipped with fixed simple open sights that cannot be easily adjusted. Open sights generally are used where the rear sight is at significant distance from the shooter's eye. They provide minimum occlusion of the shooter's view, but at the expense of precision. Since the eye is only capable of focusing on one plane, and the rear sight, front sight, and target are all in separate planes, only one of those three planes can be in focus. The challenge to the harpoon canon gunner is therefore to keep the focus on the correct plane to allow for best sight alignment. Open sights can be replaced by telescopic sights also for harpoon canons to give an accurate aiming point. However, as bad weather and rain might disturb the view of telescopic sights the open iron sights may still be fitted alongside the other sight for back-up usage.

Different telescopic sights were studied before one was chosen for trials late in the 2014 hunting season. New open iron sights of stainless steel were made and a telescopic sight - Red Ring Holosight® (RRH) - were mounted to the open sight pole of the 90 mm Kongsberg canon and fired in at an artificial target before the new sights were implemented in the hunting. The exact result of the shooting with the new sights is not known. The trial took place too late to be included in the sampling of TTD data in 2014. Also other types of holosights may be assessed. However, the gunners claim that the new sights were very successful and they do not want to go back to use traditional open iron sights.

Sampling of TTD data and results from the 2014 season

Prior to the hunting season 2014 the data-sampling scheme that had been used for collection of TTD data for minke whales in Norway (Øen 1995, 2006) was adapted to sampling TTD data for fin whales. An experienced Norwegian veterinary officer well trained for TTD data collection after several season in the Norwegian minke whale hunt, was engaged and trained for this specific job. In addition to TTD, the behaviour of the whale after being shot, data on whale length, estimated range of shooting, the angle between the shot direction and the whale's long axis, the impact point on the whale, the detonation site, necropsy finds, grenade function and possible reshooting should be recorded.

The necropsy was given high priority and was carried out at the land station. To avoid any selection of animals, the veterinarian left the boat to do the necropsy of each carcass available, and then went out again with the first possible boat after the necropsy was finished. In cases of necropsy of whales where he had not been present on board at the killing, information of behaviour of the whales when shot and angle of shot were collected from the gunners' report schemes, available video recordings and interviews with the gunners and crews.

The time from a strike to the animal's death was recorded by using stop-watch. The time of death was recorded as recommended by The International Whaling Commission (IWC 1980), which is the moment at which cessation of flipper movement, relaxation of the mandible, or sinking without any active movement occur. In addition to these behaviour signs of death the recorded TTD should be verified through the findings of organ damage demonstrated at the autopsy. Shooting range and angle of the shot relative to the animal's long axis were estimated without instrumental aid.

Reports were received for 50 fin whales. No whales were reported lost.

The statistical analyse of sampled data was carried out by Professor Lars Walløe of The University of Oslo and the results of the survival plot (TTD) for the 50 fin whales are shown in Fig. 1. Instantaneous death was recorded for 42 whales (84 %). The whales not instantly killed (8) were reshot with penthrite grenade. The median survival time for those whales was 8 minutes with the shortest survival time of 6.5 minutes and the longest survival time of 15 minutes.

In 2014 like in 2013 the gunners have tended to shoot the whales slightly more from behind (about 135°-180° - relative to the animal's long axis) than from the recommended side position (45°-135° - relative to the animal's long axis). The analysis showed that also whales shot slightly from behind had high IDR (Fig. 2). Results from minke whaling however show that it is a significant higher risk for “poor hits”, stray shots or detonation outside the most vital areas followed by longer survival time by shots fired from the front (0°- 45°) or from behind (135°-180°) than shots fired from the side (45°-135°) (Øen 1995, 2006). Five of the eight fin whales that survived the first shot had been shot from behind or from the front.

Detonation in the chest, in or at the thoracic spine, neck or brain resulted in 100% instant death. Detonation inside the chest caused bleedings and severe damage and injuries to vital organs like heart, lungs and major blood vessels.

The recorded size/length of the whales varied from 50 to 69 feet. The shooting distance varied from 15 to 60 meter. There was a tendency that longer fin whales survived longer, and survival also increased with shooting distance. However, the differences were small and not statistically significant (8 whales). In the minke whale hunt with penthrite grenade no difference is recorded in TTD between small and larger whales, but TTD tends to increase with increased shooting range (Øen 1995).

Comments and conclusions

Results obtained from autopsy of minke whales killed with penthrite grenades show that, in addition to the direct damage the detonation inflicts on the organ or organ systems it detonates in, penthrite causes shock wave-induced acute traumatic brain injury of sufficient severity to account for an instantaneous or very rapid loss of sensibility, even when it detonates in an area remote from the skull (Knudsen and Øen, 2003).

Observations have shown that when a whale is hit and fatally wounded in vital areas by a penthrite grenade as it rises to the surface to blow it will stop swimming immediately, roll on to its back, float for a short time before sinking with slacken jaw and the flipper along side the body. In contrast, if it is fatally hit as it dives after blowing, it will pull out some of the harpoon line before stopping and sinking. If the whale does not die or loose consciousness rapidly, it usually maintains its normal position in the water and starts swimming, dives and resurfaces to blow (Øen 1995). Consequently, confirmation of death based on the behavioural signs alone cannot always be performed.

There are also cases when the IWC criteria (IWC 1980) are not met in animals that are unconscious and dead (Øen 1995). For instance, weak tail movements may be registered, or the flippers may be held at an angle for some time even if there are no signs of life. Further, when a whale rolls over on its back gravity will prevent the jaw from slacken and it will remain closed. Also studies of brains of minke whales have shown that movements definitely occur in animals with severe traumatic brain injury incompatible with a persistent sensibility or life. In some cases, whales may hold their flippers out at an angle to the body while thrashing their tails violently for a minute or two before all movements cease and the flippers relax along sides of the body. Neuropathological examinations have shown that these movements often occur in whales with severe traumatic brain injury incompatible with persistent sensibility (Øen 1995; Øen and Knudsen, 2003) and that spinal reflexes probably trigger these convulsions after motor control of the spinal cord has been lost due to damage of the higher controlling centres in the brain. For comparison, in slaughter animals the occurrence of such convulsions are considered to be a good indicator that the animal is unconscious (Blackmore and Delany, 1988).

The data from the fin whale hunts with black powder grenades are limited and incomplete. The data available show that no whales were recorded instantly dead and only six out of nineteen (31%) were recorded unconscious within 10 seconds (Lambertsen and Moore 1983). The recorded data from the hunt with penthrite grenades in 2014 show an instant death rate of 84%, which is slightly higher than recorded for minke whales (Øen 1995; 2006). A direct comparison between black powder and penthrite grenades has some weaknesses due to lack of exact data from the hunt with black powder grenades. Nevertheless, it can be concluded that the killing efficiency of the penthrite grenades used in 2014 is superior to the former black powder grenades. Also the penthrite grenade is far more reliable in function and safer to use for the hunters.

Eight out of 50 whales were not recorded instantly dead and were reshot. The detonation of the first grenade had occurred outside the thoracic area. Five of these whales had been shot from the front or from behind which gives a higher risk of detonation outside the most vital areas. The median TTD for those whales was 8 minutes, which is about the time it takes to re-load the canon, sight in and wait for the opportunity to fire. The electronic sights that were tried and will be implemented in the future hunt improves sighting and may contribute to more accurate shooting.

The videos that were used in cases where the veterinarian had not been on board during the shooting and watched the killing of the whales was helpful with regard to information on the behaviour of the whales and angle of shot. However, video recordings used alone without necropsy of the whales can only be used to make very rough estimates of the TTD.

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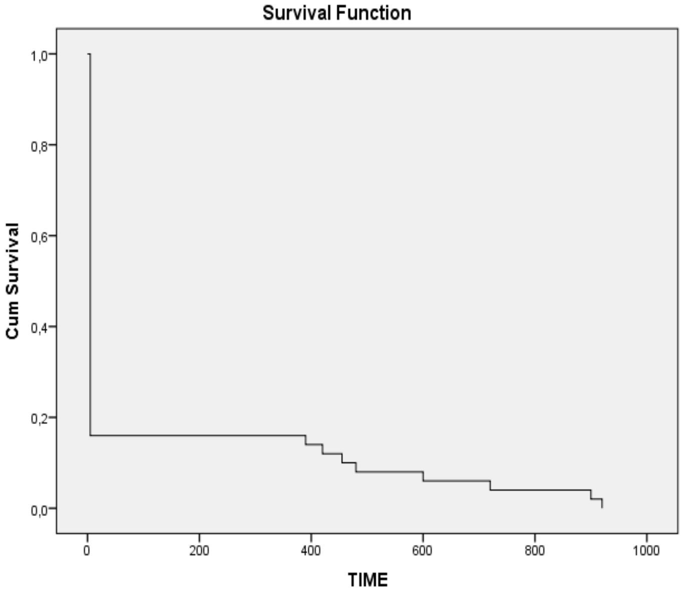

Fig. 1. Survival plot of 50 fin whales caught in Iceland 2014.
Horizontal axis: Time in seconds.
Vertical axis: proportion of whales still showing signs of life.

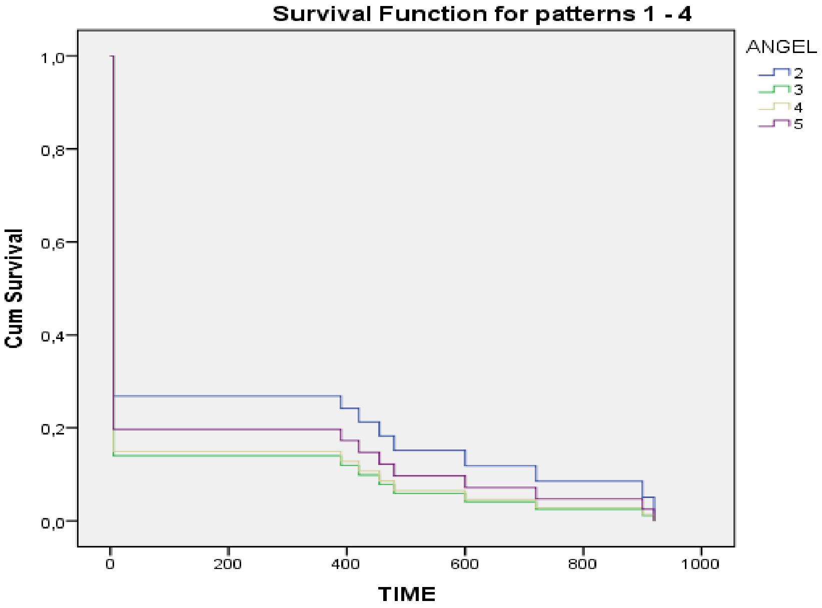

Fig. 2. Survival as function of angle for fin whales shot from different angles relative to its long axis:
2: 0°- 45°, 3: 45°-135°, 4: 135°- 180°, 5: Right from behind.
Horizontal axis: Time in seconds.
Vertical axis: proportion of whales still showing signs of life

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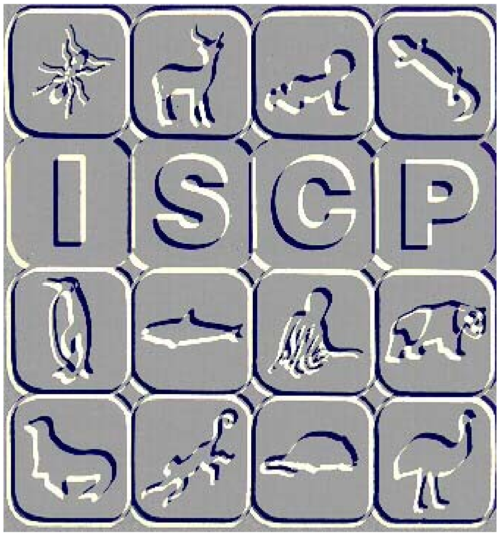

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Considerations of the Effects of Noise on Marine Mammals and other Animals

Andrew J. Wright and Lauren Highfill, ***Guest Editors***

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Noise-Related Stress and Marine Mammals: An Introduction

Andrew J. Wright and Stan Kuczaj

Marine mammals (especially cetaceans) use sound as their primary sensory input for social communication, foraging, and other vital life-processes. Background noise has the potential to interfere with these functions by masking normal sounds, and at least some noise sources have been linked to behavioral and physiological responses (with lethal and non-lethal consequences). Consequently, it is reasonable to assume that at least some acoustic sources may act as stressors (stimuli leading to a stress response) for marine mammals.

The notion that noise may act as a stressor for free-ranging marine mammals is not a new one. Several reports and reviews in both the noise and the stress literature have mentioned this possibility (e.g., Richardson et al., 1995; Fair & Becker 2000; NRC 2003, 2005; Nowacek et al., 2007). The most common conclusion in this literature is that very little is known regarding marine mammal stress responses to noise. The most common recommendation is that more data be gathered. As a result, managers have been left with little information to guide their decisions.

There are large gaps in our knowledge about the particular physiological effects that chronic, repetitive or even acute noise exposures may have on cetaceans and other marine mammals. Experiments with captive animals alone are unlikely to bridge this gap, given the ethical dilemmas that arise when one considers exposing animals to potentially harmful levels of noise. Nonetheless, we suspect that studies with captive animals will prove valuable in ascertaining the more subtle effects of noise, such as masking and interference with cognitive processing. Given the paucity of data specific to marine mammals, evidence gathered from other animal populations might constitute a baseline on which to ground hypotheses regarding the likelihood of cetaceans to experience similar stress processes.

To initiate such a transfer of information, Dokumentes des Meeres (www.sound-in-the-sea.org), as part of its ongoing project on anthropogenic noise and marine mammals, brought a number of marine mammal scientists together with a diverse range of experts from other fields to discuss the impacts of noise. The objectives of the workshop were twofold:

- to identify the potential and likely consequences of noise-induced stress for individual animals and the populations to which they belong; and
- to determine the likelihood that, and the ways in which, noise exposure may induce stress responses in marine mammals based on of what is known about the effects of noise on humans and other animals in addition to the available information for marine mammals.

These discussions are represented in two papers in this issue. The first summarizes what is known about the physiological stress response, the initiation of that response by anthropogenic noise, the importance of context (physiological, psychological and environmental) in the stress response, and the ways that noise itself can change that context (Wright et al., this issue, a). The contents of this paper are broad and it is hoped that the conclusions and findings will be of use to anyone that studies or manages any species that may be subject to disturbance by anthropogenic activities. The second paper applies to marine mammals the concepts brought together in the first, drawing on what is known about the responses of marine mammals to noise as well as other anthropogenic activities (Wright et al., this issue, b). Important contextual considerations specific to marine mammals are also discussed, and a collection of key findings and research recommendations are offered. Finally, a summary table is provided in the appendix with examples of the various known effects of stressors on an array of animals for easy comparison.

Definitions

It became clear very early on in discussions at the workshop that the disparate fields of science often used terminology in slightly, but notably, different ways. A related issue arose from the different measures of sound in air and in water, as well as conversions between the two. The latter issue is considered by Hatch & Wright (this issue), and in more detail in the references therein. However, as the discussions surrounding the terms 'stress' and 'habituation' could have lasted for the entire duration of the workshop, participants agreed to disagree, but also to adopt a set of working definitions for the purposes of the workshop.

What is stress?

Early discussions quickly revealed that participants were using the term 'stress' in a number of different ways, as discussed by Romero (2004). These included referring to:

- the threatening[1] stimuli to which an individual is exposed;
- the physiological and behavioral coping responses to those stimuli; and
- the over-stimulation of the coping responses that results in disease.

To allow for a productive dialogue the participants decided to adopt the terminology and definitions provided in Romero (2004) to distinguish between these different meanings. Consequently, we use 'stressor' to refer to a threatening stimulus, 'stress response' to refer to the various physiological and behavioral coping mechanisms, and 'chronic stress' to refer to long-term over-stimulation of coping responses. We also use the term 'stressed' (sparingly) to refer to an individual that is already experiencing a stress response that may either be chronic or acute.

The participants adopted these as working definitions while recognizing that the biomedical community itself is debating the various terminology, with the controversial concepts of 'allostasis', 'allostatic load' and 'allostatic overload' being recently proposed by McEwen & Wingfield (2003, summarized briefly below and in more detail by NRC 2005 and Romero 2004). This adoption does not represent agreement by any participant of those definitions, simply recognition that common ground would be required as we moved forward with our discussions.

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[1] Romero (2004) used 'noxious' instead of 'threatening'. However, the term noxious is often used to refer specifically to painful stimuli. Noxious stimuli will certainly provoke a stress response, but many stressors represent psychological or physiological threats in the absence of overt pain.

Allostasis

Allostasis is the maintenance of homeostasis within a changing life-cycle and environment. Animals may build up an ‘allostatic load’ when they must work harder and/or consume more to handle a normal life-history task (such as breeding or migration) or deal with some additional drain on their energy budget. When they are no longer able to fully offset the additional demands they enter a state of ‘allostatic overload’, the state in which energy requirements exceed the capacity of the animal to replace that energy from environmental resources (a ‘stressed’ state). Consequently, McEwen & Wingfield (2003) proposed that ‘stress’ only be used to refer to stimuli that require an emergency energetic response (i.e., when stimuli push the animal into a state of allostatic overload).

Allostasis does not easily consider effects without direct (if any) energetic consequences, such as loss of sleep and missed opportunity costs. As a result it is central to an ongoing debate in the biomedical world. Although this was all discussed at the workshop, the participants did not want to enter into the debate, but simply to recognize that it exists.

What is habituation?

Habituation has a specific and consistent meaning in the psychological literature: “the gradual weakening of a response to a recurring stimulus” (e.g., Domjan, 2005; Kuczaj & Xitco, 2002). Similarly, Telch, Valentiner, Ilai, Petruzzi & Hehmsoth (2000) defined physiological habituation as the “reduction of arousal that results in a disassociation between the stimulus and response propositions”. It was noted at the workshop that it is possible for overt responses to weaken without an associated reduction in physiological response. It is thus not surprising that the term “habituation” has been used in a variety of ways by those who study marine mammals, partly due to the fact that this taxonomic discipline brings together scientists with a variety of different backgrounds. Furthermore, the term “habituation” is also often invoked without reference to the literature and seemingly in conflict with the use of the term in the biomedical or psychological literature (see Bejder et al., 2006). Consequently, it has on occasion been used seemingly to demonstrate the end of impact, despite the fact that the psychological literature recognizes that habituation can be a negative consequence in itself. For example, the U.S. Minerals Management Service, Alaska Outer Continental Shelf Region (MMS Alaska OCS Region), noted in their discussion of the likely effects of the planned Oil and Gas Lease Sale 193 in the Chukchi that as “other cetaceans seem to habituate somewhat to continuous or repeated noise exposure when the noise is not associated with a harmful event, this suggests that bowheads will habituate to certain noises that they learn are nonthreatening” (MMS Alaska OCS Region 2007, pp IV-105). A precise definition or source is never offered, however it is noted in the same report that certain birds “become habituated to shipping activity… and spend the summer nesting or living nearby without apparent harm” (MMS Alaska OCS Region 2007, pp IV-196). This latter comment suggests that MMS are equating a habituated animal with one that is unaffected by further exposure to the stressor concerned.

Workshop participants were generally in disagreement with the idea that a behaviorally habituated animal is unaffected by a stressor. However, they also disagreed about which specific definition of habituation should be used. Guidance was provided by Romero (2004), who presented a definition for the related term "acclimation" as to be when an animal no longer responds physiologically in the same robust manner to repeated or chronic stressors, such as repeated handling. In acclimation, the psychological context of the stressor has effectively changed: the stimulus is no longer threatening to the animal and the physiological stress response is reduced. However, it should be noted that there are situations where a reduction in behavioral response can occur without an associated reduced physiological response, as discussed in more detail by Wright et al. (this issue, a).

Psychologists will recognize that Romero's definition of acclimation is in fact the definition of habituation (albeit focused on the physiological response), and undoubtedly wonder why acclimation was preferred to habituation. Suffice it to say that some workshop participants wished to distinguish themselves from the various perceived misuses of the term "habituation" by others, especially pertaining to the management of marine mammals, and so acclimation was viewed as a less controversial term.

An organism sometimes becomes acclimated to one stimulus but then shows sensitization to a perceivably different stimulus presented at some later time (see Domjan, 2005; Romero, 2004). The acclimation process can alter the animals' physiology such that responses to novel stressors are enhanced compared to responses of non-acclimated animals. This process is known as "sensitization" or "facilitation" and it occurs frequently, although not always, as a result of acclimation. For example, if rats exposed to repeated handling are then transferred to a novel environment their physiological stress response is higher than in naïve controls (Dallman et al., 1992). In many cases, it is the sensitized response that signals pathological consequences or acclimation to repeated exposure to a stressor (i.e., researchers look for sensitization to a novel stimulus to assess acclimation to a previous, repeated stimulus). It is important to recognize that apparently calm or other non-responsive behavior does not necessarily indicate acclimation (see Beale, this issue). In addition, acclimatizing to a stimulus (e.g., an intense sound source) may reduce the stress response, but not eliminate the potential physiological damage on, for instance, hearing. Examples of this have been seen in human behavior (see Clark & Stansfeld, this issue).

Working definitions

In light of the above, participants agreed to use the following terminology and definitions (based mostly from Romero, 2004) for the purpose of the workshop. This does not necessarily reflect the preferred usage for any individual, nor establish a position in any discussion surrounding the concepts.

Stressor: a threatening or unpredictable stimulus that causes a stress response.

Stress response: the physiological, hormonal and behavioral changes that result from exposure to a stressor.

Chronic stress: a state that an organism enters when repetitive or long-term exposure to a stressor has exceeded an organism's regulatory capacities.

Context of a stressor: the physical and psychological conditions present when a stressor appears.

Acclimation: after repeated or chronic exposure to a single stressor, an animal no longer perceives the stressor to be threatening and reduces its physiological stress response. The decrease in stress response is specific to that stressor and does not generalize to other stressors as long as the animal is capable of distinguishing between them.

Sensitization[2]: when acclimation to one stressor increases subsequent stress responses to novel stressors.

"Stress hormones": a generic and non-scientific term for hormones whose concentrations change in response to stressors and are indicative of a stress response. They are divided in two main types: catecholamines (e.g., epinephrine/adrenaline, norepinephrine/norarenaline, etc.) and glucocorticoid-steroid hormones (e.g., cortisol, corticosterone, etc.). Some hormones (e.g., cortisol) have been traditionally used as indicative of stress. However, they may exhaust under repetitive stimuli and may not reflect chronic stress.

Steroid hormones: a class of hormones (including testosterone, estradiol and cortisol) typified by a four-ring structure.

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[2] We use sensitization instead of facilitation as per Romero (2004) as this is the standard term in the psychological literature.

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Endocrinology of Stress

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When an animal detects a stressor, it initiates a stress response. The physiological aspects of this stress response are mediated through two endocrine systems. The catecholamine hormones epinephrine and norepinephrine are released from the adrenal medulla very rapidly and have numerous effects on behavior, metabolism, and the cardiovascular system. This is commonly termed the Fight-or-Flight response. On a longer time scale, the glucocorticoid hormones are released from the adrenal cortex. They interact with intracellular receptors and initiate gene transcription. This production of new proteins means that glucocorticoids have a delayed, but more sustained, effect than the catecholamines. The glucocorticoids orchestrate a wide array of responses to the stressor. They have direct effects on behavior, metabolism and energy trafficking, reproduction, growth, and the immune system. The sum total of these responses is designed to help the animal survive a short-term stressful stimulus. However, under conditions of long-term stress, the glucocorticoid-mediated effects become maladaptive and can lead to disease.

Stress, as originally coined by Selye (1946), has been the subject of study for decades. It became quickly apparent that the term “stress” actually encompasses three related topics: changes/stimuli from the environment that cause “stress” (subsequently called stressors); the physiological and psychological responses to those stimuli (subsequently called the stress response); and the diseases that result from an overstimulation of the physiological and psychological responses (subsequently called chronic stress effects). Research has focused on all three of these concepts. An enormous amount is now known about what stimuli elicit which physiological and psychological responses. We also know many of the mechanisms whereby various hormonal mediators compromise organ, tissue, and cellular function (Fink, 2007). This paper will provide a brief overview of what is known about the endocrine responses to stressors. The following general information is broadly known and widely presented. Most of the information comes from the following sources (McEwen & Goodman, 2001; Nelson, 2005; Norman & Litwack, 1997; Norris, 2007; Sapolsky, Romero, & Munck, 2000) and interested readers should consult them for more detail. Specific information and individual studies are cited independently.

Although there are many hormones that have been identified as playing a role in the vertebrate stress response, two categories of hormones are thought to form the central components of the endocrine response. These are the catecholamines, epinephrine and norepinephrine (also known as adrenalin and noradrenalin) and the glucocorticoids. Together, these hormones help to orchestrate the body’s stress response. How they do so is presented below.

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Catecholamine Responses

The catecholamines are a class of hormones consisting of a 6-carbon ring with a carbon side chain. The type of side chain determines the type of catecholamine and provides biological specificity. The two most important catecholamines in the stress response are epinephrine (Epi) and norepinephrine (Norepi). The catecholamines bind to specific membrane-bound G-protein receptors. When bound, these receptors initiate an intracellular cAMP signaling pathway that rapidly activates cellular responses. The speed at which these responses are activated provides the foundation for many of the catecholamine effects.

The suite of responses mediated by Epi and Norepi are commonly called the Fight-or-Flight response because they have immediate effects on increasing the readiness and activity of the animal. Upon detection of a stressor, Epi and Norepi are released by both the adrenal medulla and nerve terminals of the sympathetic nervous system. These hormones are produced beforehand and stored in secretory vesicles. Consequently, release of Epi and Norepi occurs rapidly after detection of a stressor. When coupled to the rapid activation of cellular processes through their receptors in target tissues, Epi and Norepi activate organism-level responses within seconds of detecting a stressor.

Epi and Norepi activate a number of responses, including: decreasing visceral activity and shutting down digestion; increasing visual acuity; increasing brain blood flow and arousal; increasing gas exchange efficiency in the lungs; breaking down glycogen to release glucose stores; inducing vasodilation in muscles; inducing vasoconstriction in the periphery; increasing heart rate; and inducing piloerection. This suite of responses comprises the classic Fight-or-Flight response and is designed to help the animal survive an acute threat such as an attack by a predator or conspecific competitor. They not only activate beneficial responses such as increasing alertness and providing energy to muscles, but also inhibit processes, such as digestion, that can be superfluous during an acute emergency.

Glucocorticoid Responses

Glucocorticoids are a class of steroid hormones consisting of a 4-ring carbon backbone with different hydroxyl groups and carbon side chains attached at various places around the rings. The particular side chain and where it is attached determines which steroid it is, and provides specificity for the various steroid receptors. All steroids share common precursors and common synthetic pathways and are interconverted, so that both the classic steroid hormones (e.g., testosterone) and their intermediates (that can also have biological activity) can be found both in tissues and in the blood. However, the primary steroids released in response to a stressor are the glucocorticoids (GCs): cortisol and corticosterone. Most species rely primarily upon either cortisol (e.g. fish and most mammals, including humans and marine mammals) or corticosterone (e.g. birds, reptiles, amphibians, and some rodents), although both can be found in most species and some species rely upon a mix of the two (e.g. some rodent species). Both hormones bind to the same receptors and appear to have identical functions in their respective species.

The release of GCs results from a hormonal cascade that begins with the detection of a stressor. Areas of the brain that interpret external and/or internal stimuli (e.g. the amygdala and hippocampus) send neuronal signals to the hypothalamus (primarily the paraventricular nucleus). The cells in the hypothalamus send axon projections to the median eminence where they terminate along capillaries of a portal blood system that connects to the anterior pituitary. Once stimulated, the hypothalamic cells release a suite of hormones into the portal blood. The most important of these hormones are corticotropin-releasing factor (CRF) and arginine vasopressin (AVP – or arginine vasotocin in non-mammalian vertebrates). (Although CRF is sometimes referred to as CRH (corticotropin releasing hormone), a recent committee addressing nomenclature proposed that CRF be adopted as the appropriate name (Hauger et al., 2003) CRF and AVP travel the short distance of the portal blood system from the base of the hypothalamus to the anterior pituitary. There they bind to receptors and stimulate the release of adrenocorticotropic hormone (ACTH). ACTH is then released into the general circulation and travels to the adrenal cortex where it binds to its receptors and stimulates the production of steroid synthetic enzymes. GCs, like all steroids, are not stored once they are produced, so there is no functional difference between ACTH-induced production of GCs, and the release of GCs into the bloodstream. Thus, the increase in production rate results in increased GCs released into the peripheral circulation. This hormonal cascade from the hypothalamus to the adrenal via the pituitary is called the Hypothalamic-Pituitary-Adrenal (HPA) axis. Although other factors, such as gonadal steroids, cytokines, and the splanchnic nerve, can also directly or indirectly modulate GC secretion, the HPA axis is the primary pathway stimulating GC release in response to a stressor.

Once released, GCs travel in the peripheral circulation primarily bound to corticosteroid binding globulins (CBG). Steroids are highly lypophilic so that most GCs are bound to CBG, but unbound GCs increase dramatically during a stress response. Whether CBG functions primarily as a carrier to deliver GCs to their target tissues, or primarily as a buffer to moderate GC function, is currently under debate (e.g. Breuner & Orchinik, 2002). Once at the target tissue, GCs pass through the outer cell membrane and bind to an intracellular cytoplasmic receptor. Activated receptors then enter the nucleus and begin acting as transcription factors. Activated receptors bind to short stretches of DNA sequences called glucocorticoid response elements and act as promoters or inhibitors of gene transcription. Consequently, the end product of GC stimulation is either the production of new proteins or the inhibition of protein production. In addition, there is evidence that a membrane-bound receptor for GCs exist. This receptor is believed to mediate rapid behavioral effects of GCs. Along with GC's effects in response to a stressor, GCs vary in a circadian rhythm and are important in regulating normal physiological processes.

In contrast to Epi and Norepi, GCs are much slower at exerting their effects. The multiple steps of the HPA axis ensure a time lag between the onset of a stressor and the increase in blood GC concentrations. In general, increases in GC concentrations cannot be detected in under 3-5 min (and occasionally longer for some species). When coupled with GCs' primary effect of altering gene transcription rates, the physiological impact of GCs begins to occur approximately 20-30 min after the onset of a stressor. If a stressor does not continue, negative feedback will generally start to reduce GC concentrations in 30-60 min, although because the newly produced proteins can continue to function, GCs' physiological effects can last considerably longer. Consequently, the catecholamines and the GCs dovetail to produce both an immediate and a longer-term response to stressors.

Although GCs alter gene transcription rates for an enormous number of genes, at the organismal level GCs can be classified as having five broad effects (Romero, 2004): increasing blood glucose concentrations; altering behavior; inhibiting growth; inhibiting reproduction; and modulating the immune system. This suite of effects is believed to help the animal recover from a stressor, shut down those systems that can profitably be delayed until the danger has passed, and prepare the animal for potential subsequent stressors. Each of these broad effects will be discussed briefly below.

The classic effect of GCs is to increase the blood glucose available to tissues involved in responding to a stressor. In fact, the name "glucocorticoids" was assigned to these hormones because of this important role, which takes two general forms. First, GCs increase blood glucose by converting protein to glycogen, thereby indirectly increasing glycogen break down into glucose by Epi and Norepi, and by stimulating the catabolism of protein to form new glucose in a process called gluconeogenesis. Second, GCs reduce the uptake of blood glucose by target tissues, resulting in higher blood glucose concentrations available to tissues involved in responding to stress. GCs do this by stimulating the internalization of glucose transport molecules from the cell surface of target tissues. Fewer glucose transporters result in less glucose utilization, the sum of which across multiple target tissues results in higher blood glucose concentrations. Tissues that need extra glucose to respond to the stressor (e.g. muscles) compensate for the GC effect and essentially have preferential access to the increased pool of blood glucose. The sum of these effects is that GCs orchestrate the allocation of energy stores during either prolonged stressors or after stressors have ended (Dallman et al., 1993).

GCs are known to alter behavior, but how they alter behavior depends upon the context in which the stressor is presented. Specific behavioral changes are difficult to predict. Although there has been an enormous amount of research on GCs' behavioral effects in the laboratory, recent research has also included studies of wild animals in their native habitats. For example, studies have shown that GCs can induce migratory activity in birds (Silverin, 1997). Depending upon the environmental context, GCs can promote a behavioral strategy of hiding and waiting out a stressor, or promote a behavioral strategy of abandoning an area and fleeing the stressor (Wingfield & Ramenofsky, 1997). The mechanisms for how GCs alter behavior are currently unknown and an active area of research, but may involve a novel membrane-bound G-protein receptor that induces rapid behavioral effects. GCs can also induce long-term behavioral changes by having a direct effect on memory formation and consolidation in the brain.

GCs inhibit growth by blocking the secretion of growth hormone from the pituitary, decreasing the sensitivity of target cells to growth hormone, and inhibiting protein synthesis (related to GC-stimulated gluconeogenesis from protein catabolism mentioned above) (Sapolsky, 1992). This is a transient effect during acute stress responses and, because growth is a long-term process, appears to have little impact on the overall growth of the animal. Prolonged exposure to GCs, however, can result in observable inhibition of growth. In humans, the syndrome is called psychosocial dwarfism (Green, Campbell, & David, 1984). Inhibition of growth is believed to be an example of GCs shifting resources away from processes that can be postponed in order to use those resources to cope with an emergency.

GCs also inhibit reproduction (Wingfield & Romero, 2001). Vertebrate reproduction is regulated with a hormonal cascade that is similar to the HPA axis. The hypothalamus releases gonadotropin releasing hormone (GnRH), which causes the pituitary to release leutenizing and follicle-stimulating hormones (LH and FSH), which in turn stimulate gamete formation and reproductive steroid production (e.g. testosterone and estradiol) by the gonads. GCs suppress this pathway in several ways: by inhibiting GnRH release, reducing pituitary sensitivity to GnRH, and reducing the sensitivity of gonads to LH. Furthermore, GCs can reorient behavior away from reproduction. Similar to the effects on growth, GCs' effects on reproduction have little impact over the short-term, but long-term stress can cause complete reproductive shutdown. Stress has even been implicated as a factor in human infertility (Homan., Davies, & Norman, 2007; Wischmann, 2003). GCs' effects on reproduction are thought to be another example of allocating resources preferentially during an emergency.

Interestingly, the reproductive system can become resistant to inhibition by GCs in some reproductive contexts. For example, if GCs allocate resources away from reproduction, and thereby reduce individual fitness (i.e. successful production of offspring), the benefit of the reproductive system ignoring the GC signal may outweigh the cost of not responding to the stressor. In semelparous species (those that breed once and then die) such as some salmon species and several Australian marsupial rodents, death occurs in all individuals (or all individuals of one sex) shortly after breeding. The proximate cause of death is extremely high levels of GCs that catabolize essential proteins (reviewed in Wingfield & Romero, 2001). Reproduction in these animals clearly continues despite elevated GCs. Furthermore, GCs do not inhibit reproduction in many short-lived species and in older individuals, and in dominant individuals in some species where the dominant individual has a limited period with access to mates (Wingfield & Sapolsky, 2003). Consequently, susceptibility to GC-induced inhibition of reproduction is highly specific depending on the importance of continuing to reproduce in the presence of stress which may vary depending upon age, sex, stage of the breeding cycle, etc.

Finally, GCs have a broad inhibitory effect on the immune system (Spencer, Kalman, & Dhabhar, 2001). This has made GCs very important clinically and they are widely prescribed as drugs. GCs have a number of effects on the immune system including: inhibiting the synthesis, release, and efficacy of cytokines (immune system proteins); inhibiting antigen presentation through reduced major histocompatibility complex (MHC) expression; reducing the activation and proliferation of T cells, B cells, and macrophages; lowering the circulating levels of lymphocytes; reducing lymphocyte chemotaxis; reducing the number of phagocytic cells at inflammation sites; stimulating atrophy of the thymus; and triggering the death of immature T and B cells. All of these effects lead to immunosuppression, especially with long-term GC exposure. There is some evidence, however, that GCs might enhance immune function in the short-term (Dhabhar, 2006; Dhabhar & McEwen, 1999). The reason GCs have such powerful immunosuppressive effects is not entirely clear, but it has been proposed as a mechanism to prevent overactivation of the immune system that could lead to autoimmune diseases.

Conclusion

The large suite of catecholamine and GC responses is believed to be essential in surviving stressors. Clearly, the lack of Epi and Norepi release, i.e. the Fight-or-Flight response, would be devastating during a predatory attack. Similarly, animals that lack GCs are unable to mount an effective stress response and quickly die (Darlington, Chew, Ha, Keil, & Dallman, 1990). All three hormones serve to orchestrate an organism's effective response to stressors in order to promote survival.

On the other hand, long-term or chronic release of these hormones can be detrimental. Repeated or constant activation of the Fight-or-Flight response can lead to cardiovascular disease. Similarly, individuals exposed to long-term or chronic GCs suffer from a number of diseases including diabetes, depression, psychosocial dwarfism, reproductive dysfunction, and immune suppression. Consequently, responses to acute stressors generally enhance fitness, but long-term exposure can decrease fitness. Clearly, successful long-term survival requires balancing acute release while minimizing chronic exposure.

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From Classic Aspects of the Stress Response to Neuroinflammation and Sickness: Implications for Individuals and Offspring

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Accumulating evidence suggests that exposure to psychological stressors leads to increased expression of pro-inflammatory cytokines and activation of inflammatory-related pathways in the central nervous system. Several logical predictions arise from these findings: (1) stressor exposure should produce changes in behavior that are reminiscent of acute illness; (2) administration of anti-inflammatory agents should ameliorate some behavioral consequences of stressor exposure; and (3) there should be convergence between anatomical and neurochemical pathways activated by stressor exposure and those involved in mitigating sickness behaviors. Importantly, these predictions have been tested in our laboratory across multiple stressor paradigms (footshock, maternal separation, and during acute alcohol withdrawal) using two species (rats and guinea pigs), suggesting that sickness may represent a more general motivational state that can be elicited by a diverse range of psychological challenges. Implications of these findings for understanding stress-related changes in behavior, mood and neuroinflammatory processes will be discussed with special reference to implications for the individual and reproductive fitness.

The concept of stress has suffered a long and contentious history with little agreement even today about what it entails (e.g., McEwen & Wingfield, 2003). The problem becomes particularly apparent when one tries to operationalize the term for scientific study, and even worse when one seeks to determine the impact of stress on individuals or populations. In its crudest form, the concept of stress can be broken down into three principle components which I will describe in some detail below, using what is known about central nervous system (CNS) regulation of the stress response as a lens through which consequences of stressor exposure might be viewed. The first component must be the evocative agent: the general construct of stress can be parsed into categorically distinct threats (often termed stressors), each of which may activate the major stress responsive systems to varying degrees. The *stress response*, therefore, becomes the second principle component and refers to the constellation of changes (behavioral, physiological, or psychological) provoked by the actual or perceived threat. Finally, the impact of stress exposure on the overall health of the organism (Component III) must in some way be a function of the stress response(s) that have been evoked by the stressor. As a result, stress-responsive systems have been studied extensively in biomedical research as core systems that mediate and/or modulate nearly all disease-related processes (whether infectious, traumatic or genetic in nature). Ecologists, on the other hand, are particularly interested in the impact of anthropogenic stressors on the welfare and reproductive fitness of diverse species. With that in mind, the goal

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of the following review is to help bridge the gap between these seemingly disparate fields.

The Classic Stress Responsive Systems

Two classic systems that are principally activated during times of stress are the sympathetic nervous system (SNS) and the hypothalamic-pituitary-adrenal (HPA) axis. Though they will be discussed categorically below, it is in fact the combined effort of the SNS and HPA axis – among other critical endocrine and neural systems – that ultimately comprise an organism's response to stress. These systems are activated rapidly in response to stressful stimuli and have a broad impact on diverse aspects of physiological functioning. Indeed, many of the delayed and/or long-term consequences of stressor exposure are set into motion as a downstream consequence of the initial SNS and HPA responses. In this regard, indirect measures of SNS activation (such as increased heart rate, blood pressure, or hyperthermia) or direct measures of SNS output (plasma concentrations of epinephrine and norepinephrine) and HPA activation (corticosteroid concentrations in plasma, tissue or excrement) are often used as an index for the severity of a stressor that has been encountered. Regardless of which measure is examined, the magnitude of the stress response is best defined as 'area under the curve' whenever possible because this measure integrates peak response with duration of stressor exposure (Barnum, Blandino Jr, & Deak, 2008; Pacak & Palkovits, 2001). Note, however, that for these measures to be useful indices of the stress response, they must be (a) assessed with respect to a known baseline or non-stressed condition in the same animal or a group of conspecifics that have been otherwise treated identically; (b) evaluated in a threatening context, since pleasurable experiences such as sexual intercourse (Bonilla-Jaime, Vazquez-Palacios, Arteaga-Silva, & Retana-Marquez, 2006), euphoria produced by drugs of abuse (Goeders & Clampitt, 2002), or anticipation of palatable food (Pecoraro, Gomez, Laugero, & Dallman, 2002) also elicit profound activation of these same physiological response systems but do not fit the intuitive mold of 'stress'; and (c) considered within the context of circadian rhythms, as corticosteroids and catecholamines both evince diurnal variation. Some caution is therefore prudent in the interpretation of physiological measures that are used to infer that a given response is a manifestation of stress.

The sympathetic nervous system is a fast-acting response to stress that can be detected within seconds of stressor onset, assuming that the onset is a punctate event (i.e., one with a clearly defined beginning and end, such as detection of a predatorial attack). In other cases, SNS activation is often described as a steadily escalating 'tone', where over the course of hours, days or months (depending on the nature of the stressor), general activity of the SNS is increased, leading to increased metabolic demand and gradual wear-and-tear on physiological systems (allostatic load) that may eventually culminate into physiological failures (allostatic overload) (McEwen & Wingfield, 2003).

Mechanistically, the vital nature of SNS responses to stress is underwritten by the redundancy evident in the system. For instance, SNS activation leads to the release of the catecholamines epinephrine and norepinephrine from sympathetic nerve terminals that innervate all organs of the body and the musculature, allowing for rapid and profound changes in whole organism physiology. Epinephrine and norepinephrine are also released from the adrenal medulla into the general circulation where it acts as an endocrine signal (i.e., affecting distal targets) that helps prolong the action of neurally-derived catecholamines. These peripheral cascades of catecholamines are regulated by autonomic structures in the CNS such as the locus ceruleus (LC), nucleus of the solitary tract (NTS), the ventrolateral medulla (VLM) and the medial amygdala. Importantly, these structures all communicate to other structures in the CNS using predominantly (though not exclusively) norepinephrine and epinephrine, and are sensitive to internal homeostatic threats (hypoxia, hypoglycemia, immune stimuli, toxin and toxicant exposure, etc). These structures (particularly the LC) receive extensive input from brain structures involved in threat perception from the forebrain, thereby regulating peripheral sympathetic outflow through descending projections that activate sympathetic chain ganglia (see Guyton & Hall, 2006) for a general overview of SNS organization and function). Together, the redundant release of catecholamines directly onto target tissues from sympathetic nerve terminals, into the general circulation and locally within the CNS produces a coordinated, whole body response to stressful stimuli.

Though activation of the hypothalamic pituitary-adrenal (HPA) axis is somewhat slower to develop (usually within 3-5 min of stressor onset), the impact of corticosteroid release from the adrenal cortex is equally profound, though on a somewhat more protracted timeline. Every nucleated cell in the body expresses corticosteroid receptors, though the relative expression of these receptors differs markedly across cell and tissue types (Spencer, Young, Choo, & McEwen, 1990) and ultimately determines organ sensitivity to corticosteroids. Corticosteroids (cortisol in humans, corticosterone in rats) are the ultimate effector of the HPA response and are the end-product of a series of hormonal secretions that are initiated by cells in the paraventricular nucleus (PVN) of the hypothalamus (Dallman et al., 1987). As a result, the hypothalamus generally, and the PVN more explicitly, receives neural input from numerous other nuclei in the CNS involved in the perception of threat (i.e., stress) and is therefore uniquely situated as a final site of integration for the stress response. From a teleological perspective, this allows diverse threats to the organism (i.e., stressors) to activate a single effector response (corticosteroid release). The stereotyped release of corticosteroids in response to diverse stressors leads to mobilization of glucose from the liver, alterations in gene expression patterns and changes in cellular metabolic activity among other far-reaching consequences, all of which ultimately promote survival in the face of diverse threats (Munck, Guyre, & Holbrook, 1984).

Sickness and Neuroinflammation as a Consequence of Stress

While SNS and HPA responses to stress occur rather quickly, these responses inandof themselves do not readily explain the diverse range of long-term consequences of stress. For instance, exposure to relatively intense stress in rodents leads to reduced food and water consumption (Deak et al., 1999a; Dess, Raizer, Chapman, & Garcia, 1988; Marti, Marti, & Armario, 1994), decreased social and sexual behavior (Retana-Marquez, Salazar, & Velazquez-Moctezuma, 1996; Short & Maier, 1993; Uphouse, Selvamani, Lincoln, Morales, & Comeaux, 2005), and reduced activity/exploration in a novel environment (Woodmansee, Silbert, & Maier, 1993). Because these changes often persist for several days following stressor termination, they cannot be explained readily at a mechanistic level by activation of the principle stress responsive systems, the SNS and HPA axis, because these responses have largely resolved by the time the behavioral adaptations emerge. It is therefore advantageous to examine physiological and behavioral processes that occur in a protracted fashion following termination of the prototypical stress responses, and these effects will be the subject of the following discussion.

When this constellation of behavioral changes is viewed from the perspective of motivation rather than as individual behavioral changes, the overall pattern of changes seems to suggest decreased propensity to engage in goal-directed behavior. For many years, the biomedical research community has likened these changes to depressive-like tendencies (Gronli et al., 2005). While this interpretation provides clarity on clinical implications of intense stressor exposure, it does little to advance our understanding of brain mechanisms underlying such widespread consequences of stress. Moreover, this interpretation would seem to violate the implicit evolutionary presumption that the stress response – and behavioral consequences that ensue – somehow act in an *adaptive* manner to promote survival.

In light of this, we prefer to view the constellation of behavioral changes observed after stressor exposure as *recuperative responses* rather than pathological ones. In doing so, it becomes immediately apparent that the collective changes in behavior observed after intense stressor exposure are strikingly similar to those observed during acute illness produced by infection, termed sickness behaviors (Hart, 1988; Kent, Bluthe, Kelley, & Dantzer, 1992a). In fact the similarities between consequences of stressor exposure and acute illness extend well beyond behavioral changes and include alterations in neurotransmitter release (A.J. Dunn & Welch, 1991), changes in cognitive function (Gibertini, Newton, Friedman, & Klein, 1995; Pugh et al., 1999), as well as changes in peripheral immune function (see Maier & Watkins, 1998 for a review). These similarities led us to propose that many behavioral consequences of stressor exposure – particularly ones indicative of a general malaise – may be aptly described as 'stress-induced sickness behaviors' (Hennessy, Deak, & Schiml-Webb, 2001). This hypothesis arose from numerous empirical findings. First of all, stress can increase the expression of pro-inflammatory cytokines in the CNS (Deak et al., 2005b; Nguyen et al., 1998), and these factors are also known to be critical for the generation of sickness behaviors precipitated by acute illness (Bluthe et al., 1999; Kent, Bluthe, Kelley, & Dantzer, 1992a; Kent et al., 1992b). Injection of lipopolysaccharide (a component of cell walls of gram negative bacteria that is often used to mimic infection) or direct administration of pro-inflammatory cytokines provokes a similar complement of behavioral changes as intense stressor exposure (Hennessy et al., 2004; Plata-Salaman & French-Mullen, 1992). Acute stress also increases expression of acute phase proteins and evokes a sustained increase in core body temperature, effects that can persist for days following stressor termination (Deak et al., 1997). Indeed, exposure to psychological stressors produces a fever response that is commonly used as a rapid and sensitive index of SNS activation (Barnum, Blandino Jr, & Deak, 2007; Oka, Oka, & Hori, 2001). Finally, and perhaps most compelling, central administration of anti-inflammatory agents can reverse many sickness-like changes provoked by stress (Hennessy et al., 2007; Milligan et al., 1998; Schiml-Webb, Deak, Greenlee, Maken, & Hennessy, 2005). Together, these data support the view that acute illness and stressor exposure produce many similar sequelae that are coordinated through common biological pathways.

In this regard, it is interesting to note that sickness responses to infection are thought to reflect a goal-directed process (i.e., a motivational state) designed to promote recuperation, not a debilitated state for the animal (Aubert, 1999; Dantzer, 2004; Hart, 1988). Evidence to support this hypothesis comes from the simple observation that sickness behaviors are more readily observed in the home cage environment of laboratory animals (i.e., a safe haven) than in a novel environment where threats are unknown. In a very clever study, it was shown that sick dams fail to rebuild their nest and retrieve pups at normal ambient temperatures, but readily do so in a cold environment that threatens her offspring (Aubert, Goodall, Dantzer, & Gheusi, 1997). Data from our own laboratory suggest that rats exhibit normal swim behavior while sick after doses of LPS that evoke a pronounced fever and increased cytokines that persist for 2-3 days (Deak, Bellamy, & Bordner, 2005a; Deak et al., 2005c). Such plasticity of behavior during times of immunological threat supports the view that sickness itself is a goal-directed, recuperative response. Our central argument, therefore, is that intense stressor exposure is followed by a similar recuperative period, mediated by common neural mechanisms.

Mechanistically, increased expression of pro-inflammatory cytokines in the CNS is likely to be the common biological mechanism that unites the consequences of stressor exposure and acute illness (Maier & Watkins, 1998). Of the many inflammatory factors that have been identified, Interleukin-1 (IL-1) appears to be particularly inducible by stress and the hypothalamus is a key structure where such changes are prevalent (Deak et al., 2005b). It is important to note, however, that not all stressors increase expression of IL-1 in the CNS. For instance, exposure of rats to simple restraint in a Plexiglas tube, brief social defeat or insulin-induced hypoglycemia had no effect on hypothalamic IL-1, while exposure to footshock, tailshock or immobilization all elicit profound increases in hypothalamic IL-1 (Deak, Bellamy, & D'Agostino, 2003; Nguyen et al., 1998; Plata-Salaman et al., 2000; Shintani, Nakaki, Kanba, Kato, & Asai, 1995). Interestingly, if simple restraint was administered in combination with a hypoglycemic challenge or on an orbital shaker, two procedures that change both the nature and intensity of the restraint experience, then increased hypothalamic IL-1 was in fact observed (Deak et al., 2005b). To the extent that increased IL-1 can be used to more broadly infer neuroinflammation, there are several potential explanations for these findings. First of all, there may be an *identifiable threshold* of stress that is necessary to provoke a neuroinflammatory response. Though stressor intensity is a notoriously difficult construct to define operationally, stressor intensity is often inferred based on the magnitude of the corticosteroid response observed (eg. Pace et al., 2005). In this regard, it is noteworthy to mention that increased hypothalamic IL-1 and plasma corticosterone concentrations bare little association if any (Barnum et al., 2008; Deak et al., 2005b).

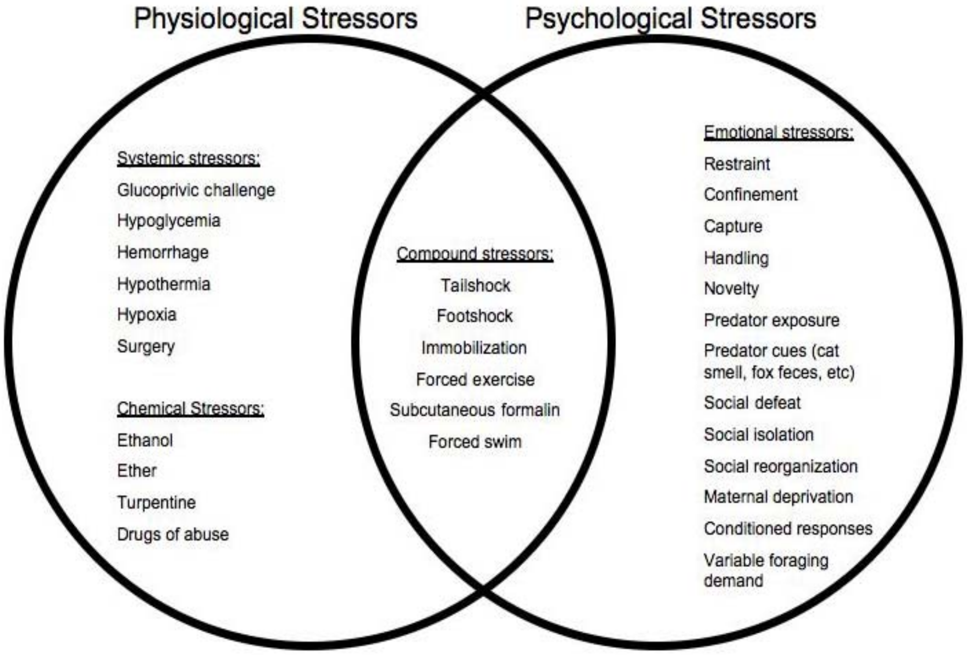

Figure 1. Venn diagrams categorizing the most commonly used stressor paradigms. Available data supports the view that most threats to mammalian species can be separated into at least two separate categories, described here as "physiological" and "psychological" stressors. Note, however, that some stressors are not readily classified into either category because the response they produce is significantly more profound than for other, more categorically distinct, stressors. To account for this, we use the term "compound stressors" to refer to stressors which fall in the overlapping portions of the Venn Diagram.

An alternative explanation for the apparent stressor-specific increases in hypothalamic IL-1 is that features of the stressors themselves are recognized in a categorically distinct fashion by the CNS and that only specific categories of stressors can activate a neuroinflammatory response. Indeed, there is general agreement among stress researchers that threats can be divided into at least two distinct categories based on the brain systems they activate (Dayas, Buller, Crane, Xu, & Day, 2001; Herman, Prewitt, & Cullinan, 1996; Sawchenko et al., 1996; Sawchenko, Li, & Ericsson, 2000). 'Psychological' stressors (also referred to as emotional, processive and neurogenic) are detected by the cognitive or perceptual apparatus of the organism and include paradigms such as restraint, novelty and predator exposure among others (see Figure 1). These stressors seem to preferentially activate forebrain and limbic structures such as the amygdala, prefrontal cortex, and hippocampus that send descending and/or lateral inputs to the PVN, thereby leading to activation of the HPA axis. 'Physiological' stressors (also referred to as physical, homeostatic or systemic), on the other hand, represent dire threats to organismic functioning. As such, physiological stress encompasses internal threats to homeostasis such as hypoglycemia, hypoxia, hemorrhage, and immune challenge. These threats are detected largely by vital regulatory centers in brainstem autonomic nuclei including the VLM and NTS. These structures provide direct noradrenergic drive to the PVN through ascending fiber tracts, thereby leading to activation of the HPA axis (Herman & Cullinan, 1997).

Interestingly, some stressors yield brain activation patterns that do not fit neatly into the psychological or physiological categories, but instead seem to uniquely activate both sets of brain structures (Dayas et al., 2001). In this regard, if emotional and physiological stressors are opposite ends of the spectrum, then some stressors may lie more centrally because they uniquely comprise characteristics of both poles. This premise is depicted in Figure 1 where Venn diagrams are used to provide an overview of the numerous stressors employed in the laboratory setting. Note that direct empirical data is not available for all of these stressors, so stressors were arranged based on intuitive similarity to other stressors and/or the common outcomes produced by them.

To the extent that stressor intensity may be reflected by activation of quantitatively greater numbers of stress-responsive brain structures, stressors that fall in the central domain (termed 'compound stressors') would be expected to produce the most severe outcomes. From a functional neuroanatomical perspective, this would be reflected by a 'compound' drive to hypothalamic structures (particularly the PVN) because drive to the PVN would arrive from brainstem structures as well as forebrain/limbic structures. It is under these circumstances that activation of a neuroinflammatory response – indicated by increased expression of IL-1 and possibly other cytokines – is most likely to occur. Initial support for this hypothesis comes from our recent work showing that exposure to restraint in combination with a hypoglycemic challenge increased IL-1 in the hypothalamus, while neither stressor alone had any effect (Deak et al., 2005b). Whether this is due to activation of both psychological (restraint) and physiological (insulin-induced hypoglycemia) stress circuits or is a synergistic response produced by direct metabolic challenge to hypothalamic neurons (produced by insulin) during an otherwise mild stressor (restraint) remains to be determined. Regardless, the dual nature of the threat led to tell-tale signs of neuroinflammation, underscoring the potential impact for individuals when faced with multiple threats (i.e., stressors) that, if encountered individually, would otherwise have little consequence. In fact, it is likely to be the synergistic interaction among diverse threats – rather than the additive or cumulative ones – that are conceptually difficult to predict, yet represent the most profound threats to the health and vitality of all species.

The next logical question becomes, How do you get from the immediate perception of threat and activation of classic stress responsive systems (SNS and HPA axis) to neuroinflammation and a sickness-like syndrome? This question becomes particularly puzzling when one considers the prominent role of corticosteroids as counter-regulators of immune processes. That is, corticosteroids are widely known for their ability to inhibit inflammatory processes and are used clinically as a therapeutic tool to rapidly supplant inflammatory processes (Munck et al., 1984). However, the doses necessary to produce anti-inflammatory effects are typically supraphysiological and there are numerous reports indicating that corticosteroids are necessary for normal progression of the immune response (Fleshner, Deak, Nguyen, Watkins, & Maier, 2002) and that lower doses of corticosteroids activate signal transduction pathways that promote inflammatory-gene expression. Indeed, there is compelling evidence that actions of corticosteroids (i.e, whether the effects are pro- or anti-inflammatory in nature) depend heavily on the tissue/cell types to which they bind (Sorrells & Sapolsky, 2007). With that said, removal of endogenous corticosteroids via adrenalectomy dramatically increases expression of IL-1 in the CNS provoked by stress (Nguyen et al., 1998; Nguyen et al., 2000), suggesting that corticosteroids constrain the development of neuroinflammation in response to stress. In contrast, the release of norepinephrine in both central nervous system structures and peripheral immune organs has been shown to increase the expression of proinflammatory cytokines (Blandino Jr, Barnum, & Deak, 2006; Johnson et al., 2005). Together, these findings suggest that neuroinflammatory consequences of stress may be mechanistically intertwined between the stimulatory actions of the SNS and the inhibitory influence of the HPA axis, though much work clearly remains to be done.

The Broader Impact of Stress-Related Neuroinflammation for Evolution and Ecology

Though the framework provided here focuses rather selectively on the ability of stress to increase pro-inflammatory cytokines in the CNS and its relationship to stress-induced sickness behaviors, the impact of cytokines and neuroinflammation extends well beyond an acute behavioral syndrome (summarized in Figure 2). Indeed, there are numerous laboratories examining the impact of neuroinflammation on cognitive function, mood, and affective disorders as well (Deak, 2007; Dunn, Swiergiel, & de Beaurepaire, 2005). From an evolutionary standpoint, these effects can be viewed as proximate consequences of stress insofar as they produce a readily observable and immediate impact on functioning of the individual. However, there is a broader cost to the individual that may not be immediately apparent and it is these costs that are most difficult to quantify. Because these costs are still for the affected individual (not offspring), I would suggest use of the term ‘distal consequences’ to describe them. For instance, normal aging of the CNS across the lifespan is associated with a transition to a greater pro-inflammatory cytokine balance, an effect that may be accelerated by repeated stressor exposure (Frank et al., 2006). Similarly, neuroinflammation is causally related to the development of neurodegenerative disorders such as Alzheimers Disease and Parkinson’s disease and may account for the earlier age of onset and worsening of symptoms produced by stress (eg. Whitton, 2007). Finally, our discussion has centered largely around neuroinflammation, but it is important to recognize that many of the same inflammatory-related changes are observed in other systems as well. As such, activation of inflammatory-related pathways during times of stress has been associated with the development and/or exacerbation of cardiovascular disease (Black, 2002), rheumatoid arthritis and Crohn’s Disease, as well as autoimmune disorders such as multiple sclerosis, lupus and Type I Diabetes. Perhaps even worse, increased IL-1 in the CNS sensitizes later stress reactivity that can be observed days to weeks later (Deak, Bellamy, & Bordner, 2005a; Johnson et al., 2002; Schmidt, Aguilera, Binnekade, & Tilders, 2003), suggesting that the impact of chronic stress across the lifespan may feed-forward into progressively more deleterious stress consequences. To this end, activation of inflammatory pathways in the CNS may more generally portend the erosion of individual health. From an ecological perspective, this would be more likely manifest as reduced longevity (due to greater susceptibility to predation) rather than full-blown disease states.

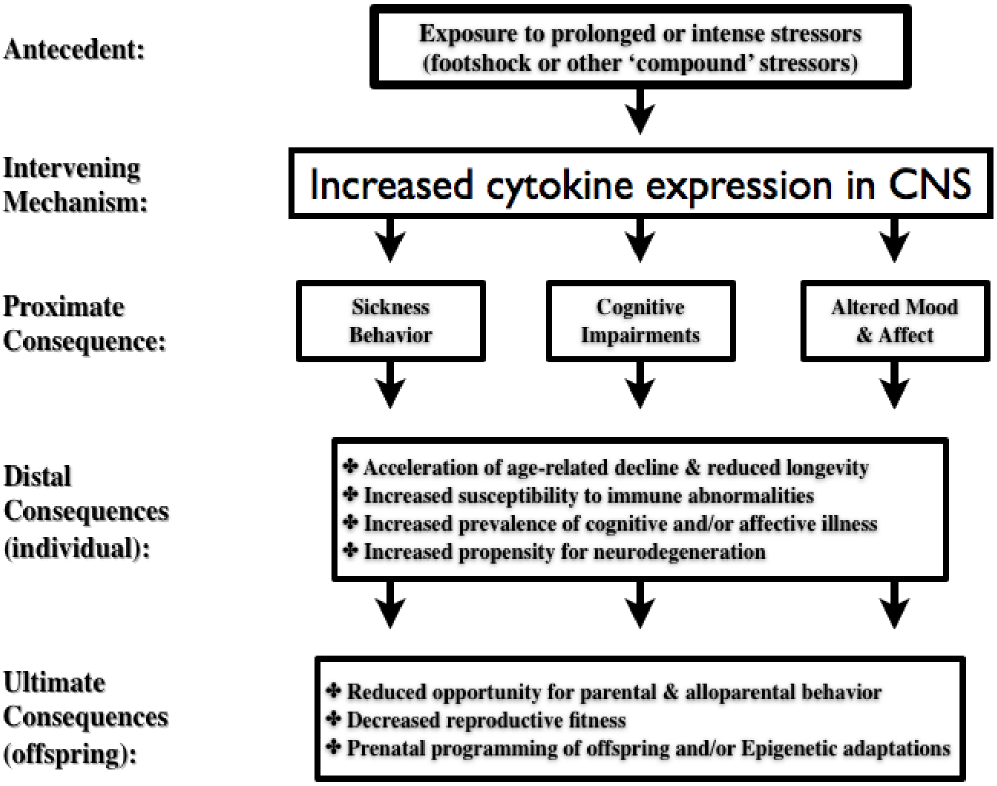

Figure 2. Schematic summary of central cytokine involvement in proximate, distal and ultimate consequences of stressor exposure.

The intrinsic or extrinsic factors that lead an individual to develop a given pathology in response to stress is not currently known in most cases. However, much the same as the ecologist is accustomed to thinking about speciation being driven by the various pressures of natural selection, the same principles may be turned inwardly towards the physiology of the individual. That is, we each possess a diverse range of organs and tissues that operate at some level of efficacy. The weakest of these organs or tissues – perhaps as a result of prior insult, developmental programming, or genetic liability – would be expected to show greater deterioration, wear-and-tear, or overt disease as a result of stress, thereby manifesting as individual differences in stress reactivity. In the end, the disease states provoked or exacerbated by stressor exposure will undoubtedly enhance susceptibility to predation in the wild.

The impact of stress is not restricted to the individual and often extends to one's offspring as well. Such 'ultimate consequences' come in the straight-forward sense that reproductive behavior is often diminished during peak periods of stress, an effect that is also observed during acute illness, particularly for females (Avitsur & Yirmiya, 1999). Poor health associated with accelerated aging may reduce the opportunity for parental and alloparental behavior, thereby reducing social transmission of critical knowledge and skills later in life. Some of the most profound effects of stress on offspring occur by altering maternal behavior. Rat dams that spend more time licking and grooming their offspring yield litters that are more resilient to stress later in life, while maternal deprivation/neglect produces the opposite effects (Kaffman & Meaney, 2007). Similar effects have been observed in non-human primates where the amount of time the mother spends foraging predicts stress reactivity and mental health of her offspring, presumably because conditions where food is scarce or difficult to acquire lead to greater neglect of offspring (Gorman, Mathew, & Coplan, 2002; Rosenblum & Paully, 1984). As such, the impact of escalating foraging demand would be expected to have a particularly adverse impact on mammalian species where parental investment is high.

With that said, we must resist the call to view stress, stress responses or the consequences of stress in a purely deleterious manner. Recall instead that the principle stress responses (SNS and HPA axis) in addition to the inflammatory response have been highly conserved across the course of evolutionary history and therefore must provide significant adaptive benefit towards survival. For instance, exposure to acute stress has been shown to improve several aspects of wound healing and immune function, while chronic exposure to stressors can produce immunosuppressive effects (Deak et al., 1999b; Dhabhar & McEwen, 1997). These findings challenge the prevalent dogma that stress has only deleterious effects on immune function and remind us that the stress response has many adaptive qualities.

Insight into the adaptive nature of the stress response can also be gleaned by examining the evolution of the endocrine and inflammatory systems more generally. Modern evolutionary views argue that endocrine systems such as the HPA axis evolved initially from unicellular organisms where they were expressed as intracellular signaling cascades, which evolved into cell-to-cell signaling pathways in multicellular organisms, and so forth (Roth et al., 1985). Evidence for high affinity corticosteroid receptors in yeast cells (*Candida albacans*) suggests that rudimentary "HPA axes" may have followed a similar evolutionary path (Malloy, Zhao, Madani, & Feldman, 1993). Though it has not been stated explicitly, the elements of neuroinflammation discussed here are all considered to be part of the 'innate' immune response, which is phylogenetically the most ancient component of the vertebrate immune system. This evolutionary framework suggests that activation of inflammatory pathways by stress is likely to generalize across taxonomic orders, though clearly more work is necessary to test this hypothesis. Based on available data, however, it is reasonable to conclude that stress-related neuroinflammation and the sickness-like cascade that ensues must also have some adaptive value. To my mind, it makes good evolutionary sense that the magnitude of the recuperative response provoked by stress should somehow vary as a function of stressor intensity. Whether ‘stressor intensity’ in this case more aptly refers to crossing some identifiable threshold or is defined by unique features of the stress experience itself remains to be determined. Regardless, it is clear that hallmark signs of neuroinflammation can be provoked by the assembly of two threats that individually are without influence on neuroinflammation, as when hypoglycemia was combined with restraint as a unitary challenge (Deak et al., 2005b). In this regard, one might speculate that exposure to threats such as low-level toxin or toxicants from the environment might interact synergistically with, or lower the threshold for, otherwise innocuous threats (brief capture, increased foraging demand, anthropogenic noise, etc) to produce more severe consequences for the individual than would otherwise be expected from isolated threats alone. But in the end, the principles of evolution remind us once again that conservation of biological function is as prevalent as niche adaptation. It is perhaps not so surprising, therefore, that surviving a threat of significant proportion requires a period of recuperation, and that natural selection has favored a unified biological approach (i.e., sickness) as the prevailing mechanism to promote recovery.

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The Behavioral Ecology of Disturbance Responses

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Measuring the impacts of anthropogenic activities on wildlife is crucial for ensuring effective management. Animal behavior is often considered a sensitive index of impact, but its use requires detailed understanding of the context dependent decisions animals make. In this manuscript I identify a number of areas where insights from the field of animal behavior are relevant to studies of human disturbance and activity. In particular, I differentiate between disturbance effects and disturbance impacts and show how context-dependent decision-making often makes animal behavior an unreliable index of impact. I show the areas where animal behavior can be useful in quantifying minimum disturbance impact when additional information is available, and identify a number of areas where further research may help improve the management of anthropogenic activities within wildlife areas.

The effective management of human activities in wildlife areas is an important conservation issue, as the footprint of human influence continues to expand (Green, Cornell, Scharlemann & Balmford, 2005) and incidental impacts of human activities (e.g. noise and disturbance) spread into more areas (Keirle, 2002; Hatch & Wright, this issue; Weilgart, this issue). Such expanding anthropogenic activity is widely perceived to lead to negative consequences for the wildlife beyond habitat loss alone (Frid, 2003; Higham, 1998; Stevens & Boness, 2003; Taylor & Knight, 2003; de la Torre, Snowdon & Bejarano, 2000; Wauters, Somers, & Dhondt, 1997). Understanding how animals respond to noise and more generally, anthropogenic activities is fundamental to resolving potential conflicts between humans and animals (Hatch & Wright, this issue; Weilgart, this issue; Wright et al., this issue, a). There are numerous ways in which it is possible to study animal responses, but changes in an animal's behavior are often the most obvious consequences of anthropogenic activities so it is not surprising that many authors use behavioral observations to understand impacts (Fortin & Andruskiew, 2003; Nettleship, 1972). However, interpretation of the results of animal behavior studies is not always straightforward and while the study of behavior within a conservation context is to be encouraged (Sutherland, 1998) insights from the wider field of animal behavior will have direct relevance to understanding. In this paper I review a number of areas where understanding animal behavior offers insights of management importance in understanding how animals may respond to human activities. This is not an attempt to fully review the impacts of anthropogenic activities on animal behavior, but rather to highlight a few important insights that have sometimes been overlooked in conservation studies (Buchholz, 2007; Sutherland, 1998).

Animal behavior is an eclectic field with a scope that ranges from purely behavioral observation (the assessment of the amount of time an animal

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spends doing various activities, for example), through questions relating to resource allocation (how many offspring to have in a litter, how much testosterone to place in an egg, etc.) to more psychological questions of how animals perceive their environment (when in a foraging patch, how long do animals remember recent weather events, etc.) (Alcock, 2003; Buchholz, 2007). Underlying the field is an attempt to understand how animals make decisions and what the consequences of these decisions are. In this paper I will attempt to show how understanding from a number of different areas of animal behavior has implications for understanding how noise and other anthropogenic disturbance is likely to impact animal conservation and welfare, starting with the simplest observations of animal behavior.

Behavioral responses to threatening stimuli

Perhaps the most obvious of the responses an animal makes to a threatening stimulus are simple behavioral responses. It is therefore unsurprising that measuring behavioral responses such the distance at which an animal flees or first responds to human presence have therefore been widely used to address a number of related questions about the impacts of disturbance. Primary among these is the simple question: does human disturbance affect animals (Blumstein, Anthony, Harcourt, & Ross, 2003; Klein, Humphrey, & Percival, 1995; Tuite, Hanson, & Owen, 1984)? Behavioral measures have also been used when human disturbance effects are assumed and the question is more to identify which populations or species are most susceptible to disturbance (Blumstein, Fernández-Juricic, Zollner, & Garity, 2005; Tarlow & Blumstein, 2007). However, behavioral responses involve the animal making a number of different decisions, so a naïve exploration of the simple behavioral response may be inadequate.

For example, on first hearing a noise, a feeding animal may stop foraging and look around for the source. If the noise or its source is threatening enough, the animal’s stress response pathways may be activated at this point, the short- and long-term physiological consequences of which are highlighted elsewhere (e.g. Deak, this issue; Romero & Butler, this issue). What an animal decides to do about this threat, however, is not fixed: it may choose to simply keep a wary eye on the threat and resume feeding, or it may flee the area to feed in a safer location. Let us assume the noise is caused by a one-off, short-term stimulus and the animal chooses to abandon the area temporarily but will return when the threat has passed. This is a short-term response to a short-term stimulus and the costs of this response are likely to fall well within the norms the animal is used to (i.e. homeostasis is maintained: Romero, 2004) so this would be an appropriate decision for the animal to make. However, if the stimulus is repeated frequently, the cost of repeated short-term responses (lost foraging time, costs of flight, etc.) may accrue meaning that an animal in the frequently disturbed environment may decide that staying put but maintaining a constant readiness to leave is less costly than fleeing. This may result in increased energetic expenditure and chronic stress with all the physiological consequences associated (Deak, this issue; Romero & Butler, this issue), but is still an appropriate decision if the costs involved in repeatedly leaving the feeding area are greater than the physiological consequences of chronic stress. If we are to accurately interpret behavioral responses to a disturbance event, therefore, it is crucial that we understand the *context* within which an animal makes decisions.

Before continuing further, it is important to note that the *effects* of a disturbance event are not necessarily the same as the *impacts* of that disturbance event. E.G., in the first example above the effect of the one-off disturbance was to make the animal temporarily leave a feeding area, an effect that was not shown by the animal in the second example. Leaving a foraging area might be assumed to be a negative impact (as noted by Gill, Norris, & Sutherland, 2001a), but the impact is likely to be largely negligible compared with the impact on the animal subjected to repeated stimuli in the second example that showed no behavioral effect but may suffer physiological consequences. If we are interested in conservation and welfare, we are clearly much more interested in impacts than simple effects (Gill et al., 2001a; Gill, Sutherland, & Watkins, 1996; Nisbet, 2000). This crucial difference is often ignored when researchers equate effect with impact: certainly human disturbance affects animal behavior, but this does not necessarily mean human disturbance has a (negative) impact on animal conservation or welfare. The previous example illustrates one case where the behavioral measure (whether or not an animal left the area) is clearly not an appropriate index of the impact of the disturbing stimuli. More generally, Gill et al. (2001a) suggested that a lack of behavioral response may not imply a lack of fitness consequence but may instead reflect a lack of choice and Beale & Monaghan (2004a) provided an empirical test showing that such theoretical arguments translate directly to the field and concluded that it is wrong to assume that the most responsive animals are those that are most vulnerable to disturbance.

It seems that context-dependent decision-making behavior therefore limits the practical utility of recording behavioral responses as an index of the impact of stressful stimuli. I therefore consider that ignoring context and using simple behavioral measures as a direct mechanism for assessing either whether animals will suffer impacts of disturbance, or for identifying which populations or species may be most vulnerable to disturbance is seriously flawed. This, however, does not necessarily mean that behavioral measurements cannot be useful for researchers interested in impacts of human disturbance provided the context under which the behavioral decisions are made is understood and no direct link between behavioral effect and disturbance impact is assumed. For example, instead of assuming effect and impact are identical, if behavioral responses are coupled with further information on the costs of the changed behavior itself a *minimum* estimate of the cost of responding can be estimated. In the earlier example an estimate of the energetic costs of lost foraging time and energy spent moving away can be estimated and put in the context of daily energy expenditure. However, for the animal that showed no behavioral response the estimated cost would be zero but as we have already seen this animal is actually much more likely to suffer stress-related impacts than the first animal. Thus estimates of cost based on behavior alone are likely to be underestimates and if the estimated cost is low it does not mean that the impact of the stimulus is necessarily low. It is also clear that this method does not allow comparison between populations or species. If the minimum cost is put in an appropriate context where its importance can be measured against other energetic costs and it can be shown that animals are not compensating for such increased energetic expenditure (e.g. by feeding at night: Lane & Hassall, 1996), the minimum potential for negative impacts can be assessed and may be substantial (Williams, Lusseau, & Hammond, 2006).

Similarly, if the context in which decisions are made is not changed, behavioral measures can be used directly to measure the relative degree to which stressors affect individuals. However, maintaining similarity of context is challenging and variations must be strictly controlled experimentally and/or statistically. If, for example, the degree of impact caused by two different types of boat engine is of interest it may be possible to approach the same individual animals in the same location at the same time of day over a relatively short time span with the two different engines and record the behavioral responses. If one engine type consistently results in greater behavioral responses it is very likely that this engine type is perceived to be a stronger stressor than the alternative. It is crucial, however, that the context is maintained as constant as possible when assessing the impact of the two potential stressors: the individuals must be the same, in the same size group, engaged in the same activity when first approached and in the same location. If any of these variables has changed, the context in which the animals find themselves will also have changed and the results will be highly suspect unless tightly controlled statistically. Statistical control may be appropriate, for example, if the number of individuals within a group is variable and group-size alters behavioral response in a predictable manner: in such cases inclusion of a group-size variable in statistical analysis will go some way to controlling for this aspect of context.

Impacts of avoidance behavior

Perhaps the next stage of assessing the impacts of behavioral responses to threatening stimuli involves asking questions about the redistribution of animals (i.e. avoidance) that is widely observed in areas where frequent disturbances are likely (Tarlow & Blumstein, 2007; Weilgart, this issue). What is the cost to the animals of this avoidance? Does it limit population in some way?

Although not yet widely applied, resource-use based models have been used as one way of assessing the population consequences of avoidance behavior (Fernández-Juricic, Sallent, Sanz, & Rodríguez-Prieto,, 2003; Gill et al., 1996; Gill, Norris, & Sutherland, 2001b; Percival, Sutherland, & Evans, 1998). Such models develop a behavior-based model to assess the impact of human disturbance, but do not rely on directly measuring the behavioral responses animals show to human presence. Instead, they assume that animals show behavioral responses to humans but suggest that if any significant fitness costs are associated with such responses, a critical, limiting resource will be under-used. Therefore, patterns of resource use are determined instead of measuring behavior directly. If resources are under-utilized in areas where disturbance is high, human disturbance is regarded as having an impact of conservation concern. For example, Gill et al. (2001b) report a study of the effect of disturbance on the Black-tailed Godwit. They showed that, despite this species being perceived as sensitive to human disturbance, no under-use of food resources was detected, presumably either because the birds fed in the most disturbed areas at times when there were few disturbances (e.g. early mornings), or because the birds chose to use the disturbed areas once resources were used up in undisturbed areas. They therefore conclude that although these animals appear to avoid human presence, this does not reduce the population size supported by the estuaries they studied. Similar issues have been studied using simulation models: Stillman et al. (2000) used an individual based model to show that avoidance behavior may lead to population decline and Blumstein et al. (2005) used a simple model to show that resource use may fall in disturbed areas but neither studies include context-based decision making.

Studies of resource use have so far focused on utilization of food supplies (Fernández-Juricic, Sallent, Sanz, & Rodríguez-Prieto, 2003; Gill et al., 1996; Gill et al., 2001b) and wintering habitat (Percival et al., 1998), but could also be used in relation to other resources, including breeding territories. However, such studies rely heavily on the correct identification of critical resources. If the effect of disturbance was measured on the use of the wrong resource, it would be possible to incorrectly conclude that human disturbance was not an important factor. It is possible, for example, that the utilization of food resources is unaffected by human disturbance, but that resting sites are negatively affected and the population declines because there are insufficient disturbance free areas to rest. Alternatively, it might be possible to wrongly identify human disturbance as limiting populations for similar reasons. For example, if some other external factor holds an animal's population artificially low (e.g. hunting pressure on migration) and these animals show avoidance of humans, they may not make full use of resources in disturbed areas: not all available resources are required to maintain the population so the animals never need to use the resources in more disturbed areas. However, it would be wrong to assume that this pattern of resource use provided evidence that disturbance was implicated in the low population of this species. If the population were to increase (e.g. because hunting pressure is reduced), animals might eventually decide to forage in the more disturbed areas because these previously unexploited resources are now required to maintain the increased population.

On the other hand, if animals do avoid areas with a high frequency of anthropogenic activity and under-use a particular resource or habitat, negative impacts are still not necessary consequences. For example, Mallord, Dolman, Brown, & Sutherland (2007) showed that woodlarks *Lullula arborea* avoided heavily visited habitat. This resulted in fewer individuals breeding in visited areas, but the few birds that did so were freed from competition and enjoyed increased breeding success, with the total number of fledglings from disturbed heaths approximately equal to the number of fledglings from undisturbed heaths where birds were breeding in higher densities. The overall population is therefore determined by a delicate balance between the improvement in breeding success due to density dependent effects and the reduction in habitat availability due to (inappropriate) disturbance avoidance. Whether this balance leads to a stable population or one in decline can only be determined by assessing disturbance impacts across the entire area of suitable habitat and estimating the number of animals that this could support in the absence of human disturbance. This, and especially the effect that might occur when disturbance is seasonal and otherwise perfect habitat becomes poor after animals have settled in the area (e.g. at holiday times) can be seen as forms of an ecological trap (i.e. anthropogenic activities have altered habitat quality such that the cues an animal uses to select a habitat are no longer appropriate: (Kokko & Sutherland, 2001).

Other measures of impacts of threatening stimuli

Other methods for determining the impacts of anthropogenic stressors have recently been reviewed elsewhere and I shall not attempt this here (Tarlow & Blumstein, 2007). However, methods involving the measurement of physiological and metabolic parameters associated with stress responses are relevant to a discussion of animal behavior because they help explain how impacts may occur even in the absence of behavioral responses.

Some penguins are noted for their lack of behavioral responses to visitors, especially in areas where visitors are frequent (e.g. Nimon, Schroter, & Stonehouse, 1995; Fowler, 1999). This lack of response led to the suggestion that these birds are “habituated”, a claim also made for other species (Nisbet, 2000) but, if a real phenomenon, it is more likely to refer to learned non-response as physiological acclimation seems unlikely (Wright et al., this issue). For example, Fowler (1999) studied the hormonal and behavioral responses of penguins in areas of differing disturbance. Fowler showed no difference in physiological responses between birds in medium and low disturbance plots, but found a significantly decreased hormonal response in the high disturbance areas, indicative of acclimation. However, as variation was large in the control plots but small in the disturbed plots the results suggest that, rather than birds acclimating, birds that showed high responses left the area. This is further suggested by the lower nesting density in the high disturbance plot (Fowler, 1999). Fowler also showed that average strength of the behavioral responses in each plot decreased with visitor levels, but did not examine the relationship between an individual’s hormonal and behavioral responses.

Additional work on the heart-rate of kittiwakes *Rissa tridactyla* and European shag *Phalacrocorax aristotelis* with a long history of exposure to human visitors also highlighted extreme individual variation in heart-rate responses to disturbance (Beale, 2004). These studies found that even when negligible changes in behavior were observed in response to a potentially threatening stimulus, heart rate of those birds that do respond could increase by 50%. This clearly indicates that these birds are likely to be experiencing physiological stress responses which must be considered chronic in areas with frequent disturbance events. However, a raised heart-rate may itself have conservation consequences, as maintaining raised heart-rates requires increased metabolic costs which may, in turn, affect demographic parameters. I estimated an increase of 7.5 – 10% in daily energy expenditure for some individual Kittiwakes in Scotland (Beale, 2004), an increase likely to result in eventual abandonment of nesting attempts once energy reserves drop below a critical level: this is indeed the proposed mechanism linking anthropogenic activity to nesting failure in this species (Beale & Monaghan, 2004b). It is also worth noting that individualistic heart-rate responses to human disturbance again indicate the importance of understanding animal behavior, where some individuals choose to respond, and others not. Only by understanding that there are susceptible and unsusceptible individuals can the observed change in breeding success be comprehended, not by simply considering the mean response of the population.

It is, of course, important to question whether even declines in breeding success reflect an impact of genuine conservation concern. Indeed, breeding success is not necessarily a good surrogate of fitness thanks in part to density dependent effects (Frederiksen, Lebreton, & Bregnballe, 2001; Olijnyk & Brown, 1999). Moreover, breeding success is often far less important in determining populations of relatively long-lived animals than winter mortality (Russell, 1999; Weimerskirsch, Brothers, & Jouventin, 1996), a distinction likely to hold for many long-lived species. A decrease in breeding success of 9%, as observed for Kittiwakes in Scotland is, in fact, unlikely to have a major impact on the population as a whole.

Conclusions

Understanding that animals are individuals that make context-dependent decisions about how to respond to their environment results is an important insight with practical application to understanding how animals respond to anthropogenic stimuli. It is also crucial to differentiate between disturbance effect and disturbance impact. I have shown how this context-dependent decision making means the use of simple behavioral indices as a direct measure of disturbance impact is unsound, and have pointed out areas where incorporating further information can make behavior measures potentially useful. I have shown how the decisions animals make about where to feed and breed can be influenced by human activities and the consequences or otherwise this might have for the population. I have shown that in birds at least, it is clear that disturbance from anthropogenic activity can reduce breeding success even in the absence of behavioral effects. I have also shown how even physiological responses to anthropogenic activity can be individualistic, indicating that a more profound understanding of these responses also required understanding decision making behavior. Throughout, I have attempted to stress the distinction between effects and impacts, a distinction that is crucially important when making management decisions. Research on the effects of human disturbance is slowly taking account of the need to understand behavior (Fernández-Juricic et al., 2003; Gill et al., 2001b; Stillman et al., 2000), though papers continue to be published that overlook context-dependant decision-making behavior (Frid, 2003; Fortin & Andreskiew, 2003; Fernández-Juricic, Vaca, & Schroeder, 2004; Blumstein et al., 2005).

Future work on disturbance impacts is likely to be valuable and the impact of recreation on biodiversity has been identified as one of the 100 ecological questions of high policy relevance in the UK (Sutherland et al., 2006). Future efforts must distinguish between effect and impact and must adequately incorporate context-dependent decision making behavior. Although behavioral measures are inappropriate for assessing the comparative impact of disturbance on multiple species (even at the same location different species will experience the environment differently and will find themselves in different contexts), there is clearly a need to identify methods to protect multiple species (Blumstein et al., 2005). It is likely that further advances may be made through the use of individual based models that allow individuals to make truly context-dependent decisions. Further studies that identify disturbance effects at multiple levels – behavioral, physiological and metabolic

– are likely to improve understanding of disturbance impacts. Finally, I believe that more study of the behavior of people in wildlife areas is likely to offer new insights into how to manage conflicts between humans and wildlife. This aspect of human disturbance research is currently largely neglected, but must be considered a crucial part of the equation.

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A Brief Review of Anthropogenic Sound in the Oceans

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Sound in the oceans is generated by a variety of natural sources, such as breaking waves, rain, and marine animals, as well as a variety of human-produced sources, such as ships, sonars and seismic signals. This overview will begin with a quick review of some basic properties of sound waves with particular reference to differences between the behaviours of these waves underwater versus in air. A basic understanding of the physics of underwater sound is critical to understanding how marine animal acoustic signals have evolved relative to their different functions and how changes in the marine acoustic environment due to increasing anthropogenic sound in the oceans may impact these species. We will then review common sources of anthropogenic sound in the oceans. The frequency contributions of three major sources of underwater anthropogenic sound and their relative intensities will be discussed: naval exercises, seismic surveys and commercial shipping. Finally, a case study examining relative inputs to a regional noise budget, that of the Gerry E. Studds Stellwagen Bank National Marine Sanctuary, will be presented to introduce the audience to methodologies for characterizing and managing sound on an ecosystem level.

A number of reviews of anthropogenic sound in the oceans (and its effects on marine mammals) have described properties of underwater sound, outlined the differences between the transmission of sound underwater versus in air and compared acoustic characteristics associated with different types of anthropogenic sources (e.g., Hildebrand, 2005; MMC, 2007; Nowacek, Thorne, Johnston, & Tyack, 2007; NRC, 1994, 2003; Richardson, Greene, Malme, & Thomson, 1995). This paper will not attempt to provide the same detailed coverage of these topics. Instead, this paper will provide a basic introduction to the sources and physics of underwater sound for the uninitiated audience and provide references for the interested reader to gain additional information.

The reviews noted above also include thorough examination of the current scientific knowledge surrounding the effects of underwater noise on marine mammals; however, Weilgart (this issue) provides a brief overview of this material. Furthermore, natural sources of sound in the oceans will not be detailed here. This is not because these sounds do not affect marine mammals, but because management of underwater noise focuses on human contributions to the marine acoustic environment, in which sound plays important natural roles.

What Is Sound? A Primer

Sound is a compression wave that causes particles of matter to vibrate as it transfers from one to the next. These vibrations produce relatively small changes in

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pressure (compared to atmospheric pressure) that can be detected by the ear.

Depicted graphically as a sine wave, the wavelength of a sound is equal to the speed of sound divided by its frequency. Thus, high-frequency sounds have shorter wavelengths than low-frequency sounds travelling in the same medium (Figure 1). The perceived "loudness" of a sound is a function of its amplitude (i.e., how much energy it carries) or intensity (the power of the wave transmitted in a particular direction in watts per square meter) and the hearing thresholds of the receiver (i.e., listener). It should be noted that the speed of sound in seawater is the same for all frequencies, but varies with aspects of the local marine environment such as density, temperature and salinity. Due mainly to the greater "stiffness" of seawater relative to air, sound travels approximately 1,500 m/s in seawater while it travels only approximately 340 m/s in air. Boundaries between two mediums with very different sound speeds act somewhat like mirrors to all sound not striking that boundary perpendicularly. Consequently, sound does not travel well between air and the oceans.

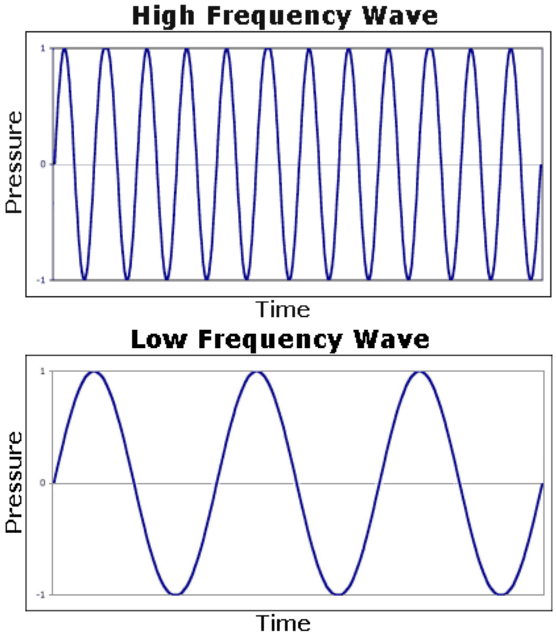

Figure 1. This diagram shows a high frequency wave (above) and a low frequency wave (below), plotted as pressure versus time. The high frequency wave has completed twelve cycles over the time shown. The low frequency wave has completed only three cycles over the same time. Diagram reproduced with permission from *Discovery of Sound in the Sea* http://www.dosits.org/ (a).

A sound's intensity is usually measured in decibels (dB), which is a relative measurement rather than an absolute measurement of wave's directional energy. Measurements in air usually reference 20 micropascals (μPa), or about the sound of a pin drop, while the standard reference in seawater is 1 μPa. Converting between sound intensities in air and water can be confusing and often the source of conflict. This is not only due to the relative nature of the decibel scale, but also the relationship between a sound's intensity and the medium it is travelling through, in addition to the different methods for measuring the level of a sound. Sound waves with the same *intensities* in water and air when measured in watts per square meter have relative *intensities* that differ by 61.5 dB. Thus, for sounds with the same absolute *intensities* in watts per square meter, one must subtract 61.5 dB to obtain the sound's relative intensities in water referenced to 1 µPa. Reference intensities cause 26 dB of this difference, while the differences in densities and sound speeds account for the other 35.5 dB of the difference in *intensities* (Urick, 1983).

As mentioned above, there are different ways to characterize a signal's amplitude. The most common methods are to measure peak-to-peak pressure, peak pressure, and root mean squared (rms). Peak-to-peak amplitude is represented in the waveform by the entire height of the sound wave, peak pressure would be the largest displacement from the central line and rms measures the average of the pressure of the sound signal over a given duration. Due to its direct relationship to the amount of energy carried by the sound wave (i.e., intensity), the rms pressure is the most common metric used to characterize sound waves (Madsen, 2005).

As a result of the physical and measurement differences described above, sounds with equal absolute intensities in seawater and air have higher relative intensity, travel faster and go farther before they loose their energy in seawater than in air. In addition, regardless of the medium the sound is travelling through, low frequency sounds travel farther than high frequency sounds because their energy is absorbed more slowly and louder sounds travel farther than softer sounds because they have more energy to disperse over distance from the source.

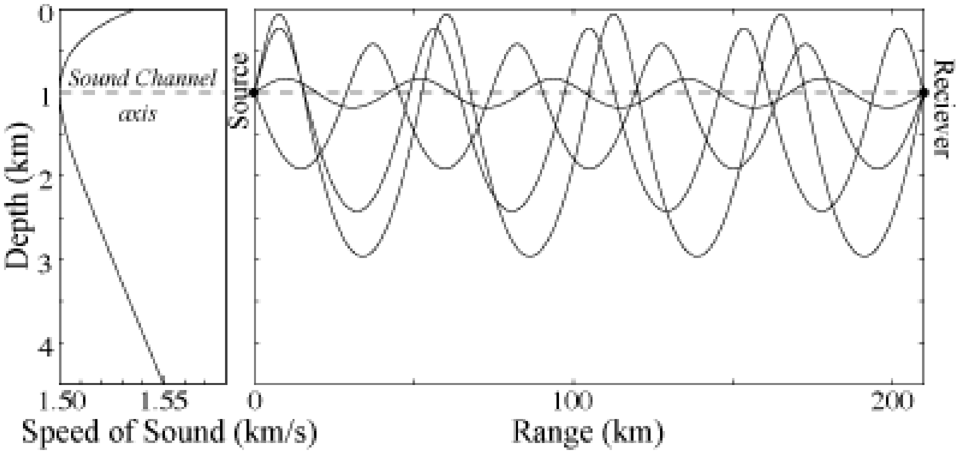

Figure 2. This diagram shows the sound channel axis. Sound speed profile from mid-latitudes is represented on the left. The paths that sound travels from a source at 1000m depth to a receiver at 1000m depth and 210km away from the source are shown on the right. Diagram reproduced with permission from *Discovery of Sound in the Sea* http://www.dosits.org/ (b) and adapted from Figure 1.1 of Munk, Worcester, & Wunsch (1995).

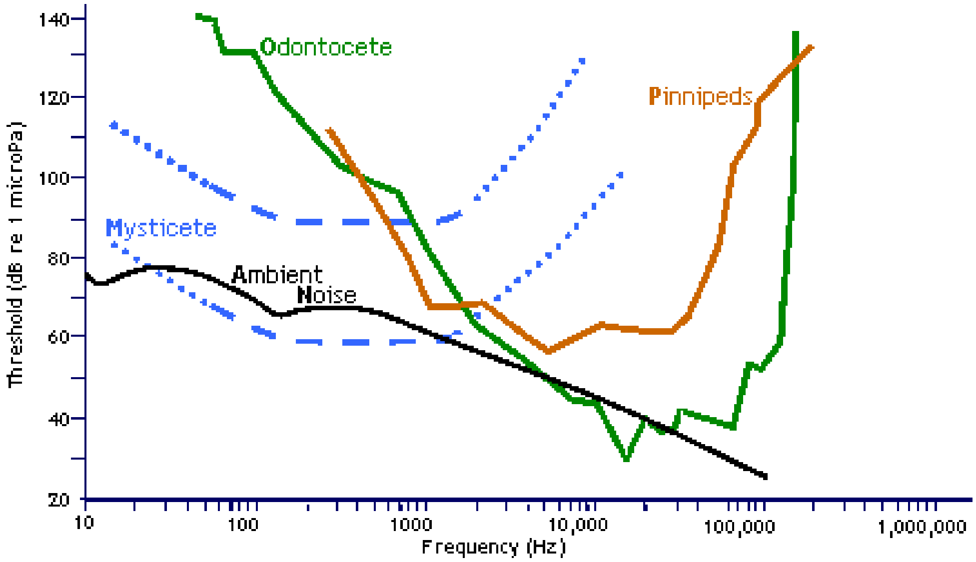

Figure 3. Estimates of the hearing thresholds for mysticetes, odontocetes and pinnipeds with ambient noise profile superimposed. The y-axis is relative intensity in underwater dB. The x-axis is the frequency of a sound on a logarithmic scale. Figure modified with permission from *Discovery of Sound in the Sea* http://www.dosits.org/ (c).

In the majority of the ocean there is often a minimum sound speed due to the predominant effects of heat from the sun and density due to depth on the speed of sound in water (salinity also plays a major role where it varies widely, such as near shore and in estuaries). The increasing sound speeds above and below this minimum tend to focus sounds like a lens at the minimum (Figure 2). Any sound travelling at about 12° or less from the horizontal are unable to escape and are refracted back toward the minimum, allowing sound to propagate much further due to a reduction in spreading and reflection and adsorption by the sea surface and sea floor. This is known as the deep sound channel, or SOFAR channel. In the deep ocean at mid-latitudes, the slowest sound speed occurs at a depth of about 800 to 1000 meters. However, the depth varies from over 1600 m in the warmest waters of the world to100 m in colder waters and can even reach the surface at the ice edge, becoming a surface sound channel.

Finally, sound is often categorized as either signal or noise. However this categorization depends heavily on the receiver (listener), who will define sounds of interest as signals and everything else that might interfere with those signals as noise. For example, Navy sonar operators would consider their sonar to be a signal, while marine mammals are likely to consider it to be noise. Concerns regarding the impacts of noise on signals must also take into account differences in species and/or individuals range of hearing. The quietest sounds, across the range of frequencies that can be heard by an individual receiver define its hearing thresholds (Figure 3).

Anthropogenic Noise

Human use of the sea, such as for shipping, military activities, oil and gas exploration, and recreation (including cruises and pleasure boating), is increasing the amount of sound that is introduced into the oceans (see Table 1). As these sounds are generally not considered to be signals by marine fauna, they will be referred here as noise. The continuing increase in anthropogenic noise in the oceans may be affecting marine life in many ways, since many marine animals have evolved to use sound as their main means to communicate, sense their surroundings, and find food underwater (Berta, Sumich, & Kovacs, 2006). As light does not travel very far in water, auditory capabilities have evolved to supplement and/or replace the use of vision for many marine animals (Bradbury & Vehrencamp, 1998). The same advantages conferred by sound relative to light underwater have led humans to deliberately introduce sound into the ocean for many of the same reasons as marine fauna: communication (e.g., sub-to-sub), feeding (e.g., fish finding sonar) and navigation (e.g., depth-finders).

The sounds produced by the range of sources in Table 1 are also highly variable, some being characterized as impulsive (such as seismic surveys) and tonal (such as sonar), comparatively loud (such as explosives) and relatively quiet (such as most fishing activities), persistent (such as shipping), short (such as winches) and very short (such as a single seismic survey pulse). Some noise sources, such as explosions, naval low frequency active sonars (LFA), some mid-frequency active sonars, high-power seismic surveying systems that are used to explore the ocean floor for oil and natural gas resources and commercial ships can all be heard over large distances, sometimes across oceans (Nieukirk, Stafford, Mellinger, Dziak, & Fox, 2004).

In general, seismic survey airguns represent the most prolific impulsive sounds introduced into the ocean by human activity. Conversely, commercial shipping is collectively making an ever-increasing contribution to the omnipresent background noise over very large spatial scales in the ocean, as well as intermittent local impacts as point sources (see below).

Many of the various sources and their characteristics have been described in previous works (e.g., Hildebrand, 2005; Nowacek et al., 2007; NRC, 1994, 2003; Richardson et al., 1995). Therefore, here we shall focus on three source types that have drawn considerable recent attention: naval exercises, seismic surveys, and commercial shipping.

Naval Exercises and Sonar

Naval activities involve a number of activities that introduce noise into the oceans, including live-ammunition training, vessel noise and explosions. However, the exercises that have been subject to the most scrutiny are those involving mid-frequency sonar operations. Around the world, mid frequency sonars have been correlated with strandings of multiple Cuvier’s beaked whales in the Bahamas and have been coincident in time and space with additional stranding incidents (see Brownell, Yamada, Mead, & van Helden, 2004; Cox et al., 2006; ICES, 2005;

Weilgart, this issue). Mid-frequency naval sonar can produce sound at levels of up to 237 dB re 1uPa @ 1m mainly at frequencies between 2-8 kHz on a 2-second duty cycle repeated as needed for variable periods. The two tactical sonars most frequently used by the US Navy, AN/SQS-53C and AN/SQS-56, are focused in the 2.6 to 3.3 and 6.8 to 8.2 kHz ranges, respectively. Approximately 145 of the US Navy's ~280 ships have mid-frequency sonar capabilities, although not all of these ships utilize these capabilities at any one time. However, the US Navy is not the only military using these or similar sonars and worldwide usage is unknown.

Table 1
Types of anthropogenic noise, with example sources. Note this is not an exhaustive list.

Noise	Example sources
Sonar	Military and commercial
Marine geophysical surveys	Commercial and research
Explosions	Military exercises and testing, dynamite fishing, offshore rig decommissioning
Acoustic deterrent devices (ADDs) and acoustic harassment devices (AHDs)	Fishing activities
Winches, onboard machinery, etc.	Fishing, research, commercial activity
Vessel noise at predominantly lower frequencies	Commercial shipping and other large vessel activity (e.g., tankers, military vessels, cruise liners, etc.)
Vessel noise at predominantly higher frequencies	Smaller commercial vessels (e.g., fishing, ferries, fast ferries, recreational boating, whale-watching and research vessels, etc.) and personal water craft (e.g., jet skis)
Ice breaking and associated engine noise	Icebreakers
Acoustic thermometry of the ocean climate (ATOC) and other sounds used for oceanographical studies	Research vessels and equipment
Noise from offshore development, both during construction and operation	Dredging and other development, (e.g., oil rigs, deep-water ports, wind farms, etc.)
Noise from coastal development (including on-ice activity) both during construction and operation	Ports and harbours, sea walls, piers, bridges, aquaculture facilities, industry and residential buildings
Aircraft (under the circumstances when sound crosses into the ocean)	Helicopters, aeroplanes (especially at supersonic speeds), spacecraft, missiles and other military projectiles
Traffic noise	Traffic on bridges and coastal roads, ice-trucking (through the ice)

Concerns were also raised regarding a surface towed low-frequency active sonar system (SURTASS-LFA) that can include up to 18 projectors in a vertical array, each producing pulses up to 215 dB re 1uPa @ 1m mostly between 100 and 500 Hz. This system utilizes the deep sound channel to propagate over very large distances. Several species of mysticetes use sounds with overlapping frequencies, and also appear to utilise the deep sound channel to increase the range of their sounds (Payne & Webb, 1971). Thus, environmental impact assessments for this sonar type have focused on changes in the feeding behaviors of blue and fin whales (*Balaenoptera musculus* and *B. physalu*; Clark & Altman, 2006; Croll, Clark, Calambokidis, Ellison, & Tershy, 2001), the migratory behaviour of grey whales

(*Eschrichtius robustus*; Tyack & Clark, 1988), and the reproductive behaviour of humpback whales (*Megaptera novaengliae*; Fristrup, Hatch, & Clark, 2003; Miller, Biassoni, Samuels, & Tyack, 2000). Although low-frequency active sonars are utilized much less frequently and by fewer Naval vessels than mid-frequency sonars (i.e., in the US Navy, only 2 ships are currently capable of deploying the SURTASS LFA system), due to the long-distance propagation capabilities of these systems, they may have more subtle impacts due to masking.

Seismic Surveys

Ships undertaking marine geophysical surveys tow seismic (airgun) arrays that emit loud sounds downward to probe under the sea bed for fossil fuels. Point-source intensity estimates for airguns are difficult due to the directional nature of the source, however arrays can produce levels equivalent to 260 dB re 1 µPa @ 1m (peak), with actual in-water pressure levels reaching maximums of approximately 235-240 dB. Although the sound is focused mainly downwards, some sound is emitted horizontally. Similarly, most of the energy is below 1,000 Hz with the predominant frequencies between 10-100 Hz, but there is considerable broadband energy, up to around 15 kHz or more, that is detectible, especially at relatively close range (Goold & Coates, 2006; Goold & Fish, 1998).

Airgun signals last around 40 ms, and are repeated every 7-20 s for several hours or days. Reflection and refraction can lengthen pulse durations (up to several seconds long) at the distance of the receiver. Although seismic surveying activity is concentrated in areas with extractable petroleum or natural gas (i.e., mostly on continental shelves, although this is changing as technology advances) the low frequency nature this source type means that the signal can travel for thousands of kilometers (Nieukirk et al., 2004).

Commercial Shipping

Noise from commercial ships is highly variable, but is generally produced at levels between 160 and 180 dB re 1uPa @ 1m (Richardson et al., 1995). Ships generate noise through their propellers, motors and gears. Noise from propellers comes from the many bubbles formed in the water by the rotating propeller blades. These bubbles quickly collapse or “cavitate” creating a loud acoustic sound. The faster the propeller rotates, the more cavitation noise. The breaking bubbles produce sound over a range of frequencies and, at high speeds, these frequencies can be as high as 40,000 Hz (Bartlett & Wilson, 2002; Wenz, 1962). However, propeller noise from large ships is usually concentrated below 200Hz. Low frequency noise generated by ships contributes significantly to the amount of low-frequency ambient noise in the ocean (Wenz, 1962). Because of the increase in propeller-driven vessels, low-frequency ambient noise has increased 10-15 dB, at an average of approximately 3 dB/decade over the past 50 years (Andrew, Howe, & Mercer, 2002; Cato & McCauley, 2002; Curtis, Howe, & Mercer, 1999; McDonald, Hildebrand, & Wiggins, 2006; Zakarauskas, Chapman, & Staal, 1990).

The spatial distribution of noise from shipping is non-uniform in the world’s oceans. In general, increases are more pronounced in the northern hemisphere because of the higher shipping volumes involved (e.g., Cato, 1976; Cato & McCauley, 2002; McDonald, Hildebrand, & Wiggins, 2006). Also, the concentration of commercial traffic into shipping lanes and around ports tends to amplify vessel noise in these regions, although shallow water propagation on the continental shelf can reduce levels in some high traffic areas. Shipping noise is also directional as it moves away from the source, sometimes strongly so, thus altering the contribution of any single ship to the ambient noise depending on whether the measurement is made at the surface versus on the bottom and/or off the bow versus of the sides or stern (Gray & Greeley, 1980).

Contributions from commercial shipping are similarly variable temporally. For example, the number and size of ships entering the global maritime transport fleet continue to increase dramatically, with implications for noise due to both total input of noise and input per unit vessel. Short-sea shipping (short distance cargo hauling) is becoming more prevalent, with implications again due to additional coastal traffic. As the Arctic Ocean ice melts due to climate change, trans-Arctic paths become the best routes between Europe and both eastern Asia and western North America. Such changes are predicted to change the ambient noise profile of Arctic waters as well as introducing additional point-source noise to this area (Southall, 2005).

A Regional Case Study: The Gerry E. Studds Stellwagen Bank National Marine Sanctuary Passive Acoustic Monitoring Program

Underwater noise from ships can be evaluated at two spatial scales: as transient, relatively high intensity sounds at close range and as omnipresent, relatively low-intensity sound over great distances. The propagation efficiency of low-frequency shipping noise has led to concerns regarding possible “masking” of marine animal signals, particularly low frequency vocalizations, with possible negative effects including diminished abilities to find mates, maintain social structure, forage, navigate and/or evade predation (Erbe, 2002; Erbe & Farmer, 1998, 2000; Morisaka, Shinohara, Nakahara, & Akamatsu, 2005; Nowacek et al., 2007; Payne & Webb, 1971; Southall, Schusterman, & Kastak, 2000). Due to the long-distance propagation of shipping noise, evidence of such effects must be evaluated when animals are closely approached as well as over large spatial scales.

In 2004, the US National Oceanic and Atmospheric Administration (NOAA) Fisheries’ Ocean Acoustics Program further addressed this issue by sponsoring an international symposium on “Shipping Noise and Marine Mammals” (Southall, 2005). Symposium attendees found that prior to developing regulations and/or designing technology to mitigate shipping noise on marine mammals more research was necessary to determine the relative contributions made by identified sound sources to the total noise field. Such descriptive data gathering was also a central recommendation from an NRC (2003) report, which also stated the importance of characterizing temporal variation (e.g., annual, seasonal, monthly, and daily) and spatial variation when measuring sound fields. While the NRC Committee and the NOAA Symposium were focused globally, many of their resultant insights and recommendations can be applied at a smaller “case-study” scale to provide a more local understanding of the noise-marine mammal issue. Insights achieved from case studies can then be used to inform the issue on national and international scales.

Such a case study is being developed within the Gerry E. Studds Stellwagen Bank National Marine Sanctuary (SBNMS or sanctuary), where collaborators are generating methodologies to merge data from passive acoustic monitoring devices with vessel tracking systems and to identify the contributions made by various classes of noise (Hatch et al., in review). The SBNMS is an "urban" marine sanctuary located to the east of Boston, Massachusetts, U.S.A. in close proximity to a densely populated coastal zone (Figure 4).

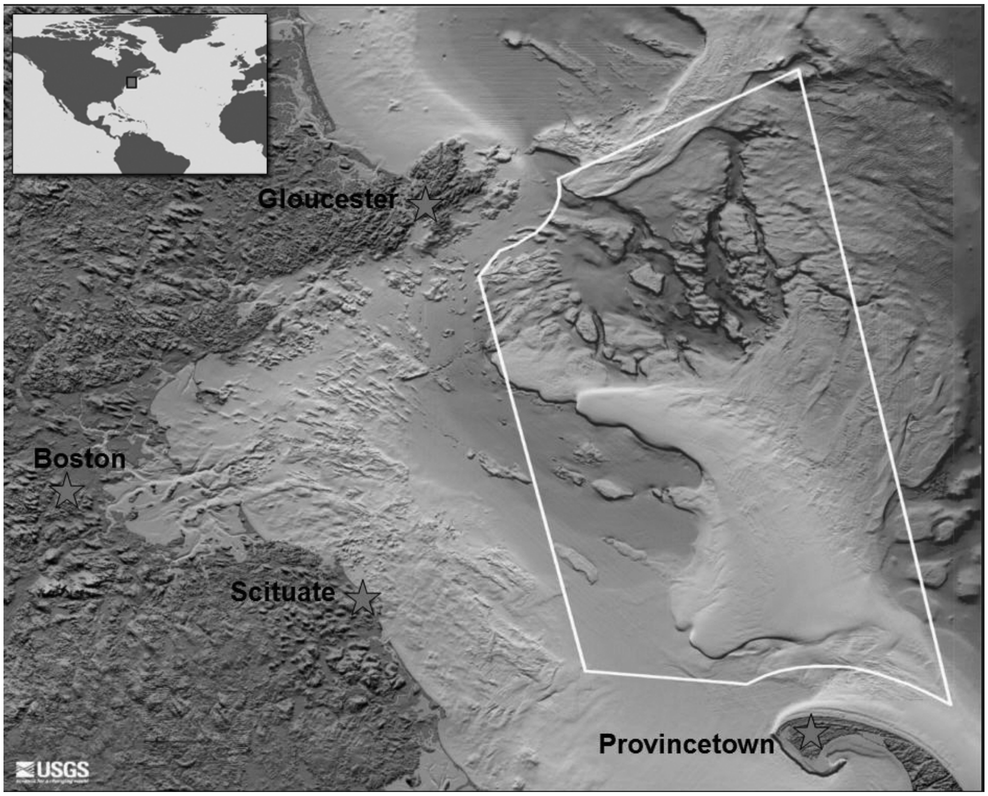

Figure 4. Location, boundaries and bathymetry of the Gerry E. Studds Stellwagen Bank National Marine Sanctuary in Massachusetts Bay off the northeast coast of the United States.

Stellwagen Bank, the central feature of the sanctuary, is home to some of the oldest and highest capacity commercial fisheries in the world and is an important feeding ground for endangered marine mammals such as the North Atlantic right whale (*Eubalaena glacialis*), humpback whale and fin whale. Because the Boston Traffic Separation Scheme (TSS) (the United Nations International Maritime Organization's recommended route for commercial vessels en route to and departing the Port of Boston) transits the sanctuary, these vulnerable marine species are at high risk of collisions with vessels and exposure to shipping noise.

Beginning in January 2005, a collaborative research team comprised of SBNMS, NOAA Fisheries' Northeast Fisheries Science Center, and Cornell

University’s Bioacoustics Research Program deployed nine-ten autonomous recording units (ARUs) (Calupca, Fristrup, & Clark, 2000) to monitor the low frequency (10-1000Hz) acoustic environment of the SBNMS. Through additional collaboration with the US Coast Guard’s Research and Development Center, data from four Automatic Identification System (AIS) receivers have been used to track all large commercial traffic transiting Massachusetts Bay and surrounding waters. Under the International Maritime Organization (IMO)’s current mandates, all ocean-going commercial traffic over 300 gross tons or carrying over 165 passengers, as well as all tugs and tows, are required to carry Automatic Identification System (AIS) transmitters (Federal Register, 2003; IALA, 2004). Shipboard AIS transponders transmit a vessel’s position, identity and other characteristics (including but not limited to length, beam, draught, cargo type, destination and speed) as often as every two seconds.

AIS data are extracted by the SBNMS and the University of New Hampshire’s Center for Coastal and Ocean Mapping using custom software written in Python (Python Software Foundation, 2007) added to the NOAA package (Schwehr, 2007). Analyses are then conducted to describe the abundance, behaviour and distribution of different vessel types over various spatial and temporal scales. Analysis of received levels at each ARU are used to compare the low frequency intensities of highly trafficked versus less highly trafficked locations of the sanctuary. Variations in received levels are then correlated with variations in vessel abundance, distribution and/or behaviour. Future research will continue to quantify the relative contribution of noise per vessel type to the sampling region’s total “noise budget” (NRC, 2003). These analyses, together with synchronous year-long analyses of vocal behaviours of several endangered whale species in the SBNMS, will be used to inform management of sanctuary resources and initiate sanctuary ocean noise policy. For example, better understanding the large-scale and long-term behaviour of vessels and their acoustic footprints is currently aiding the SBNMS to quantify acoustic benefits to whales due to the recent shifting and narrowing of the Boston Traffic Separation Scheme (IMO, 2006).

Summary

Although descriptive data, including time-series data from longer-term monitoring efforts, continue to be collected and analyzed, it is clear that noise from numerous anthropogenic sources is both extensively and increasingly present within the marine environment. Technological innovation and climate change are allowing human activities to leave both deeper and larger acoustic “footprints” in the world’s oceans. In response to increased accessibility and/or the growing use of remote sensing capabilities, new acoustic signals continue to be designed to address commercial, research and defense needs. In addition to purposeful use of acoustic sources, incidental noise from coastal development and vessel traffic are exposing greater proportions of marine life to increasing levels of noise. The vast majority of human-produced sources of underwater noise have intensified over a very short timeframe in evolutionary terms, providing only a few generations (at most) for species to adapt.

Experts agree that a better understanding of the relative contributors to the total ocean noise in areas of concern is needed. With its high concentrations of both acoustically-active endangered species and human activities that produce noise, Stellwagen Bank National Marine Sanctuary represents a perfect test-bed for both characterizing noise inputs and examining their impacts on marine life. Results from this highly collaborative research effort will be used to assist government agencies in fulfilling their responsibilities to identify, implement and monitor means of balancing the protective needs of marine species and ecosystems with the commercial, recreational, research and defensive needs of humans.

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Effects of Noise on Rodent Physiology

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Experiments are described in which Sprague Dawley rats were deliberately subjected to a daily 15-min white noise regime (90 dB) for 3 or 6 weeks, to determine its effects on the cardiovascular system and intestinal mucosa. In one set of experiments cardiovascular responses were monitored by radiotelemetry. Exposure to noise increased heart rate and mean arterial pressure and reduced stimulation of the parasympathetic nervous system. In the second set of experiments, one group of rats was exposed to the noise protocol for 3 weeks and a second group was not. All the rats were then anaesthetized and the small intestines of half the animals were fixed for microscopy. The remaining rats had their mesenteric microvasculature perfused for one minute with fluorescent albumin before fixing for microscopy. The rats exposed to noise showed significantly more eosinophils and degranulated mast cells in the intestinal villi than the quiet rats. In addition, the villi were swollen and the epithelial cells had widened junctions. The noise group also showed significantly more leakage of fluorescent albumin from the mesenteric microvessels. These experiments demonstrate that 90 dB white noise reduces stimulation the parasympathetic nervous system and also induces an inflammatory response in the intestinal mucosa, resulting in structural damage. These results are consistent with a stress response.

Several studies have shown that noise in animal care facilities can reach as high as 90 – 100 dB (Pfaff & Stecker, 1976; Milligan, Sales & Khirnykh, 1993). Such levels of noise can induce physiological and behavioral responses in laboratory rodents such as increased plasma corticosterone levels, reduction in body weight, decrease in gastric secretion, changes in immune response and tumor resistance, and a decrease in reproductive function. Behavioral responses include increases in total activity, grooming themselves and their cage-mates, and rearing onto their hind legs (Clough, 1982; Gamble, 1982; Sales, Wilson, Spencer, & Milligan, 1988; Milligan et al., 1993, Baldwin, Primeau, & Johnson, 2006). These changes are similar to those seen in rodents exposed to other stressful situations (Sharp, Azar, & Lawson, 2003). In spite of the evidence that noise levels in animal facilities are often high enough to produce uncontrolled physiological and psychological responses, the acoustic levels continue to be not as monitored as other environmental factors (lighting, temperature, humidity, etc).

Although noise has deleterious effects on rodent physiology, little is known about how the autonomic nervous system (ANS) is affected. Such information would indicate the state of emotional stress of the animals (Cerutti, Bianchi, & Mainardi, 1995). It is essential that the stress status of laboratory animals is monitored and controlled because stress may alter the experimental data obtained from those animals (Poole, 1997). One way of recording changes in the ANS is to measure the beat-to-beat changes in heart rate (i.e. heart rate variability, HRV). The variability is due to the changes in the activity of the sympathetic and

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parasympathetic nerves of the ANS, resulting in an alteration of sympathovagal balance. Acute social and psychological stressors affect the ANS by increasing sympathetic activation and decreasing parasympathetic activation, and these actions are reflected in changes in HRV. This article describes experiments in which groups of rats were exposed daily to a 15-min white noise regime (90 dB) for three weeks, to determine the effects of noise on the ANS (Burwell & Baldwin, 2006). Since stress responses can exert their influence by affecting ANS and endocrine output to the viscera (Mayer, Naliboff,, & Chang, 2001) further studies are described (Baldwin et al., 2006; Baldwin & Bell, 2007), in which a similar noise protocol was used to determine effects of noise on the integrity of the intestinal mucosa and mesenteric microvessels. The experimental methods are fully described in the publications cited above and just are outlined briefly here.

Method

Effects of Noise on ANS

Animals. Six male Sprague Dawley rats weighing 375 – 400 g were obtained from Charles River Laboratories (Portage, MI). Three of the rats were implanted at Charles River with PhysioTel® C50-PXT telemetry transmitters (Data Sciences International (DSI), St. Paul, MN), allowed to recover and shipped to Tucson, AZ. Upon arrival, each implanted rat was pair-housed with a non-implanted rat. No data were collected from the non-implanted rats; they served only as cage-mates for the implanted rats. Lights were on from 06:00 until 18:00. All research procedures and animal care were reviewed and overseen by the University of Arizona’s institutional animal care and use committee (IACUC).

Experimental Protocol. The same animals were used throughout the experiments and were subjected to 3 or 6 weeks of daily noise, separated by 3 weeks of quiet time. The white noise stimulus consisted of a combination of frequencies from 10 Hz to 10 kHz that were electronically generated and recorded onto a CD in a 15-minute segment played between 8:00 and 8:15 each morning. The total SPL of the white noise in the animal room was 90 dB as compared with the background noise of 50 dB. On three mornings per week, telemetry data were collected before (07:50 – 08:00), during (08:00 – 08:15) and after (08:15 – 08:25) delivery of the noise. During quiet (control) periods, no stimulus was delivered and telemetry data were collected for 15 minutes sometime between 07:50 and 08:25. For three nights per week, when the rats were in their active phase, during noise experiments and quiet periods, telemetry data were collected for 15 minutes sometime between 20:00 and 21:00. Three distinct frequency ranges were identified in the power spectrum of the data: very low frequency (VLF, 0.05 – 0.25 Hz), low frequency (LF, 0.25 – 1.00 Hz), and high frequency (HF, 1.00 – 3.00 Hz). Spectral analysis of HRV in times of emotional stress shows an increase in LF power, a decrease in HF power, and an increase in the LF/HF ratio.

Statistical Analysis. Data were compared under different conditions, within the same animal and during the same observation period, using the paired Student t-test, with $p < 0.05$ considered to be statistically significant, after checking that the data passed the tests for normality and equal variance. All data are presented as mean ± standard error of the mean (SEM).

Effects of Noise on Intestinal Mucosa and Microvascular Leakage

Animals. Male Sprague Dawley rats were housed in pairs in cages as described previously (Burwell & Baldwin, 2006) in two separate identical rooms. The one intentional difference between the environments in the two rooms was that the rats in one of the rooms received a white noise stimulus (90 dB) for 15 minutes each day at the same time every day, for 3 weeks, just before the lights were switched off at 18:00. These rats are referred to as ‘noise’ rats. The rats in the other room (‘quiet’ rats) did not receive the white noise stimulus. Both rooms were chosen so that they were remote from noise-producing equipment, such as cage washers. Apart from the investigator, the animal care technician was the only person who entered the rooms. Background noise in these rooms did not exceed 50 dB. A third group of rats were housed in the ‘noise’ room for 3 weeks and then moved to the ‘quiet’ room for a further 3 weeks to determine whether noise-induced effects on the intestinal mucosa could be reversed. These rats are referred to as ‘recovery’ rats.

Experimental Protocol. After three weeks the animals were anesthetized for surgery (Baldwin, Primeau, & Johnson, 2006). Half of the animals from each room had their intestinal ileum prepared for light and electron microscopy in order to evaluate degranulation of mucosal mast cells, migration of eosinophils from the blood into the lamina propria, mean width of villus lamina propria and integrity of the mucosal epithelium (8 rats per group). To prepare the ileum for microscopy, the portal vein was incised for use as a flow outlet and the intestinal microvasculature was perfused at physiological pressure with physiologically-buffered Karnovsky fixative. After one hour, an 8 cm segment from the ileum was excised and fixed for one more hour. The segment was then divided into 4 portions that were incubated in 2% diaminobenzidine, post-fixed in osmium tetroxide, dehydrated and embedded in Spurrs’ resin. The tissue was thick-sectioned for light microscopy and stained with 1% toluidine blue; it was also thin-sectioned for electron microscopy and stained with uranyl acetate and lead citrate. Thick sections were observed using an Axioplan microscope (Zeiss, Germany) equipped with 20x (numerical aperture 0.6) and 40x (numerical aperture 0.75; water immersion) Zeiss objectives. Thin sections were observed for electron microscopy using a model CM12 Phillips electron microscope (FEI Company, Tacoma WA).

In later experiments the presence of reactive oxygen species (ROS) was monitored in ‘noise’ and in ‘quiet’ rats by exposing a small segment of mucosa and suffusing it with dihydrorhodamine (DHR) 123 under epi-fluorescence microscopy. Niu et al. (1996) have shown that superoxide can be detected in the tissue using DHR which only fluoresces when in contact with ROS, specifically hydrogen peroxide-derived oxidants, and intra-vital digital micro-fluorography allows for quantification of oxidant production.

For the remaining animals (6 rats per group) the superior mesenteric artery was cannulated, the animals euthanized (Baldwin & Bell, 2007) and the mesenteric microcirculation was perfused for one minute with fluorescent albumin followed by fixative. The mesenteric tissue was then observed under epi-fluorescence microscopy to determine the mean number and area of leakage spots of fluorescent albumin per unit length of venule. In later experiments some of these rats were fed a special diet with increased concentrations of the antioxidants, vitamin E (10,000 IU/kg diet) and α-lipoic acid (1.65g/kg diet).

Statistical Analysis. For each parameter the Kruskal-Wallis test was applied for comparing different animals within the same group, and the Mann-Whitney Rank Sum test for comparing pairs of groups. The n was taken as the number of rats in a group and a p-value < 0.05 indicated significance.

Results

Effects of Noise on ANS

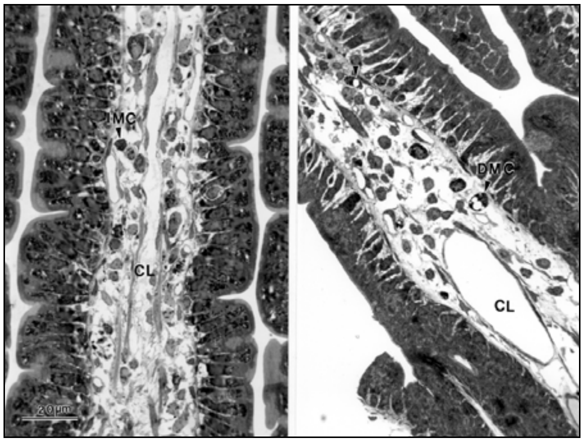
In response to white noise all 3 rats showed significant increases in HR and MAP (8% and 15%, respectively), compared to before the stimulus, and these parameters stayed elevated during the 10 minutes after the stimulus. No consistent or significant patterns were observed regarding the sympathetic nervous system (power of the LF range) in any of the rats in response to the white noise. However, an attenuation (12-13%) of the parasympathetic nervous system (power of the HF range) during and/or after the white noise was observed in all rats. Corresponding shifts in the sympathovagal balance (LF/HF ratio) were also observed during and after the white noise compared to before the stimulus. The increases in the LF/HF ratio were often small because the sympathetic nervous system remained relatively unchanged as the parasympathetic nervous system was attenuated.

Effects of Noise Stress on the Structure of the Intestinal Mucosa

Overall Appearance. Upon visual inspection, the small intestine of the 'noise' rats was noticeably more swollen and inflamed (hyperaemic) than seen in the 'quiet' rats. In addition, the Peyers' patches along the whole length of the jejunum and ileum were more swollen, suggesting increased activation of the immune system.

Light Microscopy. Longitudinally cut thick sections of parts of villi from a 'quiet' rat and a 'noise' rat are shown in Figures 1a and 1b, respectively. An intact mast cell (IMC), identified by its stained granules, in the lamina propria and adjacent to the central lacteal (CL) can be seen in Figure 1a. Degranulated mast cells (DMC) in the lamina propria can be seen in Figure 1b. There were significantly more degranulated mast cells per villus cross-section in the 10 villi closest to each edge of each Peyers' patch examined in 'noise' rats than in 'quiet' rats (3.95 ± 0.80 (SEM), 60 villi versus 0.35 ± 0.29, 80 villi). The Kruskal-Wallis test demonstrated that there was much greater variance between groups ($p<0.001$) than within groups ($p = 0.06$). 'Recovery' rats did not show a significant reduction in the number of degranulated mast cells, compared to the 'noise' rats (2.37 ± 0.83, 115). Similar results with degranulated mast cells were obtained when the 'noise' and 'quiet' rooms were reversed. Villi near Peyers' patches showed 2.77 ± 0.72 and 0.39 ± 0.48 for 'noise' rats and 'quiet' rats respectively. A one-way blocked ANOVA test demonstrated a significant difference between 'noise' and 'quiet' groups, but not between rooms, *per se* indicating that the data were not confounded by intrinsic differences between the rooms themselves. In villi near Peyers' patches significantly more eosinophils per villus section could be seen in the lamina propria of 'noise' rats than of "quiet" rats (9.46 ± 0.44, 60 villi versus 4.58 ± 0.38, 60 villi.)

Overall, the intestinal villi from 'noise' rats were significantly more edematous than those from 'quiet' rats, as assessed by measurements of villus lamina propria width using light microscopy. The mean villus widths of the 'noise', 'quiet' and 'recovery' groups were 57.0 ± 0.9, 39.0 ± 0.7 and 59.0 ± 0.7 μm, respectively (4 animals/group, 40 villi /animal). The distended central lymphatic vessels in villi from 'noise' rats (compare CL in Figures 1a and 1b) and the greater area of cell-free tissue indicate that the increased width of the villus lamina propria was produced by edema, rather than by increased cell growth. The villi of the 'recovery' group were just as edematous as those from the 'noise' group, consistent with the finding that the number of degranulated mast cells also remained high in this group.



a. **b.**

Figure 1. Light micrographs of longitudinally cut thick sections of parts of villi from a “quiet” rat (a) and a “noise” rat (b). The sections were stained with toluidine blue. See enlarged central lacteal (CL) in (B). Scale bar: 20 μm.

Electron Microscopy. Representative photomicrographs of the mucosal epithelium from the three groups of rats are shown in Figures 2a-c. Figure 2a demonstrates that in ‘quiet’ rats, the epithelial cells (E) were generally attached to each other and to the basement membrane. Very few eosinophils were evident. ‘Noise’ room rats, on the other hand, (Figure 2b), usually demonstrated large numbers of epithelial cells that were separating from each other and, in places, were separated from the basement membrane. Epithelial cells were considered to be separated from each other if a distinct gap could be seen between adjacent cells which extended in length from the basement membrane to the top of the cell nuclei (nearest the epithelial surface microvilli). Epithelial cells were considered to be separated from the basement if a gap appeared between the main body of the cell and the remnants of the cell adhering to the basement membrane.

Many intestinal villi contained eosinophils (EO) and partially degranulated mast cells (MC). In figure 2b an inter-epithelial leukocyte (IEL) and capillary (C) are also visible. Three weeks in the quiet room, following 3 weeks in the noise room, produced some epithelial repair (Figure 2c). Although the epithelial cells were still somewhat separated from each other, and extended long, tenuous cytoplasmic projections from their junctional aspects, the cells were rarely separated from the basement membrane.

Presence of Reactive Oxygen Species in Intestinal Mucosa

Significantly more intense DHR fluorescence was seen in the villus epithelium of ‘noise’ rats (58 ± 10 (SD), arbitrary units, 9 rats, 93 villi), compared to ‘quiet’ rats (35 ± 13, 3 rats, 55 villi), and fluorescent granules appeared in the lamina propria of ‘noise’ rats. These results imply that the noise-induced mucosal damage was oxidative in nature

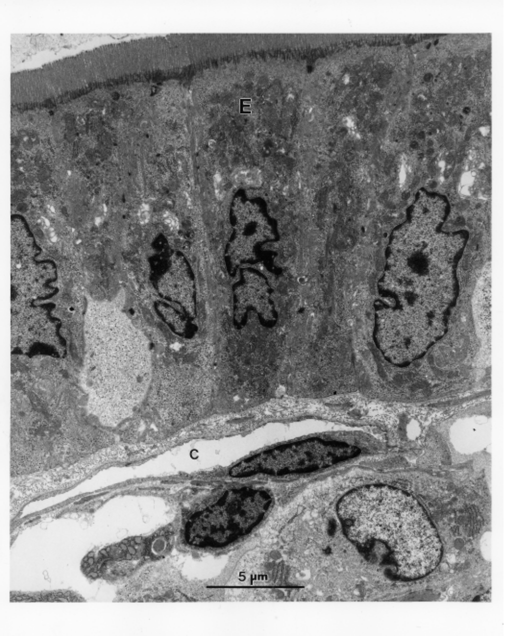


Figure 2a. Demonstrates that in "quiet" rats, the epithelial cells (E) were generally attached to each other and to the basement membrane. Very few eosinophils were evident.

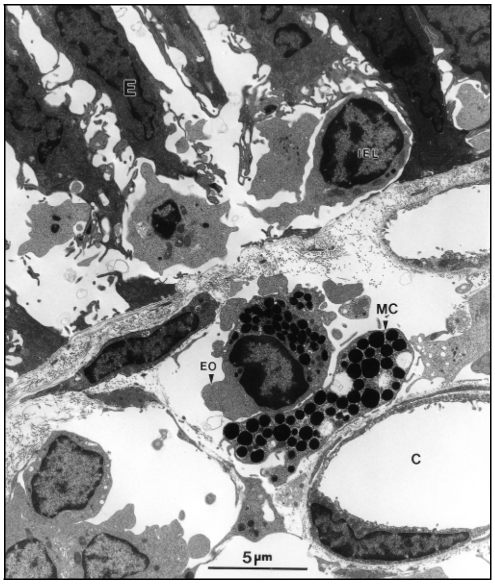


Figure 2b. "Noise" room rats usually demonstrated large numbers of epithelial cells that were separating from each other and, in places, were separated from the basement. Many intestinal villi contained eosinophils (EO) and partially degranulated mast cells (MC). In this figure an interepithelial leukocyte (IEL) and capillary (C) are also visible.

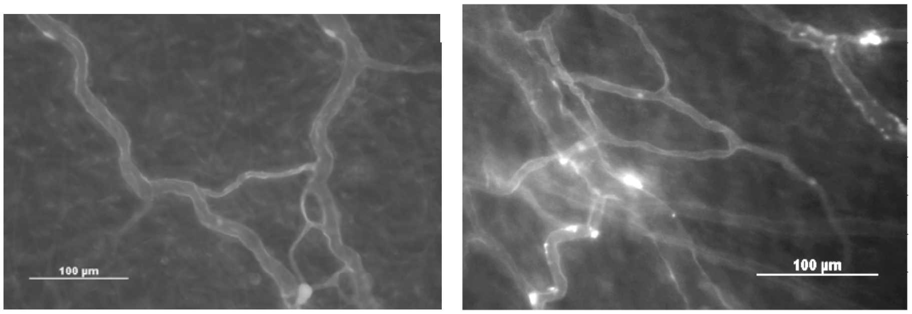
Figure 2c. Shows that three weeks in the quiet room, after 3 weeks in the noise room, resulted in some epithelial repair. Scale bars: 5 μm.

Effects of Noise Stress on Microvascular Leakage

Rats from the noise group (n=9) demonstrated significantly more leakage sites (3.84 ± 0.46 (SEM) x 10^{-3} μ^{-1}, n=95 venules) and a significantly greater leakage area per length of venule (3.20 ± 0.49 μ^2/μ), than rats from the quiet group (n=10) (1.38 ± 0.26 (SEM) x 10^{-3} $\mu^{-1}$and 0.30 ± 0.06 μ^2/μ, respectively, n=123 venules) or the recovery group (n=6) (1.40 ± 0.24 (SEM) x 10^{-3} μ^{-1} and 0.63 ± 0.16 μ^2/μ, respectively, n=108 venules). Rats from the recovery and quiet groups showed similar numbers of leaks per length of venule, but the recovery group demonstrated significantly greater leak area per venule length than the quiet group, although still significantly less than for the noise group . The percentages of venules observed that contained leaks in the noise, quiet and recovery groups were 73%, 37% and 39%, respectively. Light micrographs of typical microvascular networks from a quiet group rat and a noise group rat, after perfusion with FITC-albumin, are shown in figures 3a and 3b. Extensive fluorescent leaks are visible in the network from the noise group rat but few leaks can be seen in the network from the quiet group rat.

Mast Cell Degranulation

The mean number of degranulated mast cells per microscopic field of view (1.13 mm^2) was significantly greater for the noise group (13.75 ± 0.77) and the recovery group (12.09 ± 0.90) than for the quiet group (7.43 ± 0.36). These results indicate that daily noise markedly increases microvascular permeability in rats, and that this change may be stimulated by mast cell degranulation.



a. **b**.

Figure 3. Light micrographs of mesenteric microvascular networks after perfusion with fluorescent (FITC)-labeled albumin. (a) Network from an animal that had not been exposed to daily noise. No leaks can be seen. (b) Network from an animal that had been exposed to daily noise. Many leaks of FITC-albumin from the venules are visible. Scale bars: 100 μm.

Antioxidants and Microvascular Leaks

Vitamin E with α-lipoic acid significantly reduced noise-induced venular leakage to fluorescent albumin although not to control levels. The quiet control animals (n=6) had a mean number of leaks per micron length of venule of 0.44 ± 0.06 (SEM) x 10^{-2} μ^{-1}, (n= 341 venules), compared to 3.05 ± 0.32 (SEM) x 10^{-2} μ^{-1}, (n= 294 venules, n=6 rats) for noise alone, and 1.04 ± 0.19 (SEM) x 10^{-2} μ^{-1}, (n= 304 venules, n=6 rats), for noise and vitamin E with α-lipoic acid. The results for leak area per micron length of venule were similar, corresponding values being 0.44 ± 0.10 (SEM) $\mu^2\mu^{-1}$, 6.60 ± 0.88 (SEM), 1.90 ± 0.51(SEM) and 2.33 ± 0.29 (SEM). Thus leak number was significantly reduced by about 66% with vitamin E and α-lipoic acid. Leak area was reduced even more, by 70% with vitamin E and α-lipoic acid.

Discussion

Exposure of rats to 90 dB white noise every day increases both HR and MAP when recorded during, and immediately after, the noise. It could be argued that the increases in HR and MAP produced by noise could have been caused by increased activity rather than by a stress response. However, that is unlikely in these experiments because apart from a startle response, lasting a second or so on the first day of the noise, very little activity was observed at this time. Thus the increased cardiovascular parameters were caused by a stress response. In this study we show that a decrease in the activation of the parasympathetic nervous system is responsible for the cardiovascular response, rather than an increased activity of the sympathetic autonomic branch. This effect is not surprising because the parasympathetic branch is dominant when animals are asleep, as was the case when the rats were exposed to the noise. The elevations of HR and MAP seen during the daily exposure to white noise are consistent with data obtained by other investigators from rodents exposed to stressful situations, such as handling, restraint, cage-changes and injections (Sales, 1972; Kramer et al., 1993; Kramer et al., 2000; Sharp, Zammit, Azar, & Lawson, 2002; Sharp et al., 2003).

It might be argued that since the cardiovascular effects of noise only resulted in small increases in HR and BP (about 10-15% of initial values) that noise would not be a major confounding factor in rodent experiments. However, the stimuli used in these studies were only delivered once a day, at the same time every day and for short duration, unlike the audible sounds that routinely occur in animal facilities. As reported by other authors, noise levels peak many times during the day in an animal facility and contain a wide range of frequencies (Pfaff & Stecker, 1976; Sales et al., 1988; Milligan et al., 1993). Because noise levels in animal facilities tend to be poorly controlled, the cardiovascular state of the animals may also be poorly controlled and unpredictable. Although stress does not always compromise health and welfare, and in fact the stress response is necessary for survival in the wild, stress always disturbs the body's homeostasis and imposes a cost to the body, particularly when it is elicited repeatedly. This cost arises if stress-induced mediators, such as adrenal hormones, neurotransmitters, cytokines etc., are released too often.

Not only does exposure to 90 dB white noise alter cardiovascular parameters in rats; the small intestine and mesenteric microvessels become inflamed. It is not clear whether this response is mediated via the hypothalamic-pituitary-adrenal axis because accurate measures of plasma corticosterone concentrations before and during the noise could not be obtained without causing further stress to the animals. Windle et al. (1998) found that plasma corticosterone concentrations in rats varied periodically throughout the day but increased significantly in response to 114 dB noise for 10 min., if the onset of the noise coincided with the rising phase of a basal corticosterone pulse. This result suggests that the intestinal responses observed in the present study in response to noise may have been a stress response that was mediated via the hypothalamic-pituitary-adrenal axis.

The intestinal damage appeared to be oxidative in nature. Activated phagocytes, such as neutrophils, eosinophils and macrophages, are the best-recognized sources of free radicals and the intestinal mucosa of rats exposed to noise showed significantly larger numbers of eosinophils in the villi lamina propria compared to 'quiet' rats. These eosinophils were probably recruited by the presence of degranulated mast cells. Activated mast cells can release interleukin-5 (IL-5) that attracts eosinophils (28). In fact our electron micrographs often demonstrated eosinophils and degranulated mast cells in close juxtaposition (Figure 2b). The ROS and other products released by eosinophils may be partly responsible for the epithelial disruption observed near the Peyers' patches of 'noise' rats.

In summary, exposure of rodents to chronic noise appears to induce a stress response, as demonstrated by behavioral changes and increases in HR and MAP, that is accompanied by intestinal and microvascular inflammation, possibly triggered by increased activation of the immune system.

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The Effect of Transportation Noise on Health and Cognitive Development: A Review of Recent Evidence

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Noise from transport is an increasingly prominent feature of the urban environment. Whilst the auditory effects of noise on humans are established, non-auditory effects - the effects of noise exposure on human health, well-being and cognitive development - are less well established. This narrative review evaluates recent studies of aircraft and road traffic noise that have advanced or synthesized knowledge about several aspects of adult and child health and cognition. Studies have demonstrated a moderate effect of transport noise on hypertension, cardiovascular disease and catecholamine secretion: there is also evidence for an effect on psychological symptoms but not for the onset of more serious clinically defined psychiatric disorder. One way noise may affect health is through annoyance: noise causes annoyance responses in both children and adults and annoyance may cause stress-responses and subsequent illness. Another possible mechanism is sleep disturbance: transport noise has been found to disturb sleep in laboratory and field studies, although there is evidence for adaptation to noise exposure. For children effects of aircraft and road traffic noise have been observed for impaired reading comprehension and memory skills: there is equivocal evidence for an association with blood pressure. To date most health effects have been very little researched and studies have yet to examine in detail how noise exposure interacts with other environmental stressors. In conclusion, noise is a main cause of environmental annoyance and it negatively affects the quality of life of a large proportion of the population. In addition, health and cognitive effects, although modest, may be of importance given the number of people increasingly exposed to environmental noise and the chronic nature of exposure.

Exposure to noise in the environment from transport sources is an increasingly prominent feature of the environment. The growing demand for air and road travel means that more people are being exposed to noise, and noise exposure is increasingly being seen as an important environmental public health issue.

The direct effect of sound energy on human hearing is well established and accepted. Exposure to continuous noise of 85-90 dBA (decibels, A-weighted to approximate the typical sensitivity of the human ear) can lead to progressive hearing loss and changes in threshold sensitivities (Kryter, 1985): similar damage can be caused by exposure to a smaller number of noise events, if the sound energy is great (>135 dB Lc_{pk}, Babisch, 2005) (LC_{pk} is a measurement of peak sound pressure level over a specified period). Auditory effects of noise have typically been observed in certain industrial occupations, hence protective legislation requiring hearing protectors to be worn, however, effects are also increasingly being observed due to entertainment noise from amplified music and MP3 players.

In contrast, non-auditory effects of noise on human health are not the direct result of sound energy. Instead, these effects are the result of noise as a general stressor: thus the use of the term noise not sound: noise is unwanted sound. Non-auditory effects of noise include sleep disturbance, mental health, physiological

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function, and annoyance, as well as effects on cognitive outcomes such as speech communication, and cognitive performance (WHO, 2000). These effects of noise are less well established and accepted than auditory effects.

Noise could indirectly result in poor health in several ways. Firstly, acute noise exposure directly causes a number of predictable short-term physiological responses such as increased heart rate, blood pressure, and endocrine outputs. Chronic noise exposure may cause longer-term activation of these responses and subsequent symptoms and illness. Whether acclimation of the physiological response occurs with long-term noise exposure is not certain. Secondly, these physiological responses may be activated by annoyance. Noise causes annoyance, especially if an individual feels their activities are being disturbed or if it causes difficulties with communication. In some individuals, this annoyance may lead to stress responses, and potentially to subsequent symptoms and illness. However, there is little evidence to directly support the annoyance pathway as a mechanism for non-auditory effects. Habituation[1] of behavioral or psychological responses may occur with long-term exposure for certain individuals or for certain types of behavioral responses: however, the reduction of a behavioral or psychological response may not necessarily result in the acclimation of a physiological response.

This narrative review evaluates recent studies of transport noise that have advanced or synthesized the knowledge about several non-auditory effects: namely, hypertension and coronary heart disease, stress hormones, sleep disturbance, mental health, and cognitive development: effects for children and adults are discussed. Recent years have seen several methodological advancements in the field including the use of larger epidemiological community samples; better characterization of noise measurement; and more detailed measures of health. Evidence from longitudinal studies is beginning to emerge and studies have started to examine exposure-effect relationships, to identify thresholds for noise effects on health and cognition which can be used to inform guidelines for noise exposure. There has also been a better assessment of confounding factors: noise exposure and health are often confounded by socioeconomic position, so individuals living in poorer social circumstances are more likely to have poorer health, as well as be exposed to noise. Therefore, measures of socioeconomic position need to be taken into account when examining associations between noise exposure and health. Furthermore, factors that confound physiological health outcomes such as smoking, diet, and activity levels also need to be measured and adjusted for in analyses.

Review of the Evidence

Noise Exposure Assessment

Assessments of noise exposure use established metrics of external noise exposure which indicate the average sound pressure level for a specified period

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[1] Habituation is distinguished from acclimation in this paper in the following way. Habituation refers to the lessening of a behavioural or psychological response to noise, with repeated or chronic exposure: e.g. a reduction in sleep disruption or annoyance responses. Acclimation refers to the lessening of a physiological response to noise, with repeated or chronic exposure: e.g. a reduction in cortisol levels.

using dBA as the measurement unit (dBA is the unit of A-weighted sound pressure level where A-weighted means that the sound pressure levels in various frequency bands across the audible range have been weighted in accordance with differences in hearing sensitivity at different frequencies). Metrics typically employed are L_{Aeq16} and L_{day} which indicate average noise exposure (in dBA units) over a 16 hour daytime period usually 7am-11pm; L_{night} which indicates noise exposure at night (11pm-7am); and L_{dn} which combines the day and night measures to indicate average noise exposure over the 24 hour period, with a 10dB penalty added to the night-time noise measure. These metrics are usually modeled using Geographical Information Systems. Some studies measure noise exposure in the community, which is less reliable if measurements cover short time-periods. Studies have also examined exposure to maximum noise levels (e.g. L_{Amax} - maximum sound pressure in dBA units), as in pathophysiological terms it is not clear whether overall 'dose' of noise exposure is important in determining effects on health or whether peak sound pressure of events or the number of noise events might be important.

Whilst people are often exposed to sounds from more than one source, to date, studies have tended to focus upon only one type of noise exposure, such as aircraft or road traffic noise. Studies that have examined ambient noise and, thus, exposure to more than one source (e.g. Lercher, Evans, Meis, & Kofler, 2002) have not been able to attribute health effects to specific noise sources within the environment. Little is known about the effects on health of combined exposure and it is possible that combined exposure has a cumulative impact or it could be synergistic (see Nilsson & Berglund, 2001). Furthermore, noise exposure often co-occurs with air pollution, because of source-specificity, and studies have yet to explore the implications of probable interactions between noise and air pollution for human health.

Annoyance

It is beyond the limits of this paper to include a review of the effect of noise exposure on annoyance responses. Annoyance is a multifaceted psychological concept including both evaluative and behavioral components (Guski, Schuemer, & Felscher-Shur, 1999), used to describe negative reactions to noise. Annoyance is an important health effect of noise (WHO, 2000). Annoyance is the most reported problem caused by transport noise exposure and is often the primary outcome used to evaluate the effect of noise on communities. Acoustic factors such as noise source, exposure level and time of day of exposure only partly determine an individual's annoyance response: many non-acoustical factors such as the extent of interference experienced, ability to cope, expectations, fear associated with the noise source, noise sensitivity, anger, and beliefs about whether noise could be reduced by those responsible influence annoyance responses (WHO, 2000). Studies have derived exposure-effect associations for the effects of different noise sources on annoyance responses (Miedema & Vos, 1998; Miedema & Oudshoorn, 2001), finding that aircraft noise produces greater annoyance responses than road traffic noise at the same level of exposure.

Hypertension & Coronary Heart Disease

Epidemiological evidence for effects of noise on coronary heart disease and coronary risk factors in adults has been mixed. These inconsistencies may be attributable to the use of varying outcome measures, ranging from weaker self-report measures of hypertension and drug use to more objective measures of blood pressure: as well as to whether confounding factors associated with coronary heart disease such as age, gender, smoking, and body mass index have been taken into account.

Evidence for effects of transport noise exposure on hypertension and ischaemic heart disease is strengthening (Babisch, 2006a). The unique multi-centre HYENA study found increased risk of hypertension related to long-term noise exposure, for both night-time aircraft noise and daily average road traffic noise, for individuals who had lived near to one of six major European airports for five years or more (Jarup et al., 2008). The analyses adjusted for important confounders (age, gender, body mass index, alcohol intake, physical activity, education) and had a good measure of hypertension based upon blood pressure measurements, supplemented by self-reports of a diagnosis of hypertension and/or use of anti-hypertensive medication. Another recent study demonstrated an effect of aircraft noise exposure on the use of anti-hypertensive drugs around Cologne-Bonn airport, particularly for those exposed to night noise (Greiser, Greiser, & Janhsen 2007): however, no data about confounding factors was included in the analyses. A study of road traffic noise and medication use which did adjust for confounders found an effect but only for subjects between 45-55 years and for those exposed to >55 dBA L_{den} (de Kluizenaar, Gansevoort, Miedema, & de Jong, 2007). A study of over 28,000 blood pressure records from around Kadena airport in Okinawa, Japan, found a dose-response relationship between aircraft noise exposure and systolic blood pressure (Odds ratio (OR)=1.29 95% Confidence Intervals (CI)=1.13-1.47) after taking age, gender and body mass index into account: however, no effect was found for diastolic blood pressure, although a weaker measure of self-reported hypertension did show an association with noise exposure (Matsui et al., 2001). Similarly, a study around Arlanda airport in Sweden found that self-reported hypertension was more prevalent among people exposed to average aircraft noise levels of at least 55dBA (LA_{eq}) or maximum levels above 72 dBA (L_{Amax}), after taking age, gender, smoking and education into account (Rosenlund, Berglind, Pershagen, Jarup, & Bluhm, 2001). A recent Swedish study found an association between road traffic noise exposure and self-reported hypertension, after taking age, gender, smoking, occupation and house type into account (Bluhm, Berglind, Nordling, & Rosenlund, 2007): (OR=1.38 95%CI 1.06-1.80 per 5dBA increase in noise exposure). Associations were stronger for those who had lived at the address for more than 10 years and for females. However, a German study of incidence of myocardial infarction found an effect of road traffic noise only for males who had lived at their address for at least 10 years (Babisch, Beule, Schust, Kersten, & Ising, 2005). An effect of aircraft noise on incidence of myocardial infarction has also been demonstrated for individuals exposed to >50 $L_{Aeq24\ hours}$, with stronger associations found for older subjects (Eriksson et al., 2007).

Meta-analyses have established that noise has a significant effect on risk for hypertension and coronary heart disease. A meta-analysis found that for aircraft noise a 5 dBA rise in noise was associated with a 25% increase in risk of hypertension compared with those not exposed to noise (van Kempen et al., 2002). Two meta-analyses of the effect of road traffic noise exposure on coronary heart disease, where outcomes ranged from blood pressure and hypertension to ischaemic heart disease and myocardial infarction found that environmental noise above 65-70dBA was associated with a 10 to 50% increase in risk (Babisch, 2000; 2006a). A recent study estimated that 3% of the total cases of myocardial infarction in Germany are attributable to road traffic noise (Babisch, 2006b).

There is some evidence for annoyance as a possible mediating factor between noise and cardiovascular outcomes. A ten year study of nearly 4000 men from Caerphilly in Wales, found that high annoyance at baseline predicted incidence of coronary heart disease many years later but only for men who were free of chronic disease at baseline: for men with chronic disease at baseline, noise exposure but not annoyance was associated with the incident of coronary heart disease (Babisch, Ising, & Gallacher 2003). This suggests that noise annoyance may have a moderating effect on the development of coronary heart disease. A recent study of 3000 residents in a city in Serbia found that men who were extremely annoyed by traffic noise had an increased risk of reporting hypertension and myocardial infarction, compared with those not annoyed; no similar relationship was observed for women (Belojevic & Saric-Tanaskovic, 2002). However, these cross-sectional findings should be treated cautiously, as men with cardiovascular disease may be more likely to develop annoyance in response to noise. Further, longitudinal research on annoyance as a mediating factor is required.

Epidemiological evidence for effects of noise on coronary risk factors in children has been mixed, which may be due to a number of methodological problems including lack of control for confounding factors, such as parental blood pressure, as well as being limited to considering the effect of noise exposure at school (van Kempen et al., 2006). A cross-sectional study around Schiphol (Amsterdam) and Heathrow (London) airports found an effect of aircraft noise at home, as well as night time aircraft noise exposure on systolic and diastolic blood pressure for 9-10 year old children but no effect for aircraft noise at school (van Kempen et al., 2007); these findings suggest that it may specifically be aircraft noise exposure during the evening and night that affects children’s blood pressure. For road traffic noise exposure, this study found that exposure at school was associated with decreased systolic and diastolic blood pressure. A study of younger children, aged 3-7 years, found an association between night-time road traffic noise exposure at home and systolic blood pressure, as well as an effect of day-time road traffic noise exposure at kindergarten (Belojevic, Jakovljevic, Stojanov, Paunovic, & Ilic, 2007). Whilst these recent studies are methodologically stronger than previous studies, additional studies focusing on the effect of different noise sources, in different settings are required before further conclusions can be drawn about noise effects on children’s blood pressure.

Stress Hormones

Studies of endocrine markers of noise exposure have demonstrated conflicting results. Adrenaline, noradrenaline and cortisol, all of which are released by the adrenal glands in situations of stress, have been examined. One difficulty in studying these hormones is that salivary and urinary measures of these hormones are easily biased by unmeasured factors; studies also often have small sample sizes. Cortisol, in particular, is difficult to examine, as it has diurnal variation and is usually high in the morning and low in the evening making it difficult to measure effectively.

Evidence of effects of road traffic noise exposure on endocrine markers in adults is weak and inconclusive (see Babisch, 2003): one study found an effect of being exposed to levels above 65 dBA for raised cortisol but not adrenaline levels, although this was on a sample of only 28 individuals (Poll, Straetemans, & Nicolson, 2001). A larger study found an effect of road traffic noise on noradrenaline but not adrenaline (Babisch, Froome, Beyer, & Ising, 2001).

The findings of studies of noise effects on endocrine markers in children are similarly mixed, despite larger sample sizes. Two of the largest studies to date, examining children living near Heathrow airport in West London, found no association between aircraft noise exposure above 66 dBA L_{Aeq} and morning salivary cortisol measures (Haines, Stansfeld, Job, Berglund, & Head, 2001a), nor, in a similar study, between aircraft noise exposure above 62 dBA L_{Aeq} and twelve-hour urinary cortisol, adrenaline and noradrenaline measures (Haines et al., 2001b).

Overall, further studies on the effects of noise on endocrine responses are required. Previous studies of adults are hampered by their small sample sizes, which may reflect the unwillingness of individuals to provide biological samples. As well as inconclusive evidence, little is known about whether raised endocrine responses observed in some studies represent normal short-term responses to environmental stress or a longer-term activation of the endocrine system. There is a lack of understanding about how long-term activation of the endocrine system links to health impairment and whether endocrine responses can habituate to noise exposure is not certain.

Sleep Disturbance

Exposure to night-time noise can potentially interfere with the ability to fall asleep, shorten sleep duration, cause awakenings and reduce perceived quality of sleep (Michaud, Fidell, Pearsons, Campbell, & Keith, 2007) and could affect health in two ways. Firstly, by impacting on biological responses, such as increasing heart rate, awakenings and sleep quality, as the individual responds to stimuli in the environment (HCN, 2004). Activation of some biological responses could have long-term effects on health. Secondly, sleep disturbance can impact on well-being, causing annoyance, irritation, low mood, fatigue, and impaired task performance (HCN, 2004). In terms of noise exposure, it has been suggested that continuous noise exposure is more likely to interrupt REM sleep, whilst intermittent noise is more likely to interfere with slow wave sleep (Passchier-Vermeer, Vos, Steenbekkers, van der Ploeg, & Groothuis-Oudshoorn, 2002).

Research on evidence for an effect of noise exposure on sleep disturbance is generally stronger from laboratory studies than from field studies. However, comparison between the findings of laboratory and field studies can be limited as laboratory studies tend to involve individuals who are not chronically exposed to noise, whereas, individuals who are chronically exposed to noise may exhibit habituation, where sleep disturbance becomes diminished, following a period of chronic noise exposure. A notable recent laboratory study tried to simulate the effect of aircraft noise exposure on sleep for 128 subjects over 13 nights (Basner & Samel, 2005). Prior to the experiment, the subjects spent a noise-free adaptation night in the laboratory, as sleep is initially affected by the laboratory setting. The experiment demonstrated a prominent first night exposure effect of noise on sleep disturbance, which wore off by the second night, which was interpreted as indicating habituation to noise exposure. On the subsequent nights no significant change in sleep structure was observed if the number of noise events and maximum sound pressure level did not exceed 4*80dB, 8*70dB, 16*60dB, 32*55dB, and 64*45dB. However, this study is still limited by having examined short-term exposure to aircraft noise, and conclusions cannot be drawn from these findings about the long-term effects of exposure to aircraft noise on sleep structure (Basner & Samel, 2005).

Overall, community studies of noise exposure, examining individuals in their homes exposed to their usual noise exposures at night, have found evidence for a direct effect of noise on sleep disturbance. However, recent reviews, assessing the strength of the evidence, differ in their conclusions. A recent synthesis of field studies concluded that there was sufficient evidence that night-time noise exposure was causing direct biological responses, at approximately 40dB SEL (Sound Exposure Level), as well as affecting well-being and quality of sleep (HCN, 2004). This report found that evidence was weaker for an effect of night-time noise on social interaction, task performance, on specific disease symptoms or on fatal accidents at work. Similarly, a meta-analysis of 24 field studies, including almost 23,000 individuals exposed to night-time noise levels ranging from 45-65dBA, found that aircraft noise was associated with greater self-reported sleep disturbance than road traffic, and road traffic noise with greater disturbance than railway noise (Miedema & Vos, 2007). This analysis also found an inverted U-shaped association between noise induced sleep disturbance and age, with the greatest disturbance being found for individuals aged 50-56 years. The study concluded that transportation noise was a widespread factor affecting sleep.

In contrast, a recent review focusing solely on aircraft noise exposure concluded that findings about noise-induced sleep disturbance differ considerably (Michaud et al., 2007). The review of five studies found little evidence for an effect of outdoor noise on sleep disturbance, whilst indoor noise was associated more closely with sleep outcomes. However, there was evidence from several studies that a greater number of awakenings occur that are either spontaneous or attributable to other noise in the home, than are attributable to aircraft noise.

The equivocal conclusions of these reviews may be because the studies are comparing studies which examine a range of outcomes ranging from more objective measures of sleep disturbance, such as polysomnography and wrist-actimetry, which measures sleep disturbance based on body movements, to subjective measures, such as self-reported sleep disturbance. The measurement of sleep disturbance is challenging, as no one physical or psychological measure is accurate or reliable. The equivocal conclusions may also reflect different exposure assessments: some studies use external noise exposure, whilst others measure noise exposure in the bedroom (Miedema & Vos, 2007).

Evidence from recent studies where change in night-time noise exposure has occurred also provides some evidence for an association between noise and sleep disturbance. Whilst a Swedish study found that a reduction in road traffic noise exposure caused by a new road tunnel was associated with improvements in sleep quality and alertness, measured by actimetry and subjective reports (Öhrström, 2002), a change in night-time aircraft noise exposure at two airports was not associated with changes in noise induced sleep disturbance (Fidell, Pearsons, Tabachnick, & Howe, 2000). Few studies have included children in studies of sleep disturbance: one study used sleep logs and actigraphy to compare the effect of road traffic noise on child and parent sleep, finding an exposure-effect relationship between road traffic noise exposure and sleep quality and daytime sleepiness for children, and an exposure effect association between road traffic noise and sleep quality, awakenings, and perceived interference from noise for the parents (Öhrström, Hadzibajramovic, Holmes, & Svensson, 2006).

In conclusion, overall, there is sufficient evidence that night-noise can disturb sleep, as well as potentially affect well-being. The field still lacks longitudinal evidence, which would enable the causal association between noise exposure and the long-term health implications of biological responses and impaired well-being, related with night-time noise exposure to be examined.

Psychological Health

Given the effect of chronic noise exposure on annoyance responses, it has been hypothesized that chronic noise exposure could have a serious effect on psychological health, as noise can cause annoyance and prolonged annoyance could lead to poor psychological health (McLean & Tarnopolsky, 1977). The effect of noise on psychological health is complicated as studies have found that poorer psychological health is also associated with greater annoyance responses (Tarnopolsky, Barker, Wiggins, & McLean 1978; van Kamp, Houthuijs, van Wiechen, & Breugelmans, 2007) and greater noise sensitivity (Stansfeld, Clark, Jenkins, & Tarnopolsky, 1985; Miyakawa, Matsui, & Hiramatsu, 2007).

Studies of adults have found that noise exposure relates to an increase in the number of psychological symptoms reported, such as symptoms of anxiety and depression, rather than to clinically diagnosable psychiatric disorders (Tarnpolsky et al., 1978; Stansfeld, Sharp, Gallacher, & Babisch, 1993). A later study examined nearly 6000 inhabitants around two military airbases in Japan, and found that those exposed to noise levels of 70 L_{dn} or above had higher rates of mental instability and depressiveness (Hiramatsu, Yamamoto, Taira, Ito, & Nakasone, 1997). Additionally, those who were more annoyed showed higher risk of mental and somatic symptoms. Unfortunately, this study did not assess psychiatric diagnoses, but a recent study has found associations between noise exposure and psychiatric diagnoses as measured by the Composite International Diagnostic Interview (Hardoy et al., 2005), with individuals living close to an airport showing higher frequency of 'generalized anxiety disorder' and 'anxiety disorder not otherwise specified', compared with matched controls from another area. These findings need replication and unfortunately, it is not possible to distinguish cause from effect in these studies, which are all cross-sectional, measuring noise and psychological health concurrently. A longitudinal study around Schiphol airport in Amsterdam found no association between noise exposure levels and mental health either at baseline, or after the opening of a fifth runway (van Kamp et al., 2007).

Several recent studies have examined associations between noise exposure and children's psychological health. The Tyrol Mountain Study compared child and teacher ratings of psychological health for children exposed either to <50 or > 60 dBA L_{dn} (Lercher et al., 2002). Ambient noise (road and rail) exposure was associated with teacher ratings of psychological health but was only associated with child rated psychological health for children with early biological risk (low birth weight or premature birth). A study of children attending school near Heathrow airport in London also found that noise exposed children had higher levels of psychological distress (Haines et al., 2001b), as well as a higher prevalence of hyperactivity. The RANCH study, the largest study of road traffic and aircraft noise exposure on children's psychological health to date, failed to replicate an effect of either aircraft or road traffic noise on psychological distress in samples from the Netherlands, Spain or the UK (Stansfeld et al., 2005): however, the effect of aircraft noise on hyperactivity was replicated.

Overall, studies suggest that for both adults and children noise exposure is probably not associated with serious psychological illness but there may be effects on well-being and quality of life: this conclusion is limited by the lack of longitudinal research in this field. There is a need for further research, especially to establish if hyperactive children are more susceptible to stimulating environmental stressors such as noise.

Cognitive Development

It has been suggested that children may be especially vulnerable to effects of environmental noise as they may have less cognitive capacity to understand and anticipate environmental stressors, as well as a lack of developed coping repertoires (see Stansfeld, Haines, & Brown, 2000). Exposure during critical periods of learning at school could potentially impair development and have a lifelong effect on educational attainment. Whilst a recent study suggests that children may not be more susceptible to environmental noise effects on cognitive performance than adults (Boman, Enmarker, & Hygge, 2005), studies have established that children exposed to noise at school experience some cognitive impairments, compared with children not exposed to noise: tasks affected are those involving central processing and language such as reading comprehension, memory and attention (Haines et al. 2001a; 2001b; Evans & Maxwell, 1997; Cohen, Glass, & Singer, 1973).

One of the most interesting and compelling studies in this field is the naturally occurring longitudinal quasi-experiment reported by Evans and colleagues, examining the effect of the relocation of Munich airport on children's health and cognition (Evans, Hygge, & Bullinger, 1995; Evans, Bullinger & Hygge, 1998; Hygge, Evans, & Bullinger, 2002). In 1992 the old Munich airport closed and was relocated. Prior to relocation, high noise exposure was associated with deficits in long term memory and reading comprehension. Two years after the closure of the airport, these deficits disappeared, indicating that noise effects on cognition may be reversible if exposure to the noise ceases. Most convincing was the finding that deficits in memory and reading comprehension developed over the two year follow-up for children who became newly noise exposed near the new airport.

The recent large scale RANCH study, which compared the effect of road traffic and aircraft noise on children's cognitive performance in the Netherlands, Spain and the UK, found a linear exposure-effect relationship between chronic aircraft noise exposure and impaired reading comprehension and recognition memory, after taking a range of socioeconomic and confounding factors into account (Stansfeld et al., 2005). No associations were observed between chronic road traffic noise exposure and cognition, with the exception of episodic memory, which surprisingly showed better performance in high road traffic noise areas. Neither aircraft noise nor road traffic noise affected attention or working memory. In terms of the magnitude of the effect of aircraft noise on reading comprehension, a 5dBA L_{eq16} increase in aircraft noise exposure was associated with a 2 month delay in reading age in the UK and a 1 month delay in the Netherlands (Clark et al., 2006): this association remained after adjustment for aircraft noise annoyance and cognitive abilities including episodic memory, working memory and attention. Thus, whilst aircraft noise has only a small effect on reading comprehension, it is possible that children may be exposed to aircraft noise for many of their childhood years and the consequences of long-term noise exposure on reading comprehension and further cognitive development remain unknown.

The findings of the RANCH study, along with previous findings (Haines et al., 2001b; Hygge et al., 2002) suggest that noise may directly affect reading comprehension or could be accounted for by other mechanisms including teacher and pupil frustration (Evans & Lepore, 1993), learned helplessness (Evans & Stecker, 2004) and impaired attention (Cohen et al., 1973; Evans & Lepore, 1993). It has been suggested that children may adapt to chronic noise exposure by filtering or tuning out the unwanted noise stimuli: this filter may then be applied indiscriminately to situations where noise is not present, leading to learning deficits through lack of attention.

Discussion

In summary, there is convincing evidence for non-auditory effects of noise on health and cognition for some outcomes. Evidence for the effect of aircraft noise on children's cognitive performance is strong. Evidence for health outcomes is increasing and there is consistent evidence for a small but significant effect of transport noise on hypertension and coronary heart disease. Furthermore, there is sufficient evidence for an effect of noise on sleep disturbance. Evidence for an effect of noise on endocrine markers is weak and inconclusive, especially for adults. Health effects of noise on the endocrine system cannot yet be ruled out and further, large scale studies are required focusing on adults.

Evidence for an effect of noise on psychological health suggests that for both adults and children noise is probably not associated with serious psychological ill-health but may affect quality of life and well-being. As yet, there are no prospective studies published on the effects of noise exposure on psychological health and few studies examine psychiatric diagnoses. The conclusions from cross-sectional evidence should be treated cautiously, as individuals who are experiencing poor mental health are more likely to also evaluate the environment negatively, bringing into question the direction of causality between noise exposure and mental health.

In conclusion, noise is a main cause of environmental annoyance and it negatively affects the quality of life of a large proportion of the population. In addition, health and cognitive effects, although modest, may be of importance given the number of people increasingly exposed to environmental noise and the chronic nature of exposure. Future research needs to further develop understanding not only of the magnitude of effects and exposure-effect relationships, which can inform interventions and policy, but also needs to further consider mechanisms for the effects such as the role of annoyance, adaptation, habituation, acclimation, and coping strategies and the role these may play in non-auditory effects of noise.

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A Brief Review of Known Effects of Noise on Marine Mammals

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Marine mammals, especially cetaceans, are highly vocal and dependent on sound for almost all aspects of their lives, e.g. food-finding, reproduction, communication, detection of predators/hazards, and navigation. They are thus likely sensitive to anthropogenic noise. Sound has a large potential area of impact, sometimes covering millions of square kilometers of ocean with levels high enough to cause possible disturbance in marine mammals. There can be great variation in the reaction of marine mammals to noise, depending on such factors as species, individual, age, sex, prior experience with noise, and behavioral state. Species with similar hearing capabilities can respond differently to the same noise. Observed effects of noise on marine mammals include: changes in vocalizations, respiration, swim speed, diving, and foraging behavior; displacement, avoidance, shifts in migration path, stress, hearing damage, and strandings. Responses of marine mammals to noise can often be subtle and barely detectable, and there are many documented cases of apparent tolerance of noise. However, marine mammals showing no obvious avoidance or changes in activities may still suffer important, even lethal, consequences. Acoustically-induced strandings may displace a local beaked whale (*Ziphiidae*) population (for an extended period if not permanently) or even possibly eliminate most of its members. As beaked whales seem to be found in small, possibly genetically isolated, resident populations, even a transient and localized acoustic impact could have prolonged population consequences. Observed reactions to noise in marine mammals could theoretically result in impacts such as decreased foraging efficiency, higher energetic demands, less group cohesion, higher predation, decreased reproduction, and thus seriously impact the population. Alternatively, they may be harmless. However, noise is thought to contribute to at least some species' declines or lack of recovery (Southern resident killer whales (*Orcinus orca*), western gray whales (*Eschrichtius robustus*) off Sakhalin).

As sound travels much better than light in the oceans, many marine animals, including marine mammals, use hearing as their primary sense. Cetaceans, in particular, are heavily dependent on sound for food-finding, communication, reproduction, detection of predators, and navigation. They are therefore likely sensitive to the introduction of anthropogenic noise into their environment. Unfortunately, because sound travels further than light in water, sounds have a large potential area of impact. Low frequency sounds, such as naval Low Frequency Active (LFA) sonar and distant shipping, travel especially well and may sometimes be heard over millions of square kilometers of ocean with levels high enough to cause possible disturbance in marine mammals. Seismic surveys can raise the background noise levels by 20 dB over 300,000 sq. km. continuously for days (IWC, 2005). Human use of the sea is growing and thus increasing the amount of noise that we introduce into the oceans (see Hatch & Wright, this issue).

Several reviews have examined the various known effects of noise on marine mammals (e.g., Richardson, Greene, Malme, & Thomson, 1995; Hildebrand, 2005; Nowacek, Thorne, Johnston, & Tyack, 2007; MMC, 2007). Such efforts will not be repeated here. Instead, the intent is to provide an overview

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of the various effects that noise is known to have on marine mammals for those new to the subject. Consequently, this is not an exhaustive review. However, the examples do represent a variety of impacts including: changes in vocalizations, respiration, swim speed, diving, and foraging behavior; displacement, avoidance, shifts in migration path, stress, hearing damage, and strandings.

Especially in species as difficult to observe as cetaceans, we are limited in our ability to detect impacts. Thus, failure to find a response to noise may be more due to measuring the wrong variables or an inability to measure the right ones, rather than a true lack of response. Populations may be threatened by noise through, for instance, increased stress levels or masking, yet these effects would be difficult to detect in cetaceans, since only a handful of the ca. 84 species have population estimates that are more precise than ± 40% (Whitehead, Reeves, & Tyack, 2000). The vast majority (72-90%) of serious population declines in cetaceans would not be detected under the current population monitoring effort (Taylor, Martinez, Gerrodette, Barlow, & Hrovat, 2007). Even when responses to noise are found, the biological significance to cetacean populations is hard to discern. Usually, only short-term responses to noise are studied, for practical reasons. However, short-term effects are hard to interpret. They may be an indication of serious population consequences or they may be insignificant. Conversely, long-term population impacts may occur without dramatic or even observable short-term reactions, as has been demonstrated in bottlenose dolphins, *Tursiops* spp. (Bejder, 2005) and caribou, *Rangifer tarandus* (Harrington & Veitch, 1992). Thus, long-term studies are more useful in relating disturbance reactions to population impacts (Bejder, 2005).

Changes in Vocalizations

Increases in vocalizations may represent an attempt by the animal to overcome ‘masking,’ when a sound is obscured or interfered with, by background noise. Masking can both reduce the range over which signals can be heard and reduce the signal’s quality of information. The following observations may or may not be attempts to compensate for masking. Beluga whales (*Delphinapterus leucas*) used specific calls more often and shifted frequencies upward when boats were near (Lesage, Barrette, Kingsley, & Sjare, 1999). St. Lawrence River belugas were also shown to increase the level of their vocalizations as a response to increases in the levels of shipping noise, an indication of a Lombard vocal response (Scheifele et al., 2005). In response to high levels of boat traffic, killer whales increased the durations of their calls (Foote, Osborne, & Hoelzel, 2004). Humpback whales (*Megaptera novaeangliae*) lengthened their mating songs during exposure to LFA sonar (Miller et al., 2000). Pilot whales (*Globicephala melas*) produced more whistles in response to military mid-frequency sonar (Rendell & Gordon, 1999), as did bottlenose dolphins (*Tursiops truncatus*) in response to boat approaches (Buckstaff, 2004).

Marine mammals have also been observed to decrease their vocalizations in response to noise, sometimes ceasing to call entirely for periods of weeks or months. This can have implications for breeding, feeding, or social cohesion, depending on the calls affected. Decreases in "creaks," thought to be prey capture attempts, have been observed in a Cuvier's beaked whale (*Ziphius cavirostris*) in response to ship noise (Soto et al., 2006), and in sperm whales (*Physeter macrocephalus*) in response to seismic surveys (IWC, 2007). Sperm whales have also been observed falling silent when exposed to pingers (Watkins & Schevill 1975), mid-frequency military sonar signals (Watkins, Moore, & Tyack, 1985), seismic surveys, and low frequency ATOC-like[1] sounds (Bowles, Smultea, Würsig, DeMaster, & Palka, 1994). The ATOC-like sounds and perhaps seismic surveys had similar effects on pilot whales (Bowles et al., 1994), though the power to detect effects in this study was low.

Fin whales (*Balaenoptera physalus*) reduced their calling rates in response to boat noise (Watkins, 1986). About 250 male fin whales stopped singing for weeks-months over 10-20,000 sq. nm. in the presence of a seismic survey, resuming singing within hours-days after the survey ended (IWC, 2007). It is likely that there were breeding consequences of this behavior, as these fin whale calls are thought to function in mating (Croll et al., 2002).

Changes in Diving and Foraging Behavior

Marine mammals have been observed to change their surface behavior (e.g. swim speed, respiration rate, etc.) in the presence of seismic noise, with largely unknown consequences. However, if foraging dives are affected by noise, it is quite likely that there will be associated reductions in foraging efficiency. In addition to other responses, sperm whales undertook no foraging dives when approached closely by a seismic survey vessel emitting airgun noise, and reduced the number of fluke strokes and effort at more distant exposures (IWC, 2007). Similarly, in response to the nearby passage of a noisy ship, a Cuvier's beaked whale was seen to dive for shorter periods, with less time spent echolocating, in addition to a lower production of creaks as was mentioned above (Soto et al., 2006). It was suggested that the combined effects resulted in a 50% reduction in foraging efficiency (Soto et al., 2006).

Northern elephant seals (*Mirounga angustirostris*) increased descent rates and decreased ascent rates similar to an escape response, when exposed to the low-frequency noise of ATOC (Costa et al., 2003). Western gray whales reacted to seismic surveys by swimming faster and straighter over a larger area with faster respiration rates (IWC, 2007). In addition to a tendency for avoidance and less feeding across all cetaceans during seismic surveys, mysticetes generally spent more time at the surface while smaller odontocetes tended to swim faster (Stone & Tasker, 2006). More subtle responses to seismic surveys were also seen at quite large distances. For example, one study found that bowheads (*Balaena mysticetus*) displayed no avoidance or a change in calling or general activities, but were

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[1] Acoustic Thermometry of Ocean Climate was an oceanographic project which broadcasted loud sounds across whole ocean basins. It continues to operate under the name NPAL, or North Pacific Acoustic Laborartory.

undertaking shorter dives with a slower respiration rate at distances up to 50-70 km away (Richardson, Würsig, & Greene, 1986; Richardson et al., 1995).

Avoidance and Displacement

Displacement from critical feeding and breeding grounds has been documented in a number of marine mammal species exposed to noise. Possibly the most striking example is the displacement of gray whales from breeding lagoons in response to industrial noise (for over 5 years: Jones, Swartz, & Dahlheim, 1994) or dredging and shipping (displaced for 10 years: Bryant, Lafferty, & Lafferty, 1984). The critically endangered population of western gray whales off Sakhalin Island was also displaced from one of their primary feeding areas by seismic survey activity (IWC, 2005; 2007).

Beluga whales appeared to actively avoid icebreakers at distances of 35-50 km, remaining away for 1-2 days (Finley, Miller, Davis, & Greene, 1990; Cosens & Dueck, 1993). Killer whales were displaced from an area for 6 years by acoustic harassment devices, or AHDs (Morton & Symonds, 2002). Humpback whales avoided seismic surveys, with resting females staying 7-12 km away, although males were occasionally attracted to the sounds (McCauley et al., 2000). In addition, sighting rates of many cetaceans in UK and adjacent waters were significantly lower, and their distance to the seismic noise source (large volume airgun array) significantly higher, during periods when the source was on in comparison to those when it was not (Stone & Tasker, 2006).

Slight, but obvious, shifts in migration paths have also been noted in several species when a noise source was placed in their migration route. For example gray whales adjusted their migration path to avoid an LFA sonar source placed inshore, but not offshore (Tyack & Clark, 1988). In addition, both gray and bowhead whales have been observed detouring around continuous industrial noise (Malme, Miles, Clark, Tyack, & Bird, 1983, 1984; Richardson et al., 1985, Richardson, Würsig, & Greene, 1990).

Strandings and Fatalities

Much attention has been focused recently on acoustically-induced strandings, primarily with respect to beaked whales and military mid-frequency sonar (e.g., Fernandez et al., 2005, Cox et al., 2006). The Bahamas March 2000 mass stranding was one of the best studied of such strandings, and occurred together with naval exercises involving mid-frequency sonar. Several species of whale were found dead with injuries to their acoustic organs. The government acknowledged the fact that "...tactical mid-range frequency sonars aboard U.S. Navy ships…were the most plausible source of this acoustic or impulse trauma." (NOAA & U.S. Navy, 2001). This stranding was the only stranding for which baseline beaked whale survey data were available. Thus, it could be determined that there were no sightings of Cuvier's beaked whales for a 20 month period (May 2000 - February 2002) following the stranding, despite increased field effort in 2000 and 2001 (Claridge, 2006). Sighting rates since February 2002 appeared to be back to those found from 1997-1999 (Claridge, 2006). The at least temporary and possibly permanent disappearance of pre-stranding known individuals seems to indicate that the affected local population of Cuvier's beaked whales was isolated from a larger population, implying that a population-level effect may have resulted from the brief transit of five naval vessels using sonar (Balcomb & Claridge, 2001; IWC, 2005). It is unknown how many whales from the local population of the species were killed during the naval exercise, but at minimum they were displaced from their former habitat. Beaked whales appear to be found in small, possibly genetically isolated, local populations that are resident year-round (Wimmer & Whitehead, 2004; Balcomb & Claridge, 2001). Such population characteristics make beaked whales particularly vulnerable to disturbance and population impacts.

Other cetacean species may also be involved in acoustically-induced strandings (see ICES, 2005), and the possibility that noise can lead to strandings and/or death in marine mammals exists beyond naval sonar. For instance, seismic noise has been implicated in a stranding of beaked whales (Hildebrand, 2005).

Hearing Damage

Noise has the potential to induce temporary hearing loss (either across the frequencies or more specific to a smaller frequency band), also known as temporary threshold shift (TTS), if it is loud or long enough in duration. In general, the higher the sound level and/or longer the duration, the more likely TTS is to occur. If exposure is prolonged or repeated or even as a result of one very loud noise event, the hearing damage can become permanent, also known as a permanent threshold shift (PTS). Experiments with captive bottlenose and beluga have, however, shown that both tonal (e.g., Schlundt, Finneran, Carder, & Ridgway, 2000) and very short duration impulsive (Finneran et al., 2002) sounds are capable of causing TTS, although the sound levels required for the impulsive sounds to do so were much higher than the 1 second tonal signals. Combining her research results along with other cited studies, Cook (2006) generally found that captive animals showed more hearing loss than similar-aged free-ranging dolphins. TTS and PTS are thought to have very similar effects on marine mammals as masking: reduction in foraging efficiency, reproductive potential, social cohesion, and ability to detect predators.

Hearing damage can kill indirectly, as in the case of humpback whales found fatally entangled in fishing gear at the same time and place as underwater explosions were occurring (Todd et al., 1996). Humpback whales in the area displayed no avoidance or behavioral reactions to the explosions, yet an unusual pattern of fatal entanglement occurred, suggesting hearing damage (if whales use sound to passively detect nets) or some other compromise to their navigation or sensory systems. Based on a good baseline of typical whale entrapment rates and patterns, it was found that entrapment rates both at the time and in the nearby area of blasting were dramatically and significantly higher, even though there were fewer fishing nets in the area (Todd, Stevick, Lien, Marques, & Ketten, 1996). Additionally, re-entrapments of the same animals occurred, something that had not happened for the previous 15 years. It is important to note that, based on the whales' behavior, one would have incorrectly concluded that the explosions did not impact the animals, were it not for the special case of higher and unusual entanglement rates or patterns.

Noise and Stress

Although several reviews have entertained the possibility that noise induces a physiological stress response in marine mammals, there have been few studies. Romano et al. (2004) exposed a captive beluga whale and bottlenose dolphin to sounds from a seismic water gun and (for the bottlenose dolphin) 1-s, 3-kHz pure tones. They looked for various hormones in the blood, including cortisol, before and after exposure and saw changes (especially with the seismic sound) that were considered detrimental. These changes increased with increasing sound levels, and were significant. Thomas, Kastelein, & Awbrey (1990), however, did not find elevated stress hormone levels in the blood after playbacks of oil drilling platform noise to captive belugas, though their measures were less sensitive than those used in Romano et al. (2004). Miksis et al. (2001) found that heart rate in a captive bottlenose dolphin increased in response to threat sounds produced by other dolphins.

Context and Consequence

There can be great variation in the reaction of marine mammals to noise, depending on such factors as species, individual, age, sex, prior experience with noise, and behavioral state. Species with similar hearing capabilities can respond differently to the same noise (IWC, 2007). There are many documented cases of apparent tolerance of marine mammals to noise, which also demonstrate much variability. For example, bowhead whales tolerated an increase in 40 dB in seismic survey noise when feeding in summer than during the fall migration, where broadband received levels of airgun pulses corresponding to avoidance were 120–130 dB re 1 µPa (rms over pulse duration) and above (Richardson et al., 1995, Richardson, Miller, & Greene, 1999). Other examples of apparent tolerance can be found in sperm whales with seismic surveys in Norway (Madsen, Møhl, Nielsen, & Wahlberg, 2002), blue (*Balaenoptera musculus*) and fin whales with LFA sonar (Croll et al., 2001) and sea lions (*Zalophus californianus*) to AHDs (NMFS, 1996). It is not known what the consequences of this apparent tolerance are: it may represent acclimation or habituation of some kind, but may also represent an unrelenting need, e.g. for feeding or reproduction, to remain in a particular location despite exposure to noise, that could result in increased impacts from masking, hearing loss, and other potential effects, such as stress.

The observed reactions to noise in marine mammals could theoretically result in impacts such as decreased foraging efficiency, higher energetic demands, less group cohesion, higher predation, decreased reproduction, and other effects, thus seriously impacting the population as well as the individual. Alternatively, they may be harmless. However, noise is thought to contribute to at least some species' declines or lack of recovery (Southern resident killer whales, Sakhalin gray whales; NMFS, 2002; IWC, 2007).

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Environmental Noise and Decision Making
Possible Implications of Increases in Anthropogenic Noise for Information Processing in Marine Mammals

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Recent increases in anthropogenic noise in the marine environment are a source of concern for the current welfare and future fitness of many marine mammal species. In this article I explore the specific question of how environmental noise could affect information processing. I also discuss the possible changes in behavior that would result, and how these changes could negatively impact the welfare and fitness of marine mammals. I identify two ways in which environmental noise could affect decision-making. First, environmental noise could add statistical noise to the detection of auditory signals, either masking them completely or rendering them ambiguous. Animals can respond to this problem either by moving away from the source of noise, or by altering the characteristics of their signal processing to increase the signal to noise ratio. Second, environmental noise could generate emotional states of fear or anxiety that cause biases in information processing. Anxiety is an emotion that functions as an early warning of potential threats, and is associated with a suite of changes in information processing including sensitization to stimuli potentially associated with threats, and pessimistic biases in decision-making resulting in increased risk aversion. Although these changes are clearly beneficial in the short term, chronic anxiety is likely to result in behavioral changes that will be detrimental to an animal's fitness in the longer term. Thus, there are likely to be subtle effects of noise on decision-making that have not so far been considered in relation to the effects of anthropogenic noise on marine mammal behavior.

The Problem

Anthropogenic noise has increased dramatically in the marine environment in recent years (Andrew, Howe, Mercer, & Dzieciuch, 2002; Hatch & Wright, this issue), and it is therefore important to consider how this change could affect the welfare and fitness (i.e. lifetime reproductive success) of marine mammals (Fair & Becker, 2000; Wright et al., this issue, b). Environmental noise can potentially impact the welfare and fitness of animals via a number of different mechanisms. For example, loud noises can directly damage animals' ears, and chronic exposure to moderate levels of environmental noise is associated with physiological and anatomical changes in both rats and humans that are associated with negative health consequences (Baldwin, this issue; Clark & Stansfeld, this issue; Wright et al., this issue, a). Environmental noise may also have less direct effects on behavior, and possibly also fitness, by causing alterations in information processing and consequent decision-making. These latter effects may be subtler than the direct effects of noise, however through the alterations in behavior that they cause they could be equally detrimental to animal welfare and long-term fitness. In the remainder of this article I will describe and discuss some of the effects of

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noise on information processing. I should stress at this point that there is currently very little information about these effects in marine mammals, and consequently the majority of my examples will come from studies of other more easily studied animals such as laboratory rodents and birds. However, there is every reason to expect that marine mammals should respond in similar ways to other animals when confronted with increases in environmental noise, and the limited information that we do currently have for marine mammals supports this prediction (Wright et al., this issue, b).

Information Processing and Noise

The performance of adaptive behavior relies on an animal possessing accurate information about the world (Dall, Giraldeau, Olsson, McNamara, & Stephens, 2005). Natural selection has equipped animals with the cognitive mechanisms that they need to process information and generate adaptive behavior within the environments in which they have evolved. The brain receives information about the state of the environment via the senses and about the state of the body via its own internal monitoring mechanisms. On the basis of this information, decision mechanisms in the brain generate appropriate physiological and behavioral responses.

Sound is an extremely important source of information for marine animals. The superior propagation of sound in water as compared with air, coupled with reduced visibility in the sea have led to hearing becoming an important sense in many species of marine mammals and probably also fish. For example, many marine mammals use vocalizations for both intra-specific communication and for echolocation, meaning that auditory information is crucial to activities including locating food, making foraging decisions, avoiding predators, choosing mates and social behavior. As a consequence of the importance of sound in marine mammal ecology, it makes sense that marine mammals have evolved specialized mechanisms for processing sound-related information, and that these mechanisms might be particularly sensitive to changes in environmental noise.

The term information processing refers to everything that goes on between information entering an animal via its sense organs and observed behavior (see Figure 1 for a summary). Thus, the brain can be viewed as an information-processing organ. I will discuss two routes via which environmental noise could potentially alter information processing in marine mammals.

First, environmental noise could add statistical noise to the detection of auditory signals, masking the incoming information completely, changing it in some way, or rendering it ambiguous. Second, by generating an emotional state, such as fear or anxiety, environmental noise could provoke changes in decision-making mechanisms congruent with the induced state. Below I enlarge on each of these possibilities and provide examples of the changes in behavior that might result.

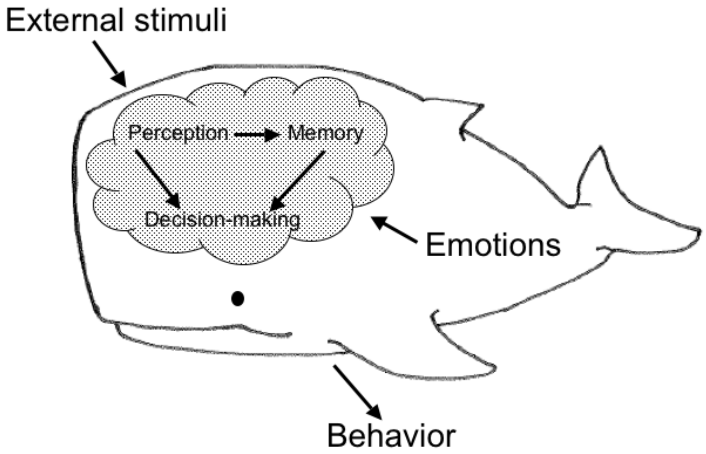

Figure 1. The basic elements of an information-processing model of behavior. Environmental noise could affect information processing in animals either by interfering with the in-coming information from the environment, or indirectly, by evoking internal emotional states such as anxiety that then bias information processing mechanisms.

Detecting Signals in Noise

Many animals face the problem of distinguishing biologically important stimuli, such as conspecific signals or returning echoes, from background noise (for a review see Brumm & Slabbekoorn, 2005). Some mistakes are inevitable, because most signals have some degree of variation associated with them, and natural environments are characterized by permanent background noise of biotic and abiotic origins. Figure 2 illustrates a typical signal detection problem in which an animal looking for a potential mate is faced with distinguishing conspecific calls from those of other species. Although I have chosen this particular example, it is important to realize that the same basic scenario could apply to discriminating any type of auditory information from background noise including returning echoes, sounds of other species and abiotic noises such as those produced by weather, seismic activity and boats. In Figure 2 both types of call are somewhat variable in frequency, as depicted by the normal distributions, and there is an area of overlap in which the two types of call cannot be distinguished on the basis of frequency alone. As a result, conspecific signals will sometimes be incorrectly ignored (misses) and calls of other species will sometimes be incorrectly identified as conspecifics (false alarms, see Table 1). Both types of mistakes have associated costs; in this example, misses will result in passing up a potential mate, whereas false alarms will result in time waste courting the wrong species and possibly infertile mating attempts. In different scenarios the costs will be different; for example in the situation where an animal has to detect the sound of an approaching boat from background environmental noise a miss could result in physical injury or even death, and a false alarm could result in prematurely leaving a good foraging patch.

The problem faced by natural selection is how to minimize the costs of misses and false alarms. Signal detection theory, originally developed in a military context to deal with the problem of identifying significant objects such as planes on noisy radar screens, can be used to quantify this trade-off (e.g. Wiley, 1994). In short, the position of the criterion for discriminating the two types of call will depend on the relative costs of the two types of mistakes: if misses are cheap or false alarms particularly costly then it will pay to set a conservative criterion (i.e. further towards the right) and only initiate mating or stop foraging if the sound is highly characteristic of a conspecific vocalization or a boat engine, whereas if the reverse is true and misses are costly or false alarms cheap, then it will pay to set a less stringent criterion (i.e. further towards the left) and classify a wider range of signals as those of potential mates or dangerous boats. The optimal position for the criterion will depend on the specific context and the relative costs and benefits of errors versus correct responses.

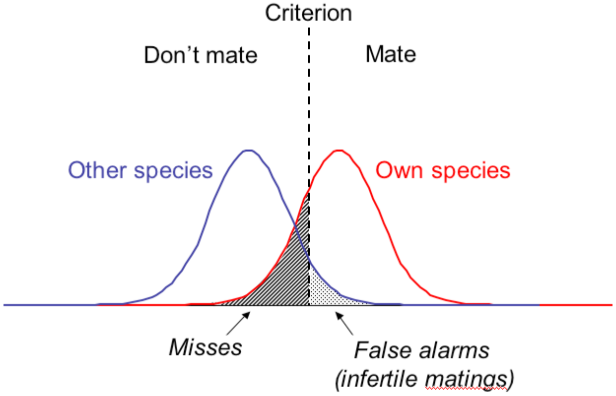

Figure 2. In this example, the x-axis describes the frequency of a call, and the y-axis describes the probability of a call of a given frequency appearing. Two probability distributions are shown: the one on the left corresponds to the calls of other species, and the one on the right to conspecific calls. The dotted line is the criterion below which calls are classified as other species and above which calls are classified as conspecific. The probability of missing a conspecific call is indicated by the hatched area, and probability of a false alarm by the shaded area.

Table 1

Types of possible response in a signal detection task.

	Signal	
Response	Present	Absent
Signal detected	Hit	False alarm
No signal detected	Miss	Correct rejection

We can use the basic framework established above to think about the possible effects of increased environmental noise on decision-making. Figure 3a shows a hypothetical example in which additional environmental noise increases the variance of the distribution of signals that should be rejected. If the criterion for rejection is unchanged (as shown in Figure 3a), then the number of misses will remain unchanged, but the number of false alarms will increase. The fitness consequences of such a change will depend on the costs of a false alarm, but if, as in the case of the above example, a false alarm translates into an infertile mating, then they could be considerable. In the most extreme cases environmental noise could completely mask biologically significant signals depriving animals of sources of information vital for their fitness.

Animals faced with an increase in environmental noise can respond in various ways to reduce the probability of errors in signal detection. Broadly speaking, either signalers can alter some aspect of their signal production to reduce the probability of errors, or signal receivers can change some feature of their signal to reduce the probability of errors. In both cases these responses could either be adaptive plasticity within the individual, or take place by natural selection over evolutionary time. However, the long life spans and generation times of many marine mammal species may severely limit their capacity to keep up with rapid environmental changes via the latter mechanism.

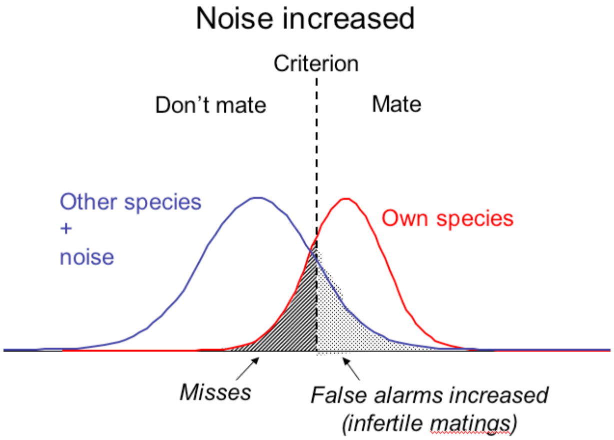

Figure 3a. Increased environmental noise makes the signal detection problem described in Figure 2 more difficult by increasing the variance of the sounds from which conspecific calls must be discriminated.

Hearing may initially appear a passive sense in which the signal receiver has little latitude for improving signal detection. However, there are a number of mechanisms involving both perception and behavior via which signal receivers can reduce the probability of errors in detection. At the behavioral level, it may be possible to improve the signal to noise ratio by moving closer to the source of a signal or away from the source of noise. At the information processing level, the signal receiver could change the criterion for classification. For example, moving the criterion to the right will serve to reduce the false alarm rate at the expense of increasing the miss rate (Figure 3b). Many perception adaptations have also been identified in species as diverse as insects, frogs, birds and bats (reviewed in Brumm & Slabbekoorn, 2005). Research on perception is usually derived from laboratory studies, making it difficult in marine mammals, however recent research on hearing in fish under noise conditions has the potential to identify the strategies used in fish (Wysocki & Ladich, 2005).

Signalers can respond by shifting the signal away from the noise by altering its frequency (Figure 3c), or sharpening the discriminability of the conspecific signal (Figure 3d), which will reduce the number of misses. An example of altering the frequency of a signal is found in urban great tits (*Parus major*), in which a correlation is observed between the amplitude of background noise and the average minimum frequency of male birds' songs (Slabbekoorn & Peet, 2003). Animals have used a number of different strategies for improving the discrimination of a signal without changing its frequency. Perhaps the most obvious way to counteract the masking effects of background is to increase the amplitude, a response referred to as the "Lombard effect". There is abundant evidence that many birds sing louder in response to increases in background noise. For example, male nightingales

(*Luscinia megarhynchos*) regulated the intensity of their songs according to the level of masking noise, thus maintaining a specific signal-to-noise ratio that is favorable for communication (Brumm & Todt, 2002). Another approach is to increase the duration of the signal or repeat the same signal more often. For example, killer whales (*Orcinus orca*) produced more easily perceived, long calls when noise from boats exceeded a threshold level (Foote, Osborne, & Hoelzel, 2004), and beluga whales (*Delphinapterus leucas*) increased the repetition of specific calls when a boat was nearby (Lesage, Barrette, Kingsley, & Sjare, 1999). It is important to realize that these compensatory strategies are not likely to be without cost. In the case of the killer whales for example, making longer calls must take either time or attention away from other important activities such as foraging, and will involve an increased energetic cost.

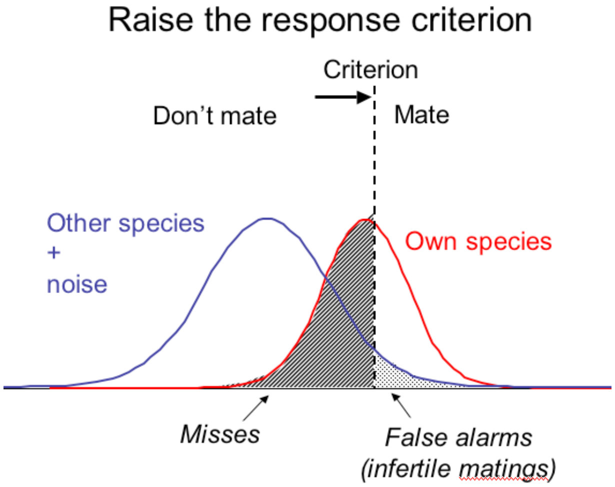

Figure 3b. Animals might respond to increased environmental noise by shifting the criterion to the right and hence reducing the possibility of false alarms at the expense of increasing the probability of misses.

Finally, both signalers and signal receivers can attempt to escape increased environmental noise either spatially or temporally. Spatial escape would involve moving to a different location where environmental noise is reduced. It is now well established that whales choose to avoid areas of high whale watching activity, and one explanation for this preference could lie in the signal detection difficulties imposed by boat noise (Wright et al., this issue, b). A major cost of using a spatial avoidance strategy is that it is likely to force animals into areas that are otherwise suboptimal. For example, whales might be forced into less good foraging areas in order to escape anthropogenic noise, which is likely to have welfare and fitness consequences. Temporal escape involves altering the timing of signaling to correspond with the time when there is least environmental noise. An example of this latter strategy was recently reported in urban robins that have shifted to singing during the night in areas where there is high traffic noise during the day (Fuller, Warren, & Gaston, 2007). Again, it is unlikely that this strategy will be without cost, because by singing at night robins may be exposing themselves to increased predation risks or depriving themselves of sleep. A possible case of temporal escape has been described in beluga whales (*Delphinapterus leucas*) that reduce their calling rate while vessels are approaching (Lesage, Barrette, Kingsley, & Sjar, 1999). It is hard to speculate about the possible costs of this change in behavior without knowing the precise function of the vocalizations involved.

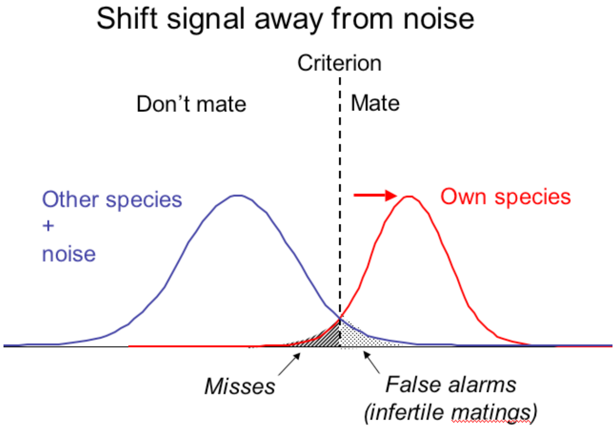

Figure 3c. Animals might respond to increased environmental noise by shifting their own signals away from the noise hence reducing the number of misses.

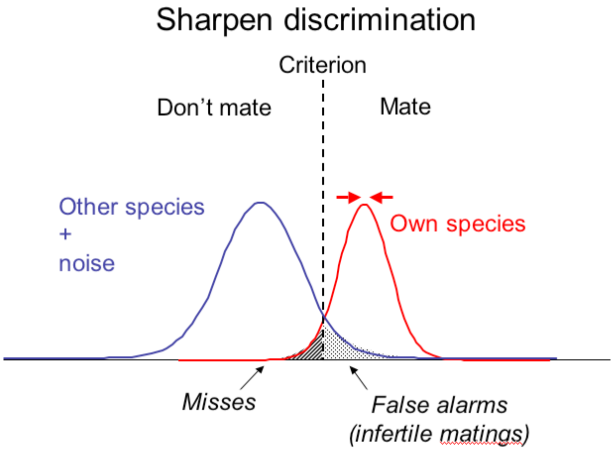

Figure 3d. Animals might respond to increased environmental noise by sharpening the discrimination of their own signals. This could be affected by reducing the variance in conspecific calls. The effect is to reduce the number of misses.

Cognitive Bias and Noise

For many animals environmental noise is an important cue that danger could be imminent. For example, many animals will rely on sound to provide them with information about the possible approach of a predator or other threat. It therefore makes sense that many animals will respond to unusual or unexpected noises with adaptive emotional reactions such as fear and anxiety. Increased levels of background noise are also associated with a stress response in humans (Clark & Stansfeld, this issue). Anxiety is an emotion that functions as an early warning of potential threats, and is associated with a suite of changes that prepare the animal for dealing with the threat. The physiological and behavioral changes that come with anxiety such as increased heart rate and vigilance are well known, however these are also accompanied by changes in information processing, referred to as "cognitive biases", that prepare the animal cognitively for dealing with the threat (Clore & Huntsinger, 2007; Mathews, Mackintosh, & Fulcher, 1997). For example, anxious humans show selective attention to threatening words (Williams, Mathews, & McLeod, 1996), and will detect an angry face amongst a large array of neutral faces more rapidly (Bryne & Eysenck, 1995). Anxious humans are also more likely to assume a negative or threatening interpretation when presented with ambiguous stimuli such as homophones (e.g. die/dye or pain/pane, (Eysenck, MacLeod, & Matthews, 1987; Eysenck, Mogg, May, Richards, & Matthews, 1991)).

Recently, "pessimistic" cognitive biases have also been reported in non-human animals housed in suboptimal cages. For example, Harding et al. (2004) trained rats on a go/no-go task to press a lever to obtain a food reward on hearing a positive stimulus (the food-delivery tone), but to refrain from pressing the lever to avoid unpleasant white noise on hearing a negative stimulus (the noise-avoidance tone). Once trained on this task, rats were allocated to either predictable or unpredictable (depression-inducing) housing. Following this manipulation the rat were tested with non-reinforced stimuli intermediate between the food-delivery and noise-avoidance tones. The animals' anticipation of the positive and negative outcomes was estimated by measuring the probability with which they lever-pressed in response to the ambiguous tones. Rats in the unpredictable group showed fewer and slower responses than rats in the predictable group. Thus, the depressed rats showed reduced anticipation of a positive event.

We used a similar approach to ask whether European starlings (*Sturnus vulgaris*) deprived of environmental enrichment in their cages show biases in their classification of ambiguous signals (Bateson & Matheson, 2007). On the basis of the previous findings in humans and rats discussed above, we hypothesized that starlings in enriched cages should be more likely to classify ambiguous signals as being associated with a positive outcome than starlings housed in standard, unenriched cages. Starlings were trained on a go/no-go procedure to discriminate between two visual stimuli (cardboard lids of white and dark grey) associated with outcomes of a different value (palatable and unpalatable mealworms hidden underneath). Individual birds' responses to unreinforced, intermediate stimuli (various shades of grey between white and dark grey) were subsequently examined while each bird was housed sequentially in both standard and enriched cages. The probability of a bird classifying an ambiguous pale grey lid as hiding a palatable mealworm was lower in standard cages than enriched cages, but this difference was only found in birds that received enriched cages first (Figure 4). Our results can be interpreted as showing a pessimistic bias in birds that have recently experienced a decline in environmental quality (see also Matheson, Asher & Bateson, 2008).

The above studies show that animals experiencing anxiety or depression induced by poor housing conditions are more pessimistic in their interpretation of ambiguous information resulting in more risk-averse decision-making. The pessimistic animals were less ready to expose themselves to unpleasant events such as white noise or quinine-tainted food. It is reasonable to hypothesize that similar risk-averse biases may be present in marine mammals rendered anxious by recent increases in anthropogenic noise. While increased risk-aversion is an adaptive response in the face of real threats, chronic pessimism is unlikely to be adaptive since it may cause animals to pass up opportunities beneficial to their long-term fitness.

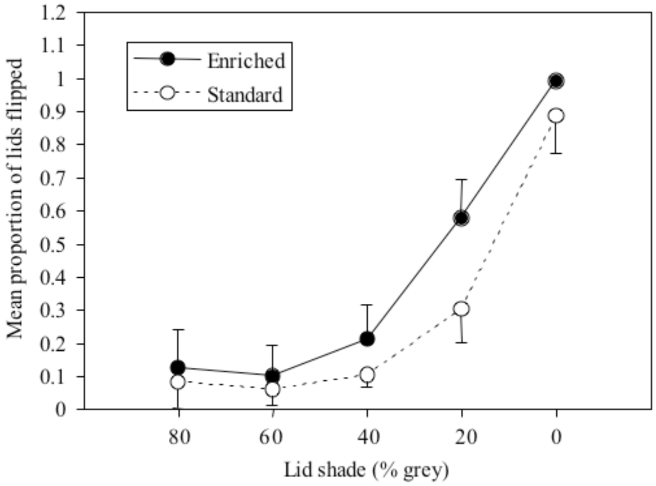

Figure 4. An example of a pessimistic cognitive bias . The x-axis shows the shade of the lid used to hide a worm. 80% grey lids were associated with unpalatable quinine-injected mealworms whereas white lids (i.e. 0% grey) were associated with palatable mealworms. Intermediate lid shades were never reinforced with either type of mealworm. The y-axis shows the proportion of times birds investigated Petri dishes by flipping off the lid (from Bateson & Matheson (2007), with permission).

Conclusions

Increases in anthropogenic noise are likely to have subtle effects on the cognition and behavior of marine mammals via at least two different mechanisms. First, noise may interfere with or mask the auditory signals available to marine mammals depriving them of important sources of information. Although evidence suggests that animals will compensate for such interference via a range of strategies, this is unlikely to be without costs. Second, noise may evoke emotional states that bring about biases in information processing and decision-making. Although these biases may have been adaptive in the environments in which the animals evolved, it is possible that they may be maladaptive in the radically different environments present in today’s oceans. Further research is needed to identify the extent to which marine mammal behavior is affected by increased levels of anthropogenic noise, and to quantify the potential welfare and fitness consequences of these changes.

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The Influence of Metal Pollution on the Immune System A Potential Stressor for Marine Mammals in the North Sea

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Marine mammals of the North Sea are loaded with metal pollutants. The environmental exposure induces concentrations bioavailable to immune cells high enough to affect their function. Such an imbalance of the immune system caused by pollutants may play a significant role in the incidence of infectious diseases in marine mammals. Metals influence the function of immunocompetent cells by a variety of mechanisms. Depending on the particular metal, its speciation, concentration and bioavailability, and a number of other factors, a continuous metal exposure will result in an immunosuppression or immunoenhancement effects. Both effects were demonstrated on the cellular level in animals of the North Sea. This article reviews metal concentrations in the North and Baltic Seas particularly in tissues of marine mammals, discusses pollutants effects on health and immune functions, and underlines the still existing problem of animals living in polluted coastal areas.

The harbor (or common) seal, *Phoca vitulina*, the grey seal, *Halichoerus grypus* and the harbor porpoise, *Phocoena phocoena* are the most prominent domestic marine mammals in the Wadden Sea. Beside these species several other marine mammals occur in the Wadden Sea and adjacent North Sea as stragglers or regular visitors such as harp seal, *Phoca groenlandica*, hooded seal, *Cystophora cristata*, ringed seal, *Phoca hispida*, bearded seal, *Erignathus barbatus*, walrus, *Odobenus rosmarus*, various species of dolphins as well as large cetaceans, e.g. the minke whale, *Balaenoptera acutorostrata,* and sperm whale, *Physeter macrocephalus*. Seals living in the coastal area are strongly influenced by anthropogenic activities such as fishery, off-shore activities, habitat destruction and environmental pollution.

Since 1978 The Netherlands, Germany and Denmark have been working together on the protection and conservation of the Wadden Sea, which results in the development of the “Trilateral Monitoring and Assessment Program” (TMAP). Within this agreement the seal population is supposed to serve as a bioindicator for the Wadden Sea ecosystem. Seals are considered as indicators for medium and long-term changes in the ecosystem due to their widespread distribution over the coastal areas, their high trophic level, which results in a bioaccumulation and biomagnification of chemicals in their tissues, their long-life span and relatively late maturity including a low reproduction rate. All these factors serve to qualify harbor seals as biomarkers of chemical exposure in the Wadden Sea.

In addition, the “Seal Agreement” has been adopted, which establishes terms of research and monitoring including the monitoring of pollution and investigations on the effects of substances e.g. organochlorine compounds, metals and oil on the seal population. These terms have been specified in the “Seal Management Plan for the Wadden Sea Seal Population” which utilizes parameters such as reproduction, mortality and health status to assess the seal population and includes e.g. immunological, physiological, toxicological, pathohistological and microbiological research.

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The growth of the harbor seal population in the Wadden Sea was interrupted by a phocine distemper virus epizootic in 1988 and 2002. In this context, the influence of pollutants on the immune system has been repeatedly discussed.

Metals in the North and Baltic Seas

In the past, the North Sea ecosystem was highly loaded with both organic and metal pollutants introduced by various anthropogenic activities within the coastal zones. Until the middle of the eighties the yearly input of metal pollution caused by rivers, direct discharge, dumping at sea, atmospheric input and combustion at sea was around 340 tonnes Cd, 75 t Hg, 11.000 t Pb, 5.000 t Cr and 2.150 t Ni (Rachor & Rühl, 1990). A review on the pollution situation in the North Sea has been published by Kersten et al., 1988. Table 1 gives an overview of selected references dealing with environmental research on metals in the North and Baltic Sea.

Current studies have shown a diminishing trend in the input of pollutants into the ecosystem. The BLMP monitoring program (Bund-Länder-Messprogramm) confirmed this general tendency for metal pollutants, however it is necessary to consider this conclusion more detailed. The concentrations of Hg, Cd, Pb and Zn in water and sediment for example are still elevated compared to the “Background Reference Concentrations” which the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) derived for the “Greater North Sea” (Schmolke et al., 2005).

The Quality Status Report of the TMAP concluded that major reductions in the input and the concentrations of metals in the Wadden Sea occurred mainly in the late 1980s until the early 1990s and continued moderately until 2002. However, local and metal specific elevated concentrations compared to the proposed background values were still frequently investigated (Bakker, van den Heuvel-Greve, & Vethaak, 2005).

Metal body burdens in the mammals of the North and Baltic Seas

Contaminants found in various marine mammal species in the North and Baltic Seas include organochlorine pollutants (Bruhn, Kannan, Petrick, Schulz-Bull, & Duinker, 1999; Hall et al., 1999; Holsbeek et al., 1999; Kleivane, Skaare, Bjorge, Deruiter, & Reijnders, 1995; Sormo, Skaare, Jussi, Jussi, & Jenssen, 2003; Troisi et al., 2000), polybrominated diphenyl ethers (Kalantzi, Hall, Thomas, & Jones, 2005; Law, Allchin, Bennett, Morris, & Rogan, 2002), perfluorinated sulfonates (Kannan et al., 2002; Van de Vijver et al., 2004) and metals (Table 2).

Table 1

Selected studies on metal concentrations in the environment of the North and Baltic Seas.

Object of investigation	Element	Location	Reference
Fish	Cd, Cu, Hg, Pb, Zn	Baltic Sea	Perttilä et al., 1982a
Fish	Cd, Cu, Hg, Pb, Zn	Baltic Sea	Perttilä et al., 1982b
Fish	As	North Sea	Falconer et al., 1983
Water (surface water)	Al, Cd, Co, Cu, Mn, Ni	North Sea	Kremling & Hydes, 1988
Sediments	As, Cd, Cu, Hg, Pb, Zn	North Sea	Chapman, 1992
Fish, Shrimp, Mussel	Hg, Se	North Sea, Belgium	Guns & Vyncke, 1992
Fish, Mussel, Sediments	Ni	Baltic Sea Gdansk Bay	Skwarzec et al., 1994
Sediments	Ag, Al, Ca, Cd, Co, Cr, Cs, Cu, Fe, K, Li, Mg, Mn, Na, Ni, P, Pb, Rb, Sr, Zn	Baltic Sea Gdansk Bay	Szefer et al., 1996
Birds	Cd, Cu, Hg, Se, Zn	North Sea, German Bight	Wenzel et al., 1996
Fish, Birds, Sediments	Organo-Sn	Polish Coast Baltic Sea	Kannan & Falandysz, 1997
Water (dissolved fraction, particulate matter)	Cd, Co, Cu, Fe, Mn, Ni, Pb, Zn	Southern North Sea	Millward et al., 1998
Fish	Hg, Cu	North Sea	Broeg et al., 1999
Sediment	Cd, Cu, Pb, Zn	North Sea, Dutch coastal zone	Laane et al., 1999
Birds	Cd, Cr, Cu, Fe, Ni, Pb, Zn	North Sea, Belgian coast	Debacker et al., 2000
Water	Co, Cu, Fe, Zn	Baltic Sea, Skagerrak	Croot et al., 2002
Sediment, Suspended particulate matter	Al, Fe, K, Mn, Pb	North Sea, German Bight	Hinrichs et al., 2002
Water (coastal water, dissolved)	Co, Cu	Western North Sea	Achterberg et al., 2003
Sediments	Ba, Cd, Cr, Cu, Hg, Ni, Pb, V, Zn	North and Baltic Sea	Breuer et al., 2004
Asteroids, Sediments	Cd, Cu, Pb, Zn	North Sea, Southern Bight	Danis et al., 2004
Water (dissolved fraction, particulate matter, surface & deeper water)	Cd, Cu, Hg, Pb, Zn	Western and Central Baltic Sea	Dippner & Pohl, 2004
Fish	Cd, Cu, Mn, Pb	North Sea, Southern Bight	Henry et al., 2004
Asteroids	Cd, Cu, Pb, Zn	North Sea, Southern Bight	Danis et al., 2006
Mussel	Cd, Cu, Ni, Pb, Zn	German Wadden Sea	Jung et al., 2006
Air, Precipitation	Hg	North Sea Area	Wängberg et al., 2007

Table 2
Summary of studies on metal concentrations in tissues of marine mammals of the North and Baltic Seas.

Species	Organ	Element	Location	Reference
Phocoena phocoena, Lagenorhynchus albirostris	B, L, M	Cu, Hg, Pb, Zn	Denmark	Andersen & Rebsdorff, 1976
Phoca vitulina	Br, K, L	Cd, Cu, Hg, Pb, Zn	German Wadden Sea	Drescher et al., 1977
Phocoena phocoena, Phoca vitulina, Phoca hispida, Halichoerus grypus, Hyperoodon ampullatus, Delphinapterus leucas	K, L, M	Cd, Cu, Hg, Pb, Zn	North and Baltic Coasts, Germany	Harms et al., 1978
Phoca vitulina	B, Br, He, K, L, Pl, Sp	Cd, Cr, Cu, Fe, Mn, Pb, Zn	Dutch Wadden Sea	Duinker et al., 1979
Phoca vitulina	Br, K, L	Br, Hg, Se	Wadden Sea	Reijnders et al., 1980
Phocoena phocoena	Br, K, L,	Cd, Cu, Hg, Pb, Zn	Scotland	Falconer et al., 1983
Phocoena phocoena, Tursiops truncates, Halichoerus grypus, Stenella coeruleoalba	B, L, M	Cd, Cr, Cu, Hg, Ni, Pb, Zn	Irish Sea	Morris et al., 1989
Phoca vitulina	L	As, Cd, Cu, Hg, Se, Zn	Norwegian	Skaare et al., 1990
Phoca vitulina, Halichoerus grypus, Tursiops truncates, Lagenorhynchus albirostris, Lagenorhynchus acutus, Delphinus delphis, Stenella coeruleoalba	L	Cd, Cr, Cu, Hg, Ni, Pb Zn	Waters around British Isles	Law et al., 1991
Phocoena phocoena, Physeter macrocephalus, Delphinus delphis, Tursiops truncatus	K, L, M	Hg	Denmark, Belgium	Joiris et al., 1991
Phoca vitulina, Halichoerus grypus, Phoca hispida	K, L	Al, Ca, Cd, Co, Cr, Cu, Fe, Mg, Mn, Ni, Pb, V, W, Zn	Swedish waters	Frank et al., 1992
Phoca vitulina	H, S	Cd, Hg, Pb	German Wadden Sea	Wenzel et al. 1993
Phocoena phocoena	L	Organo-Sn	Polish Baltic Sea	Kannan & Faladysz, 1997
Phocoena phocoena, Halichoerus grypus	L	Organo-Sn	Waters around British Isles	Law et al., 1998
Physeter macrocephalus	B, K, L, M	Cd, Cr, Cu, Fe, Hg, Ni, Pb, Se, Ti, Zn	Southern North Sea	Holsbeek et al., 1999
Grampus griseus, Lagenorhynchus albirostris, Delphinus delphis, Stenella coeruleoalba, Globicephala melas, Lagenorhyncus acutus, Kogia breviceps, Mesoplodon bidens, Mesoplodon densirostris, Hyperoodon ampullatus, Balaenoptera physalus, Balaenoptera acutorostrata	L	Organo-Sn	Waters around British Isles	Law et al., 1999
Phocoena phocoena, Lagenorhyncus albirostris	K, L, M	Hg	North and Baltic Coasts, Germany	Siebert et al., 1999

Phocoena phocoena	L	Cd, Cr, Cu, Hg, Ni, Pb, Se, Zn	England, Wales	Bennett et al., 2001
Phoca hispida	K, L, M	Cd, Hg, Pb, Se	Baltic Sea, Svalbard	Fant et al., 2001
Grampus griseus, Lagenorhynchus albirostris, Delphinus delphis, Stenella coeruleoalba, Globicephala melas, Lagenorhyncus acutus, Kogia breviceps, Mesoplodon bidens, Balaenoptera physalus, Balaenoptera acutorostrata	L	Ag, As, Cd, Cr, Cu, Fe, Hg, Ni, Pb, Se, Zn	Waters around British Isles	Law et al., 2001
Phocoena phocoena	K, L, K	Cd, Cr, Cu, Fe, Mn, Ni, Pb, Zn	Southern Baltic Sea, Danish and Greenland coastal waters	Szefer et al., 2002
Phocoena phocoena, Phoca vitulina, Phoca hispida	B, Br, K, L, M, S,	organo-Sn	Norwegian	Berge et al., 2004
Phocoena phocoena, Phoca hispida, Halichoerus grypus, Stenella coeruleoalba	L	organo-Sn	Polish Baltic Sea	Ciesielski et al., 2004
Phocoena phocoena	K, L, M	Cd, Cu, Fe, Hg, Se, Zn	Belgium, France, Germany (North and Baltic Sea), Denmark	Das et al., 2004
Phoca vitulina	Bl	Al, As, Be, Cd, Cr, Co, Cu, Au, Fe, Pb, Mn, Mo, Ni, Pd, Pt, Se, Ag, Sn, Ti, Zn	German Wadden Sea	Kakuschke et al., 2005
Phocoena phocoena	L	Hg, organo-Sn	Danish waters	Strand et al., 2005
Phocoena phocoena, Phoca hispida, Halichoerus grypus, Stenella coeruleoalba	L	Al, B, Ba, Ca, Cd, Co, Cr, Cu, Fe, Ga, Hg, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Se, Si, Sr, Tl, V, Zn	Polish Baltic Sea	Ciesielski et al., 2006
Phoca vitulina	Bl	Ca, Cu, Fe, K, P, Rb, S, Se, Sr, Zn	German Wadden Sea	Griesel et al., 2006
Halichoerus grypus	Bl	Al, As, Be, Cd, Cr, Co, Cu, Au, Pb, Mn, Mo, Ni, Pd, Pt, Se, Ag, Sn, Ti, V, Zn	German Wadden Sea	Kakuschke et al., 2006
Phocoena phocoena	K, L	Cd, Cu, Hg, Se, Zn	Southern North Sea	Lahaye et al., 2007
Phoca vitulina	Bl	Al, As, Be, Ca, Cd, Cr, Co, Cu, Fe, K, Pb, Mn, Mo, Ni, Pd, Pt, Rb, Se, Sn, Sr, Ti, V, Zn	German Wadden Sea	Griesel et al., 2008
Phoca vitulina	Bl	Al, As, Be, Ca, Cd, Cr, Fe, Pb, Mn, Mo, Ni, Se, Sn, Zn	German Wadden Sea	Kakuschke et al., 2008a
Phoca vitulina	Bl	Al, As, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mn, Mo, Ni, Pb, Pd, Pt, Rb, Se, Sn, Sr, Zn	German Wadden Sea	Kakuschke et al., 2008b

B=blubber, Bl=blood, Br=brain, M=muscle, L=liver, K=kidney, S=skin, Sp=spleen, He=heart, Pl=placenta, H=hair

Most studies on metal body burdens focused on the investigation of metal concentrations in the liver, kidney or muscle, i.e. tissues available only through post-mortem examination. In living animals the choice of samples is mostly restricted to blood and hair. However, because of sampling difficulties, up to now only few studies have reported values for metals in the blood of marine mammals (Baraj et al., 2001; Caurant & Amiard-Triquet, 1995; Nielsen, Nielsen, Jorgensen, & Grandjean, 2000) and in particular for pinnipeds in the North Sea (Griesel et al., 2006; Kakuschke et al., 2005, 2006). Current studies suggested relatively high metal concentrations in living seals of the North Sea compared to human blood reference values as well as local differences in metal concentrations (Griesel, Kakuschke, Siebert, & Prange, 2008). Furthermore newborn seals in the North Sea showed high body burdens of selected metals, probably caused by a transplacental transfer from the mother to fetus or through the milk during the lactation period (Kakuschke, Griesel, & Prange, 2008a).

Metal pollutants and marine mammal health

Metals and their effects on marine mammals have been reviewed by Das, Debacker, Pillet, & Bouquegneau (2003), O'Shea (1999), and Reijnders, Aguilar, & Donovan, (1999). Nevertheless, apart from metal body burden data, only limited information is available, especially on the related health effects. Hyvärinen & Sipilä (1984) found a relationship between stillbirths of ringed seal (*Pusa hispida saimensis*) pups from Finland and the Ni concentrations in hair samples. Experimental intoxication of harp seal (*Pagophilus groenlandicus*) with methyl-Hg by daily oral intake (25mg/kg) was found to result in lethargy, weight loss and finally death (Ronald, Tessaro, Uthe, Freeman, & Frank, 1977). The corresponding blood parameters indicated renal failure, uremia and toxic hepatitis. Rawson et al. (1993) found an accumulation of lipofuscin in the liver cells of stranded Atlantic bottlenose dolphins (*Tursiops truncatus*) caused by a Hg induced inhibition of the activity of digestive enzymes, which finally results in an increased number of liver diseases. In a case study Shlosberg et al. (1997) described progressive liver damage and finally death of a bottlenose dolphin resulting from Pb intoxication. Studies on the adrenal and testicular steroidogeneses in the grey seal (*Halichoerus grypus*) and harp seals (*Pagophilus groenlandicus)* indicated altered biosyntheses caused by metal contaminants (Freeman, Sangalang, Uthe, & Ronald, 1975; Freeman & Sangalang, 1977). Methyl-Hg intoxicated harp seals showed a low level of damage of sensory cells of the organ of Corti (Ramprashad & Ronald, 1977).

Some researchers have used an indirect approach to investigate the prediction that metal pollutants result in lower resistance to diseases. The endangered population of belugas (*Delphinapterus leucas*) in the polluted estuary of the St. Lawrence River showed high concentrations of organochlorines, heavy metals, and benzo[*a*]pyrene in tissues as well as a high prevalence of tumors which suggests an influence of contaminants through a direct carcinogenic effect and/or a decreased resistance to the development of tumors (De Guise, Lagace, & Beland, 1994). Siebert et al. (1999) investigated Hg body burden and diseases in harbor porpoises (*Phocoena phocoena*) from the German Waters of the North and Baltic Seas. High Hg concentrations were associated with a prevalence of parasitic infections and pneumonia. Bennett et al. (2001) investigated harbor porpoises found dead along the coasts of

England and Wales that died as a consequence of physical trauma as well as infectious diseases. They found that the mean liver concentrations of Hg, Se, the Hg:Se molar ratio and Zn were significantly higher in the porpoises that died of infectious diseases in comparison to those who died because of a physical trauma. Similarly, Kannan, Agusa, Perrotta, Thomas, & Tanabe (2006) and Kannan, Guruge, Thomas, Tanabe, & Giesy (1998) investigated the concentrations of butyl-Sn residues and trace elements in sea otters (*Enhydra lutris nereis*) found dead along the California coastal waters. They studied otters that died due to infectious diseases as well as those that died because of other reasons. Otters that died because of infectious diseases indicated higher concentrations of butyl-Sn in comparison to those that died as a result of physical trauma. The concentrations of Mn, Co, Zn, and Cd were elevated in the diseased and emaciated sea otters relative to the non-diseased sea otters. An elevated accumulation of tributyl-Sn was also found in bottlenose dolphins (*Tursiops truncatus*) stranded along the Atlantic and Gulf coasts of Florida (Kannan et al., 1997). These relationships are substantiated by the fact that the pollution with metals may affect the immunocompetence and disrupt the immune homeostasis of free-ranging populations of marine mammals in many areas of the industrialized world.

Metal influences on immune functions

Metals influence the function of immunocompetent cells by a variety of mechanisms. Depending on the particular metal, its speciation, concentration and bioavailability, and a number of other factors, a continuous metal exposure will result in an immunoenhancement or immunosuppression effects. Reviews of immunomodulation by metals in humans or laboratory animals include those of Chang (1996), Dean, Luster, Munson & Kimber (1994), or Lawrence & McCabe (2002), but metal influences on marine mammals in relation to environmental contamination have been only poorly investigated.

Immune cells such as macrophages can incorporate and store metal components, e.g. Hg and Se in mineral granules, as described for various marine mammal species (Nigro & Leonzio, 1996). In *in vitro* experiments, a similar incorporation of Ti was shown for blood macrophages of harbor seals (Figure 1a). Depending on the concentration, metals can be cytotoxic for immune cells as well as inhibit or stimulate cell functions, the latter in all probability by binding to proteins.

Killer cell activity, phagocytosis and transformation of lymphocytes have been investigated in various marine mammal species and evidence for the immunosuppression function of metal pollutants has been provided. The mitogen-induced proliferation of immune cells was inhibited by butyl-Sn compounds in several marine mammals and humans (Nakata et al., 2002). Phagocytosis and lymphoblast transformation in grey seal pups were adversely affected by Hg *in vitro* (Lalancette, Morin, Measures, & Fournier, 2003). The effects of heavy metals on beluga whale splenocytes and thymocytes *in vitro* indicate functional impairment (De Guise, Bernier, Martineau, Beland, & Fournier, 1996). Pillet et al. (2000) found a sex-dependent effect of Zn on phagocytic activity. In a study on harbor seal pups from the North Sea, lymphocyte proliferation was especially inhibited by Be, Pb, Cd and Hg in newborn pups (Kakuschke et al., 2008c). Interestingly, the susceptibility to the toxic effects of metals seems to be decreased in infant pups.

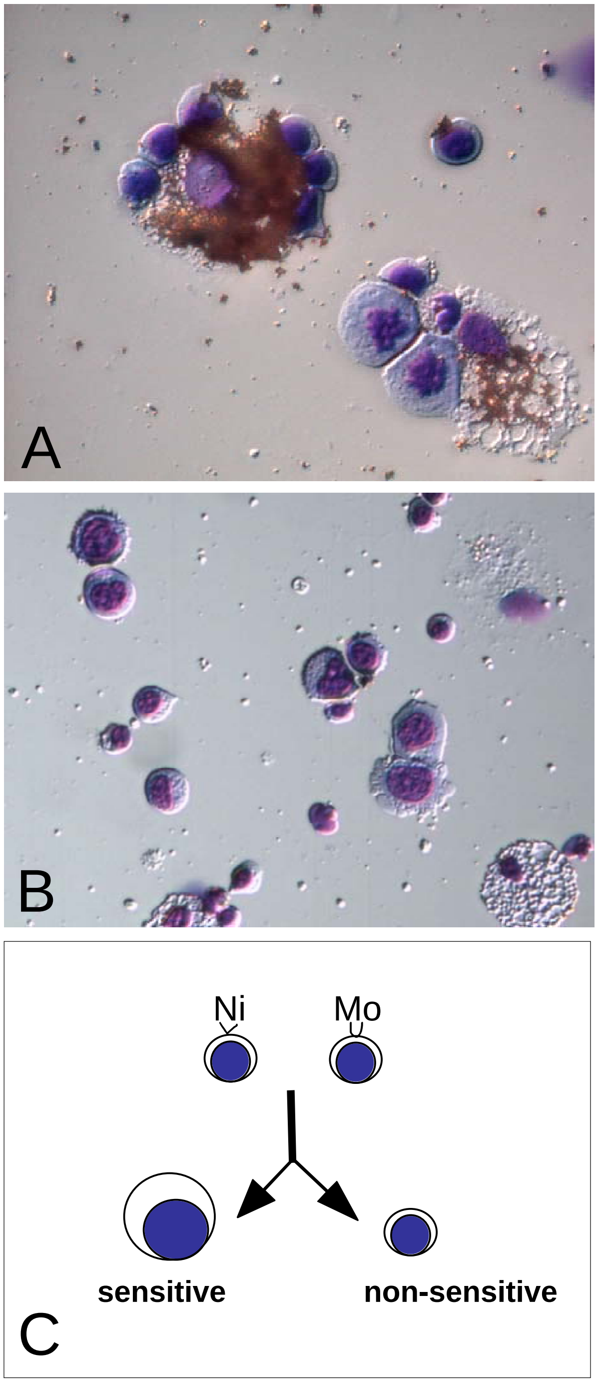

Figure 1. Morphological analysis of Ti-induced (A) and Ni-induced (B) lymphocyte proliferation. In A: two lymphoblasts, one macrophage with ingested titanium particle, and several resting lymphocytes. In B: several lymphoblasts, one macrophage, and resting lymphocytes. C: Principal transformation of lymphocytes.

In addition to immunosuppression, metal pollutants may induce immunoenhancement leading to hypersensitivity and autoimmunity. Even though the metal input into the marine system appears to have been decreasing in recent years, low-level metal concentrations can modulate the immune system. The chronic intake of metal pollutants renders marine mammals candidates for developing hypersensitivity reactions. A lymphocyte transformation test for detecting antigen-specific metal sensitivities according to the MELISA® (memory lymphocyte immuno-stimulation assay) (Stejskal, Cederbrant, Lindvall, & Forsbeck, 1994; Valentine-Thon & Schiwara, 2003; Valentine-Thon, Sandkamp, Müller, Guzzi, & Hartmann, 2005) was used to investigate pinnipeds from the North Sea (Kakuschke et al., 2005, 2006). The method is based on the fact that lymphocytes, which have been sensitized by a certain metal ("memory cells"), transform into blasts and proliferate when they are re-exposed to this metal (Figure 1). Altogether 31 pinnipeds from the North Sea were investigated, including 13 pups and 17 adult harbor seals as well as one grey seal (Kakuschke, 2006). 13 of these 31 animals showed such a metal-specific delayed type hypersensitivity reaction. The frequency of sensitizing metals was in the order Mo > Ni > Ti > Cr, Al > Pb, Be, Sn. Furthermore, a relationship between the blood levels of metals and this immunological dysfunction was reported (Kakuschke et al., 2005).

In the case study of the grey seal the hypersensitivity reaction to Ni and Be could be validated by different approaches – the proliferation of memory lymphocytes as well as the altered cytokine pattern (Kakuschke et al., 2006). With the cytokines interleukin-2 (IL-2) and interleukin-4 (IL-4) it is possible to distinguish between T-helper 1 (Th1), IL-2 secreting cells and T-helper 2 (Th2), IL-4 producing cells (Elenkov & Chrousos, 1999). The impact of stress on the cytokine pattern was recently described for harbor porpoises from the North Sea (Fonfara, Siebert, Prange, & Colijn, 2007). Kakuschke et al. (2006) measured the mRNA-expression of IL-2 and IL-4 in grey seal lymphocytes co-cultivated with the sensitizing metals Ni and Be as well as the non-sensitizing metals Hg and Cd. Ni and Be induced the lowest cytokine expression compared to the other metals and the quotient IL2/IL4 was increased due to a strong down-regulation of the Th2 cytokine IL-4, which suggests an antigen-specific delayed-type hypersensitivity reaction with a Th1/Th2 polarization toward Th1 (Kidd 2003).

Summary

The environmental exposure with metals is believed to affect marine mammal health adversely. One mechanism whereby metals can alter the health status is through modulation of immune homeostasis. Metals may change the response repertoire by direct and indirect means, which include changes in cell proliferation, phagocytosis, protein expression or other cell functions. Some resulting effects may include immunosuppression or acute as well as chronic inflammatory processes leading to hypersensitivities or autoimmune diseases. The multiple influences of metals on the immune system underline the importance of metals pollution as a potential stressor for marine mammals.

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Potential Synergism between Stress and Contaminants in Free-ranging Cetaceans

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Noise has increased significantly over the last decades in oceans, and this trend is accelerating in large part because of oil exploration and exploitation, both of which are expanding worldwide. Considered together with recent evidence that noise disturbs the behavior, echolocation, navigation and communication of marine mammals, it is likely that noise, increasingly encountered by marine mammals, will add to their allostatic load. Glucocorticoids (GCs) are the major hormones that mediate the long term effects of stress. GCs' effects depend, among other factors, on the intracellular concentrations of the various isoforms of the glucocorticoid receptors (GR). Tissue and cell-type specificity are also conferred by the presence in target cells of GR ligands such as chaperones, co-chaperones and modulatory element binding proteins whose concentrations vary according to tissue, cell types and even to the cell cycle phase. The normal regulation of GCs production in adult life relies on the normal development of the hypothalamus-pituitary adrenal (HPA) axis in uterine and early postnatal life, which in turn depends on the absence of chronic stress imposed to both the mother and newborn during these critical periods. Worldwide, cetacean populations, such as the beluga population inhabiting the St Lawrence Estuary (SLE) in Canada, are exposed to anthropogenic stressors, and are contaminated by persistent lipophilic contaminants of which many are abundantly transferred to newborns during lactation. GCs and certain organochlorine contaminants (OCs), for instance dioxin-related polychlorinated biphenyls (DRPBs), mediate their prolonged and profound effects through nuclear receptors such as aryl hydrocarbon receptors (AhR). These effects are exerted on most organs, especially on the developing brain and lymphoid organs of fetuses and juveniles and on adrenal glands of adult mammals. Multiple interactions have been demonstrated between GCs and OCs, often through interactions between their receptors. These interactions may disturb the delicate balance required by immature and adult mammals to react optimally to stressors.

Stressors elicit a fairly stereotyped response in higher vertebrates, including marine mammals. In general, the elevation of circulating GCs levels that follows exposure to various stressors – including noise - is beneficial. High GC levels become detrimental however when they occur over a long period, when the stressor is persistent or repeated (Deak, this issue; Romero & Butler, this issue; Sapolsky, Romero, & Munck, 2000; St. Aubin, De Guise, Richard, Smith, & Geraci, 2001; St Aubin & Dierauf, 2001).

The sympathetic nervous system (SNS) responds within seconds to stressors by releasing preformed catecholamines (CAs) (epinephrine and norepinephrine) from the adrenal medulla into the blood circulation. This release quickly increases heart rate and blood pressure, which is part of the acute - or fight or flight – response. These effects occur within seconds because CAs bind adrenergic receptors present in peripheral tissues. The binding triggers an

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immediate intracellular biochemical cascade through secondary messengers (Romero & Butler, this issue). When extreme, this response may kill animals and humans through CAs' toxic effects on heart muscle fibers (McEwen, 1998, 2000). In addition, within several minutes, CAs induce the production of T helper cells (Th)-1, proinflammatory (or cell-mediated immunity) cytokines (see below), probably to prepare the organism to fight bacterial invasions secondary to potential wounds.

Concurrently with CA release, hypothalamic neurons trigger indirectly the release of GCs from the adrenal glands. Hypothalamic neurons first signal the pituitary to release ACTH via the corticotrophin releasing hormone (CRH). In turn and within minutes, ACTH triggers the synthesis and release of GCs from the adrenal cortex where GCs are synthesized from cholesterol (hence their lipophilicity). GCs are then distributed indiscriminately throughout the stressed organism, and traverse the lipid-based cytoplasmic membranes of most cells. This broad distribution explains in part GCs' impact on a wide variety of cells. Each cell type, including inner ear cells (cochlea, organ of Corti), is distinguished by the presence of various isoforms of intracytoplasmic GR and other GC ligands such as chaperones, co-chaperones, and modulatory element binding proteins (heat shock protein 90 (hsp 90), immunophilins and GMEB-1 respectively), ensuring that GCs' effects are tissue and cell type specific (Canlon, Meltser, Johansson, & Tahera, 2007; De Bosscher, Vanden Berghe, & Haegeman, 2002; Horner, 2003). Elevated GC levels elicited by acute stress repress the CA-induced production of proinflammatory cytokine by Th1 cells through GR. The present review will address the potential interactions between contaminants, stress and the immune system in marine mammals at the molecular level. It will not deal with the possible role of stress on the high cancer rates seen in some populations of marine mammals (Martineau et al., 2002). The latter will be addressed elsewhere (Martineau, in preparation).

Immune system: A review

The immune system is classically divided in two major branches, innate and adaptive. The innate branch, constantly in standby alert to defend the body against microorganisms or trauma, is not antigen (Ag)-specific, and has no memory of previous encounters with microorganisms, e.g. it reacts the same way regardless of the number or extent of previous encounters. Most of those microorganisms that invade the body are quickly eliminated by the members of the innate system, monocytes/macrophages, neutrophils and natural killer (NK) cells, through acute inflammation. Acute inflammation is characterized by increased vascular permeability resulting of the action of histamine and bradykinin, but also of interleukin (IL)-1 and Tumor Necrosis Factor alpha (TNF-α). The latter two molecules, "IL-1-like cytokines", are produced by local macrophages, and are major actors of inflammation, for which they are called proinflammatory cytokines. IL-1-like cytokines also induce the expression of adhesion molecules by endothelium used by neutrophils to adhere to the walls of capillaries adjacent to inflamed sites. Interleukin (IL)-8, a molecule also synthesized by endothelial cells, has complex effects on neutrophils, resulting in their firm adhesion to vascular walls and sequestration at the inflammatory site. Then neutrophils traverse these walls to migrate into damaged tissues which become infiltrated – and destroyed – by large numbers of neutrophils.

If acute inflammation cannot eliminate the aggressing microorganism, and/or if damages are too heavy, chronic inflammation ensues after several days. Neutrophils are progressively replaced by extensive numbers of monocytes/macrophages which engulf and kill microorganisms, and clean up tissue debris. Lymphocytes and fibroblasts accompany macrophages (fibroblasts synthesize collagen, a major component of fibrous (scar) tissue).

Simultaneously, macrophages and dendritic cells (DC) (specialized macrophages), also produce IL-12, which triggers the production of interferon (IFN)-γ by lymphocytes. In turn, IFN-γ further increases the ability of macrophages to kill microorganisms. Macrophages start presenting antigens to $CD4^+$ naïve T cells, a lymphocyte subpopulation. The IL-1 and TNF-α produced by macrophages also activate these lymphocytes, thus launching the first steps of an immune response.

In contrast to the innate branch, the adaptive branch is antigen (Ag) specific and is endowed with memory, e.g. its cellular members (lymphocytes and their products) recognize a given Ag a long time after they first encounter it. Antigen presenting cells (APCs) e.g. macrophages, dendritic cells (DC) and B cells, phagocyte foreign invaders such as bacteria, and break them down into minute fragments which are physically presented on their surface to $CD4^+$ T cells. DCs are the most efficient APCs and the most important in activating lymphocytes. On the APC surface, the Ag is presented within a cleft of certain surface proteins called major histocompatibility complex (MHC) molecules. This encounter causes undifferentiated ($CD4^+$) T cells to produce one of two distinct cytokine patterns, Th1 or Th2. The Th1 pattern, generally seen as pro-inflammatory, is directed at intracellular invaders such as viruses and certain bacteria. The Th2 pattern, broadly considered as anti-inflammatory, is central to humoral immunity (or “antibody-mediated” immunity). Antibodies are most efficient at fighting extracellular parasites such as helminthes (ex.: nematodes, cestodes, trematodes) and most pathogenic bacteria.

Th1 and Th2 are mutually antagonistic. For instance, Th1 differentiation is inhibited by IL-4, the major Th2 cytokine involved in differentiating T cells into Th2 cells (IL-4 is produced by Th2 lymphocytes, mast cells and eosinophils). The severity of tissue destruction in an organ or at a particular anatomical site during an attack by a pathogenic agent is the result of the Th1/Th2 balance prevailing at that site (with a high ratio being synonymous of severe tissue damage). A third category of T cells (T reg) has a negative regulatory effect on both Th1 and Th2 cells by the production of transforming growth factor (TGF)-β.

Which pattern will be followed depends among other factors on the type of APC (there are many types of DC and macrophages), the nature of the presented Ag, and the local relative concentrations of other cytokines. The production of IL-12 by APCs, mostly by DC, plays a central role in the differentiation of T cells into Th1 cells. Th1 cells are responsible for cell-mediated immunity; they release cytokines among which IL-2 is central for macrophages and cytotoxic T cells ($CD8^+$) activation. Cytotoxic T cells ($CD8^+$) are lymphocytes committed in killing otherwise normal host cells infected by viruses or intracellular bacteria and abnormal host cells such as tumor cells.

Th2 cells produce a battery of cytokines (IL-4, -5, -9 and -13) that help B cell differentiating into antibodies-(IgE) producing cells. Other cytokines involved in Th1 to Th2 differentiation include CCL1 (CC- chemokine ligand 1), which plays a role in cardiovascular diseases and allergic diseases such as asthma.

IFNs are an essential part of the innate system that participates also to the adaptive system, for instance by increasing MHC proteins expression. These molecules are released in the microenvironment where they have an effect on the cells that produce them (autocrine effect) as well as on adjacent cells (paracrine effect). All those cells become protected against viral infection (interferons *interfere* with viral infection) among other effects. IFNs are classified in two groups: type I group is composed of IFN α, β and ω, which are produced by almost all cell types mainly to protect against viral infection. Their expression is partially under the control of transcription factors nuclear factor kappa B (NF-κB), interferon regulator factors (IRF)-3 and other transcription factors (IRF-3 activation itself is triggered by viral infections). Reciprocally, the expression of type I IFNs leads to IRF-3 activation, resulting in a positive feedback loop (Jonasch & Haluska, 2001).

Type II IFNs are composed of a single member, IFNγ, which plays a central role in inducing the Th1 pattern. IFNγ is produced by APCs (among which DCs are the most important), Th1 cells and NK cells. Along with IL-12, IFNγ helps differentiating T cells into Th1 cells, and the latter in turn produce more IFNγ. As importantly, IFNγ activates macrophages in at least two ways: it enhances the capacity of macrophages to kill intracellular parasites, and triggers the production of IL-12, -6 and -18 by macrophages, which further increases Th1 differentiation.

. NF-κB is a family of five transcription factors: NF-κB1 (p105/p50), NF-κB2, RelA, RelB and c-Rel, all involved in inflammation. All members form homo- or heterodimers which repress or activate the expression of a plethora of mammalian pro-inflammatory genes such as IL-1, -2, -4, -8, -12, IL-2R, and others. NF-κB1 and NF-κB2 homodimers decrease the transcription of these pro-inflammatory genes whereas RelA and RelB activate it. NF-κB members are implicated in IL-12 expression by APC, and thus are essential to Th1 differentiation. They also play a central role in innate immunity, inflammation and infection, suppression of lymphocyte apoptosis (programmed death), and DC development (Caamaño & Hunter, 2002). Inactive NF-κB lies in the cytosol bound to IκB, an inhibitor. Various factors such as cytokines and growth factors, or cellular stresses such as bacteria and viruses, trigger the phosphorylation of IκB, which then releases NF-κB. The latter translocates to the nucleus where, like GR and the AhR, it recognizes specific DNA sequences, appropriately named κB sequences.

Glucocorticoid receptor

GC-mediated GR activation accounts for the anti-inflammatory effects of GCs. Activated GR blocks the expression of all pro-inflammatory cytokines such as IL-1 and Th1 cytokines, leaving intact the production of “anti-inflammatory” Th2 cytokines. Thus GCs protect cells and tissues from damages inflicted by exaggerated cell-mediated Th1-type immune response (Ramirez, Fowell, Puclavec, Simmonds, & Mason, 1996; Sapolsky et al., 2000). Liganded GR also activates the transcription of anti-inflammatory proteins such as Clara cell protein 10, IL-1 receptor antagonist, lipocortin, mitogen-activated protein kinase phosphatase-1, neural endopeptidase, and serum leukoprotease inhibitor. Liganded GR activates these genes by binding DNA, specifically the GRE sequences located in the regions that control the expression of these genes.

GR-mediated repression of Th1 functions is mainly exerted through transcriptional repression of at least three pro-inflammatory transcription factors, NF-κB, IRF-3, and AP-1 (the latter is a complex made of two nuclear molecules, c-fos and c-jun). The liganded GR represses the transcription of these factors by protein-protein interactions, not by binding DNA elements. Most of these anti-inflammatory effects are mediated by interactions between liganded GR α and NF-κB. It has been hypothesized that NF-κB may compete with GR for coactivator molecules necessary for the transcription of genes targeted by both activated GR and NF-κB. These two coactivators, “Steroid receptor coactivator-1” (SRC-1) and “p300/CBP”, are responsible for making gene promoters accessible to the transcription machinery by acetylating histones. Importantly, SRC-1 and p300/CBP also bind the AhR, a cellular receptor which mediates the toxicity of many contaminants. In addition, p300/CBP also binds IRF-3, suggesting that competition for coactivators could occur between GR, NF-κB and AhR (Smoak & Cidlowski, 2004; Tian, Rabson, & Gallo, 2002). IRF-3 augments IFN α and β transcription and also elevates the transcription of other pro-inflammatory genes such as Il-15 and RANTES, a chemoattractant of eosinophils and monocytes (Hiscott et al., 1999; Taniguchi, Ogasawara, Takaoka, & Tanaka, 2001). The activated GR becomes tethered to DNA-bound IRF-3, and inhibits the transcription of IRF-3 target genes (Kassel & Herrlich, 2007).

Elevation of GC circulating levels prior to exposure to loud noise protects the inner ear from audiogenic trauma and conversely, a failure to elevate GC levels prior to or during audiogenic trauma increases damages (Canlon et al., 2007). In contrast, chronic stress, which results from repeated or prolonged exposure to a stressor and leads to prolonged adrenocortical stimulation by ACTH and exposure to high GC levels, has deleterious effects on most organs, especially on the brain and the immune system (Table 1) (McEwen, 1998; Sapolsky et al., 2000; Romero & Butler, this issue). Note that sustained high levels of ACTH are correlated morphologically with hyperplasia and hypertrophy of the adrenal cortex (Ulrich-Lai et al., 2006). For instance, suicide victims, patients suffering depression and captive non human primates exposed to social stress all show an increase of adrenal mass due to chronic stress (Swaab, Bao, & Lucassen, 2005).

Table 1

Similarities between glucocorticoid receptor (GR) and aryl hydrocarbon receptor (AhR).

Characteristic	GR	AhR	Reference
Function	Nuclear receptor for endogenous hormone, glucocorticoid (released under physiological stress).	Nuclear receptor for xenobiotic. Regulate (enhance) exogenous compound metabolism.	Hahn, 2002; Escriva, Safi, Hänni, et al., 1997; Tian et al., 2002.
	Important for development		
Intracellular location	Intracytoplasmic. Ligand- activated migration to nucleus		
Constitutive ligand	hsp90		
Ligand hydrophobicity	Hydrophobic		
Other ligands	NF-κB		
Target sequence	GRE	DRE (dioxin responsive element) or Xenobiotic responsive element (XRE)	
Natural endogenous ligands	Glucocorticoids	Unknown	
Targets	Multiorgans		
Effects timescale	Prolonged		
Major immune cells targets	T cells		
Selected effects of long term ligand-mediated activation	Immune suppression (T-cell apoptosis and decreased thymus development)	T cells, B cells, dendritic cells	Kerkvliet, 2002
	CYP induction		Herold, McPherson, & Reichardt, 2006. McMillan, McMillan, Glover, et al., 2007.
	Neurotoxicity		Hahn, 2002; Wang, Faucette, Gilbert et al., 2003.
	Diabetogenic		De Kloet, Vreugdenhil, Oitzl et al., 1998; Williamson, Gasiewicz, & Opanashuk, 2005.
			Buckingham, 2006; Remillard & Bunce 2002; Matsumara, 1995.

Stress in cetaceans

Most studies carried out on captured cetaceans to measure stress-induced elevation of GCs suffer drawbacks, some of which are inherent to cetaceans: basal cortisol values are low, interindividual variations are wide, and increases in cortisol levels following stress exposure are lower than those seen in terrestrial mammals. Other drawbacks are inherent to wildlife studies: a long interval may elapse between chase/capture and sampling time, which makes difficult determining basal cortisol levels (Bossart, Reidarson, Dierauf, & Duffield , 2001; Ortiz & Worthy, 2000; St. Aubin et al., 2001; St Aubin, 2001; St Aubin & Dierauf, 2001; St Aubin, 2002 a, b). In spite of these problems, elevated cortisol levels have been associated with stressors in marine mammals and in Eastern Tropical Pacific (ETP) dolphins which are captured after the intensive chase involved in tuna fishing (Bossart et al., 2001; St. Aubin, Ridgway, Wells, & Rhinehart, 1996; St Aubin, 2002 a, b). Chased ETP dolphins showed typical evidences of acute stress such as elevated circulating GC levels, high circulating levels of glucose, decreased circulating levels of iron, thyroid hormone levels, and the presence of a typical "stress leukogram" (increased number of circulating white blood cells due to neutrophils, and decreased numbers of lymphocytes and eosinophils). Other evidences of acute stress seen in these animals were clearly deleterious, such as the observed necrosis of cardiac muscle fibers, probably due to catecholamine overload (Cowan & Curry, 2002; St. Aubin, 2002 a, b).

In porpoises (*Pocoena phocoena*), Th1 proinflammatory cytokines levels were lower and cortisol levels were higher in accidentally captured animals than in captive animals. This difference was consistent with the switch from the Th1 proinflammatory to the immunosuppressive Th2 cytokine pattern seen in response to stressors (and high cortisol levels) in laboratory animals and humans (Fonfara, Siebert, & Prange, 2007; Fonfara, Siebert, Prange, & Colijn, 2007).

Anthropogenic background noise has increased tremendously in oceans over the last decades because of increased maritime traffic and exploration for and exploitation of oil and natural gas. Cetaceans are sensitive to seismic air and waterguns used for these industrial activities (Finneran, Schlundt, Dear, Carder, & Ridgway, 2002). Papers presented in this issue and other studies indicate that both diffuse (e.g. background) and source noises impact the behavior, social communications and navigation of free-ranging cetaceans, and presumably cause stress in these animals (Aguilar Soto et al., 2006; Fair & Becker 2000; Finneran et al., 2002; Foote, Osborne, & Hoelzel, 2004; Hatch & Wright, this issue; Ridgway, et al., 2001; Schlundt, Finneran, Gardner, & Ridgway, 2000; Wright et al., this issue, b). Anthropogenic sound is likely to impact whales even in the deep ocean because it can be transported over thousands of miles, and even deep diving whales can be impacted because high hydrostatic pressures prevailing at great depth do not decrease the hearing acuity of whales (Ridgway et al., 2001). Whether high cortisol levels due to noise or to other stresses can protect whales' inner ear from noise-induced damage is of course highly speculative at this point.

Contaminants and immunosuppression in cetaceans

Some populations of cetaceans are severely affected by multiple anthropogenic stressors. Cetaceans are long lived animals which occupy top positions of the food chain, and whose body is composed of a high percentage of lipids. Thus, it is not surprising that lipophilic contaminants widespread in the food chain and resistant to metabolism accumulate at very high levels in the tissues of these animals. In addition, contaminant levels are often higher in juvenile animals than in adults because contaminants are transferred to newborns from females through cetaceans' lipid-rich milk (Hickie et al., 2000; Martineau, Béland, Desjardins, & Lagacé, l987).

The beluga whale population which inhabits the St Lawrence Estuary (SLE), Quebec, Canada, was severely reduced by hunting from about 7,800 in 1866 to a current estimate of 1,100 animals (Standard error = 300, 95 % confidence interval = 500-1,800) (Department of Fisheries and Oceans Canada, 2007). The population has failed to recover although hunting ended in 1979. Systemic examinations of stranded carcasses started in 1982 have shown that these animals are severely contaminated by lipophilic contaminants compared to Arctic beluga whales. Many of these compounds are known immunosuppressors that often target the adrenal glands, the final effectors of all stress responses (De Guise, Martineau, Béland, & Fournier, 1998; Letcher, Klasson-Wehler, & Bergman, 2000a; Letcher et al., 2000b; Martineau et al., l987; Martineau et al., 1988; Martineau et al., 2002; Martineau, Mikaelian, & Lapointe, 2003).

SLE beluga whales also suffer a variety of opportunistic infections and parasite infestations, suggesting that they are immunosuppressed. In marine mammals, contamination with DRPBs has long been associated with immunosuppression. DRPBs-induced immunosuppression has been suspected to play a role in making harbor seals (*Phoca vitulina*) more sensitive to phocine morbillivirus. These viruses killed more than 20,000 harbor seals in 1988 in the Baltic Sea. Significantly higher tissular concentrations of polychlorinated biphenyls (PCBs) were measured in striped dolphins (*Stenella coeruleoalba*) affected by the 1990-92 morbillivirus epizootic in the Mediterranean Sea, compared to concentrations observed in previous and later years. This difference led to the conclusion that DRPBs may have impaired the dolphins' immune response to the viral infection (Aguilar & Borrell, 1994). A similar association between morbilliviral infection and high OC tissular levels has been observed in common dolphins (*D. delphis ponticus*) from the Black Sea (Birkun et al., 1999).

Young harbor seals fed for 2.5 years with fish contaminated with DRPBs and other pollutants showed compromised immune functions when compared with a group of seals fed with less contaminated fish (reviewed in van Loveren, Ross, Osterhaus, & Vos, 2000). Harbour porpoises stranded in the UK showed a significant, positive association between PCB levels and the number of nematodes infecting them (Bull et al., 2006). In porpoises whose blubber showed total PCB concentration above 17 µg/g, total PCBs levels were significantly more elevated in animals dying of infectious diseases than in those dying from trauma. Below a 17 µg/g concentration, there was no correlation, suggesting that PCB-induced immunosuppression increases the frequency of infectious diseases (Jepson et al., 2005). PCB concentrations in the SLE population are higher than this putative threshold.

Deficits in immune functions are difficult to evaluate directly in free-ranging cetaceans, largely owing to the problems associated with rapidly obtaining and processing samples in the field. A logical approach to show that the immune functions of a given population are impaired would be comparing its immune parameters to those of a control population less exposed to pollutants. Many factors render such a comparison difficult: populations unexposed to pollutants probably do not exist, the inaccessibility of some populations, which introduce variables in the time required to collect and process samples, the stress of capture, which triggers cortisol release, and genetic differences. An indirect approach - measuring a pollutant dose-response effect - allows avoiding these drawbacks. In free-ranging harbor seals, the ability of lymphocytes to proliferate when stimulated by mitogens was negatively correlated with PCB concentrations. In dolphins, increased concentrations of PCBs and DDT in blood were shown to be inversely correlated with lymphocyte responses (Lahvis et al., 1995). Another approach consists in measuring the *in vitro* response of immune cells from a presumably "normal" population to pollutants added in concentrations identical or similar to those found in the tissues of contaminated animals from the same species. The proliferative response of beluga lymphocytes to mitogens and their spontaneous proliferation are impaired *in vitro* by exposure to concentrations of p,p'-DDT and PCB 138 similar to those found in tissues of SLE beluga (PCB 138 is one of the most abundant PCB congeners present in SLE beluga tissues) (De Guise et al., 1998). Measurements of cytokine production by stimulated phocid (*Phoca vitulina*) lymphocytes similarly exposed *in vitro* to DRPBs and PAHs showed a decrease in IL-2 production, suggesting that DRPBs might impair one of the major very first steps of cell-mediated immune response (Neale, Kenny, Tjeerdema, & Gershwin, 2005).

Beluga and other marine mammals are contaminated with a complex mixture of PCB congeners, distinct compounds and their metabolites. Such mixtures affect not only lymphocyte functions but also phagocytic cells such as neutrophils and monocytes in humans, beluga and dolphins (Levin, Morsey, Mori, & De Guise, 2004; Levin, Morsey, Mori, Nambiar, & De Guise, 2005a, b; Mori, Morsey, Levin, Nambiar, & De Guise, 2006). *In vitro* exposure of phocid macrophages to PCB and PAH caused decreased IL-1β production (Neale et al., 2005).

Contaminants, cytokines and stress

Similarly to GCs' effects, DRPBs' effects are prolonged and are mediated through an intracytoplasmic receptor, the AhR, for which DRPBs have enormous affinity (Barouki, Coumoula, & Fernandez-Salgueroc, 2007) (Table 1). Similar to the GR, the AhR is widely distributed in many organs and cell types, and often has contradictory effects, depending on cell type and organ. Many of these effects are mediated through AhR binding to NF-κB, which leads either to NF-κB activation or inhibition depending on cell type and previous cell stimulation.

Historically, the AhR was first described as a sensor of exogenous contaminants such as DRPBs and PAHs (Denison & Nagy, 2003). AhR binding to these contaminants triggers a complex cellular response resulting in increased expression of cytochrome P450 (CYP) enzymes, enzymes involved in the degradation of various endogenous and xenobiotic compounds. Like GRs, which are constantly exposed to endogenous GCs in most animals and humans, AhRs are constantly exposed to their ligands, DRPBs, because these compounds are now ubiquitous in the environment and in the tissues of animals and humans (Savouret, Berdeaux, & Casper, 2003).

In the absence of a ligand, the AhR, like the GR, rests inactive in the cytosol, bound to several proteins among which hsp90, the same ligand that binds the GR. Upon binding DRPBs, AhR dissociates from hsp90 and translocates to the nucleus, where, like the liganded GR, it binds a specific DNA sequence, the xenobiotic responsive element (XRE). The XRE is present within the promoters of multiple genes, among which CYP1A1 (Table 1). Intracytoplasmic CYP1A1 generates many highly reactive metabolites from benzo[a]pyrene (B[a]P) (these metabolites, not B[a]P *per se*, are responsible for the powerful carcinogenicity of B[a]P). Beluga and seal AhRs have been cloned, and both show a high affinity for DRPBs, comparable to that of mice strains susceptible to DRPB toxicity, and thus these species should show the same susceptibility to DRPBs toxicity (humans are less susceptible to dioxin toxicity than rodents because the human AhR shows a weaker affinity for DRPBs) (Jensen & Hahn, 2001; Kim, Hahn, Iwata, Tanabe, & Miyazaki, 2002). As demonstrated *in vivo* in laboratory rodents, AhR gene expression can be induced in presence of DRPBs. Consistent with this finding, a "dose-response" relation has been found in the livers of free-ranging contaminated Baikal seals: AhR mRNA levels were proportional to DRPBs tissue concentrations (Kim,et al., 2005).

Ligand-activated AhR can interfere with GCs' effects in many ways depending on cell type, tissue, species, and on the duration of DRPB exposure (Ruby, Leid, & Kerkvliet, 2002). In order to increase the transcription of their target genes, the AhR, GR and NF-κB must bind certain transcriptional coactivators and corepressors. Two AhR coactivators, SRC-1 and p300/CBP, also bind the GR. In addition, p300/CBP also binds IRF-3 (Servant, Grandvaux, & Hiscott, 2002; Smoak & Cidlowski, 2004; Swanson, 2002; Tian et al., 2002). Although competition between GR and NF-κB for these coactivators does not seem to be involved in NF-κB repression by GR, it is possible that, when a combination of stress, inflammation, viral infection and DRPBs occur[1], together AhR, GR and NF-κB compete for SRC-1 and p300/CBP and possibly for other transcription factors such as the GR interacting protein 1 (GRIP-1) (Kassel & Herrlich, 2007).

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[1] The infection of DRBPs-contaminated cetaceans by viruses is well documented (Aguilar & Borrell, 1994; Kassel & Herrlich, 2007).

Through AhR binding, DRPBs affect macrophages, DCs, T and B cells, all actors central to innate and adaptive immunity. For instance, liganded AhR triggers the expression of pro-inflammatory cytokine genes in human macrophages, whereas it triggers apoptosis in T cells and DCs (Camacho, Singh, Hegde, Nagarkatti, & Nagarkatti, 2005; Ruby, Funatake, & Kerkvliet, 2004; Vogel, Sciullo, & Matsumara, 2007). All lymphoid organs, especially the thymus, are affected (thymus, spleen, lymph nodes). DRPBs affect B cells directly, and probably impair T cells both directly and indirectly. Dioxin exposure also results in the appearance of a T reg cell subpopulation in mice (Funatake, Marshall, Steppan, Mourich, & Kerkvliet, 2005). Together these perturbations explain that rodents experimentally intoxicated with dioxin are more susceptible to a wide variety of infectious agents.

DRPBs cause chronic inflammation (more specifically macrophage infiltration) in many organs probably because these compounds increase proinflammatory cytokines (Fan, Yan, Wood, Viluksela, & Rozman, 1997; Nyska et al., 2004; Pande, Moran, & Bradfield, 2005; Vogel et al., 2004; Vogel, Nishimura, Sciullo, Wong, & Matsumura, 2007a; Vogel, Sciullo, & Matsumura, 2007b). In primary human macrophages and in a human macrophage cell line, DRPBs increase the production of a battery of pro-inflammatory cytokines (IL-1β, B cell activating factor of the tumor necrosis factor family (BAFF), B lymphocyte chemoattractant (BLC), IRF3, CCL1, TNF-α, and IL-8) (Diaye et al., 2006; Vogel et al., 2004; Vogel et al., 2007a; b). In contrast, DRPBs seem to have severe negative effects on DCs. In mice primary DCs, dioxin decreases the nuclear translocation and binding to κB DNA sequences of NF-κB, leading to accelerated maturation and apoptosis (Ruby et al., 2004). It should be kept in mind that these experiments vary in many respects, among which the animal species, the cell type and the lack or presence of cytokine-mediated cell activation. For instance, Vogel, Sciullo, & Matsumara (2007b) used an unstimulated human macrophage cell line in which RelB and AhR cDNA were transfected, whereas in contrast, a non transfected DC line from mice, activated by TNF-α, was used by Ruby et al. (2002).

In marine mammals, DRBPs exposure seems to decrease IL-1 production by macrophages. Peripheral blood mononuclear cells (PBMC) (monocytes and lymphocytes isolated from blood) from 4 free-ranging harbor seals captured from the wild were exposed to PCB congener 169, a DRBP. This exposure significantly decreased IL1-β production. This result is in apparent contradiction with one of the above study where IL-1 β production was increased (Vogel et al., 2004). Again, many differences in the protocols used may explain this discrepancy. Firstly, no time course measurements were carried out in the seal study, e.g. phocid IL-1 was measured only after 4-hour incubation. Thus an increase in IL-1 levels would have been missed if it occurred 4 hours after exposure. This is a serious concern given that the increase in IL-1 production seen in human macrophages was detected 6 hours post exposure (Vogel et al., 2004). Secondly, the contaminant concentrations used in the two experiments were widely different: seals PBMCs were exposed to a 20-µM concentration of PCB congener 169 whereas the human macrophage cell line was exposed to 10-nM dioxin. Accounting for PCB 169 toxic equivalency factor (0.01), phocid seal PBMCs were exposed to a dioxin toxicity level 20 times higher than that used for the human macrophages. Thirdly, PBMCs are composed of lymphocytes and monocytes. Thus decreased IL-1β production could have been due to Th1 activity by the lymphocytes present in the cell mixture because Th1 activity represses IL-1β production by macrophages. Fourth, PBMCs could have been impacted by the high plasma cortisol levels expected from capture especially considering that PBMC were isolated up to 8 h after capture (Neale et al., 2005). Finally variation in species susceptibility to dioxin toxicity may also contribute to these apparently conflicting results.

In wildlife, PCB-contaminated fish provided some of the first hints that GC and AhR cellular pathways are somewhat related. Upon capture, PCB-contaminated fish did not show the expected elevated cortisol levels that capture normally triggers in noncontaminated fish (Hontela, Rasmussen, Audet, & Chevalier, 1992; Hontela, 2005). Recent experiments carried out in fish have provided mechanistic explanations for these early observations. In contaminated fish, AhR activation decreases GC synthesis by inhibiting two key proteins involved in two rate-limiting steps of the GC synthesis, first the steroidogenic acute regulatory protein (StAR), which transports cholesterol to the mitochondrial inner membrane and second, the cholesterol side chain cleavage (P450scc or CYP11A1/scc) enzyme, which converts cholesterol to pregnenolone, the first step of cortisol synthesis. In other words, AhR-ligand contaminants hamper one of the major adaptive responses to stress. Considering that both cortisol synthesis pathways and proteins involved in GC synthesis are highly conserved in animals, most likely these findings can be applied to higher vertebrates (Aluru & Vijayan, 2006). DRPBs metabolites can also bind the GR, competing with endogenous GCs and inhibiting GC synthesis (Brandt, Joensson, & Lund, 1992; Durham & Brouwer, 1990; Johansson, Nilsson, & Lund, 1998). Moreover AhR also mediates the endocrine disruption associated with DRPBs toxicity: among other effects, liganded AhR triggers the destruction of the estrogen and androgen receptors (ER and AR) through ligation with ubiquitin (Ohtake et al., 2007). The ER, AR and GR are all members of the superfamily of nuclear hormone receptors because of the many structural and functional similarities they share. For instance, in prostate cancer patient, an AR double mutant could bind cortisol (Zhao et al., 2000). Because of these similarities, it is possible that AhR also causes GR degradation.

DRPBs adrenal toxicity

Many OCs and their metabolites also severely damage the adrenal glands, the final effector organs of stress. There are several reasons why adrenal glands are vulnerable to these compounds. The vascular supply of the adrenal cortex is disproportionately large compared to the adrenals' mass. In addition, the adrenal cortex is rich in both lipids and CYP enzymes because it synthesizes steroids from cholesterol, which explains why adrenals accumulate high concentrations of lipophilic contaminants, which are then metabolized into more toxic molecules by the CYP enzymes (Harvey & Everett, 2003).

Degenerative and proliferative changes consistent with chronic stress and DRPBs intoxication are commonly observed in the adrenal cortex and medulla of SLE and Western Hudson Bay beluga whales and the severity of these lesions increases with age in both populations. The younger age of much less contaminated control beluga whales sampled from Hudson Bay precluded a comparison of lesion severity and prevalence between age-matched groups (Lair et al., 1997).

According to existing reports, adrenocortical cysts are rare in marine mammals except in SLE beluga and white-sided dolphins (Geraci & St. Aubin, 1979; Lair et al., 1997). In white-sided dolphins, these lesions were attributed to sinusoidal blockage or hypersecretion, and were considered associated with stress related with reproductive functions since 100 % of females and only 20 % of males were affected. No lesions have been observed in the adrenal glands of other Odontocetes species beside increased medullary and/or cortical mass in Atlantic bottlenose dolphins (*Tursiops truncatus*) and harbour porpoises (*Phocoena phocoena*) with chronic stress (Clark, Cowan, & Pfeiffer, 2006; Kuiken et al., 1993). These observations suggest that the rarity of adrenal lesions in cetaceans other than beluga and white-sided dolphins is not artifactual.

Several evidences suggest that OC metabolites may cause adrenal cysts. The toxicity of OCs metabolites for the adrenal cortex such as O,p'DDD, noticed during early toxicity assessments of DDT, has long been used for the treatment of pathological adrenal cortex hypersecretion (Cushing syndrome) in both human and veterinary medicine (Hart, Reagan, & Adamson, 1973; Rijnberk, 1996). Other OC metabolites such as $MeSO_2OC$ are adrenocorticolytic in rodents, and some of these compounds, such as 3-$MeSO_2$-4,4'-DDE, compete with GRs and inhibit GC synthesis (Brandt et al., 1992; Durham & Brouwer, 1990; Johansson et al., 1998). In grey and harbor seals from the Baltic Sea, adrenocortical hyperplasia has been attributed to contamination with PCB and DDT based on epidemiological data (Bergman & Olsson, 1985; Olsson, 1994; Olsson, Karlsson, & Ahnland, 1994). In Baltic grey seals, 3-$MeSO_2$-PCB levels were highest in females with adrenocortical hyperplasia (Haraguchi, Athanasiadou, Bergman, Hovander, & Jensen, 1992), a sex distribution reminiscent of that seen in Atlantic white-sided dolphins affected by adrenal cysts.

Both SLE beluga and Atlantic white-sided dolphins are contaminated with high amounts of OCs and their metabolites (Martineau et al., l987; McKenzie, Rogan, Reid, & Wells, 1997; McKinney et al., 2006; Muir et al., 1996; Troisi, Haraguchi, Simmonds, & Mason, 1998). High blubber concentrations of $MeSO_2$-PCB and $MeSO_2$-DDE have been detected in SLE beluga. In fact, these concentrations are the highest among cetaceans, including Hudson Bay beluga (the concentrations found in SLE beluga are also higher than those found in humans exposed to PCB during the Yusho industrial accident) (Letcher et al., 2000 a, b). SLE beluga and white-sided dolphins both form abundant methylsulphones from PCBs. Thus, because of their long life span, both species may have been exposed to high levels of adrenotoxic OC metabolites for decades (Martineau et al., 2003).

There is apparent contradiction between the adrenocortical hyperplasia epidemiologically associated with $MeSO_2$-DDE in seals, and the adrenocortical degeneration induced by these compounds in laboratory animals and possibly in SLE beluga (Brandt et al., 1992; Jönsson, Lund, Bergman, & Brandt, 1992; Jönsson, Lund, & Brandt, 1993; Jönsson, Rodriguez-Martinez, Lund, Bergman, & Brandt, 1991). Perhaps OC metabolites-mediated degeneration of the adrenal cortex alternates with ACTH-mediated regeneration since in mammals, the destruction of the adrenal cortex and/or the interference with GC synthesis normally triggers the feedback control of the HPA axis. Decreased GC levels due to adrenocortical destruction normally increase the production of ACTH by the pituitary, which leads to hypertrophy (increased cellular size) and hyperplasia (increased cell numbers) of the adrenal cortex in order to reestablish normal serum GC levels. Note that contaminant-induced damage to cortisol-producing cells has been observed in contaminated fish in the St Lawrence River (Hontela et al., 1992; Hontela, 2005; Rijnberk, 1996; Ulrich-Lai et al., 2006). Thus, it is possible that adrenal lesions affect taxonomically divergent species because of environmental exposure to similar adrenotoxic lipophilic compounds.

It is probable that the pathologic effects of ingesting low OCs'doses over decades - such as occurs in free-ranging mammals - differ from those of large single doses typical of toxicity experiments carried out in laboratory animals. SLE beluga, white-sided dolphins, harbour porpoises and Baltic grey seals are exposed to complex and different cocktails of OC compounds which generate different metabolites that alter the distribution and even the nature of each other (van Birgelen, Ross, DeVito, & Birnbaum, 1996). For instance, by contrast to cetaceans, pinnipeds have a high capacity for generating PCB methyl sulphone and have high CYP2B activity (Boon, Oostingh, van der Meer, & Hillebrand, 1994; Reijnders & de Ruiter-Dijkman, 1995; Troisi et al., 1998). The combined pathologic effects of these complex mixtures are probably not the same as those of single compounds or metabolites typically used in toxicological studies. In addition, the effects of toxic xenobiotics vary according to species, sex, genetic background, age and the developmental stage at which experimental animals are first exposed (Jönsson, Rodriguez-Martinez, & Brandt, 1995). For instance, Baltic Grey and Harbor seals contaminated in nature with OC show adrenocortical hyperplasia, a purely proliferative lesion, of which the severity is proportional to tissue OC concentrations whereas in SLE beluga in contrast, a mixture of degenerative and proliferative lesions affects the adrenal cortex (Lair et al., 1997; Olsson et al., 1994). Adrenocortical hyperplasia in harbor porpoises contaminated with OCs is not proportional to their OC tissular levels (Kuiken et al., 1993). This could be related to the relatively higher CYP2B-dependent ethoxyresorufin-*O*-deethylase (EROD) activity or other metabolic differences shared by both harbor porpoises and pinnipeds (reviewed in Martineau et al., 2003).

Conclusion

Noise is a likely source of major stress in marine mammals due to increased anthropogenic activities practiced worldwide in an industrial mode. Stress and some lipophilic contaminants exert their effects through two nuclear receptors, GR and AhR, both present in lymphocytes, and whose functions are intertwined because they bind common ligands such as NF-κB. For instance, GCs are competed out by some PCB metabolites, and GC synthesis is decreased by AhR activation. In addition, the adrenal glands, the end producers of acute and chronic stress hormones, are themselves the target of some OC metabolites. Thus, it is safe to say that responses to stressors, acute and chronic, are disrupted by at least some OCs and /or DRBPs in contaminated marine mammals. As shown by the seemingly conflicting effects of dioxin exposure on IL-1 production by immune cells from different species, the methods used to assess mechanisms of immunotoxicity *in vitro* have to be standardized in terms of cell types employed (cell line versus primary cells; genetically engineered cells versus non genetically engineered cells; cell mixture versus pure population), duration of exposure (with time course measurements), and contaminants concentration (which should include concentrations found in wild animals) (Neale et al., 2005; Vogel et al., 2004).

Pathologists faced with the task of determining the contributing factors, or the causes of wildlife mortality, rarely have clinical information such as GC circulating or fecal levels. To compensate for this lack, adrenal and pituitary glands of dead or live animals should be examined in details because in animals and people, chronic stress and the accompanying sustained ACTH production over extended periods are expected to lead to macroscopic pathological changes in adrenal glands, of which the most obvious is probably increased mass (Clark, Cowan, & Pfeiffer, 2006; Swaab et al., 2005).

We propose that such baseline data – which could be determined on live animals, by echography or magnetic resonance imaging for instance- would help in assessing the presence of chronic stress when confronted with a declining wildlife population from which it is difficult to extract clinical data (e.g. data from live animals). Concurrently, other means of obtaining GC levels from live animals, such as measuring tissue GCs levels from skin biopsies, should be developed.

To this author's knowledge, there have been no animal toxicity studies to address the effects of stressors on the potential toxicity of environmental contaminants or therapeutic compounds. This is especially true with regards to marine mammals. Yet it is clear from this review that DRPBs can antagonize GC-mediated chronic stress responses: GCs repress the synthesis and release of all proinflammatory cytokines whereas on the contrary, at least in certain cell types, DRPBs increase expression levels of proinflammatory cytokines such as IL-1 β, TNF-α, IL-8, BAFF and of pro-inflammatory transcription factors such as IRF-3. It is also possible that AhR, GR, IRF-3 and NF-κB compete for the same coactivators, and/or that unexpected effects result from cross-talks between these receptors and transcription factors if inflammation, viral infection, DRPB contamination and chronic stress coincide temporally.

Together, the interactions between variable intracellular concentrations of GCs, GR isoforms, mineralocorticoid receptors, cytokines and co-transcription factors such as NF-κB and IRF-3 subtly modulate immune functions during stress, to avoid immune or inflammatory overreactions, or on the contrary to enhance the immune system in order to eliminate microorganisms and/or their toxins (Sapolsky et al., 2000). Any disturbance of this finely tuned system and of its development by xenobiotic compounds through AhR, or by chronic stress through sustained high GCs levels, is likely to have undesirable consequences on the immune and inflammatory responses. Some of these outcomes might be unexpected. For instance, the inner ear relies on optimal adjustment of GCs, GR and other GR ligands (chaperones, co-chaperones, and modulatory element binding proteins) to avoid damage following audiogenic stressors. The failure to elevate GC levels in response to audiogenic trauma such as those that are likely induced by the intense sound produced by oil exploration might increase damages to the inner ear of cetaceans exposed to such noise (Canlon et al., 2007; Finneran et al., 2002; Horner, 2003).

The exposure to some OCs and to other exogenous stressors such as noise either *in utero* or during early life threatens the integrity of the immature mammalian immune system, and compromise the adaptive response to subsequent stressors. Juvenile cetaceans are often more contaminated than adults because they absorb contaminants from lactating mothers, and some OCs are especially toxic for developing organs such as thymus and brain. Thus juveniles are particularly put at risk by OC contamination and noise.

New or improved conceptual frames for stress have recently emerged (McEwen 1998, 2000; Sapolsky et al., 2000). All confer the HPA axis and its development a central role in the response to stressors. Most consider contaminants as another stressor (Romero, 2004; Sapolsky et al., 2000). Yet at least some of these stressors, DRPBs, target the adrenal glands, the very same organ whose integrity allows mammals to respond adequately to daily stressors.

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Fishery Effects on Dolphins Targeted by Tuna Purse-seiners in the Eastern Tropical Pacific Ocean

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Dolphins in the eastern tropical Pacific Ocean (ETP), particularly spotted (*Stenella attenuata*) and spinner (*Stenella longirostris*) dolphins, are subject to fishery-induced stress due to chase and encirclement by tuna purse-seiners intent on capturing the large yellowfin tuna that are frequently found associated with dolphin schools in this area of the Pacific Ocean. The direct, observed mortality of dolphins in the fishing nets has decreased over the years from several hundred thousand annually during the early 1960's when the fishing practice originated, to less than 5000 dolphins annually (thought to be a biologically insignificant level) since the early 1990s. Despite the decrease in observed mortality, the dolphin populations have not been recovering as expected. In an effort to determine whether fishery-related stress may be contributing to this lack of recovery, through unobserved effects on survival or reproduction, a variety of studies have been and continue to be conducted examining various aspects of interactions between ETP dolphins and the tuna purse-seine fishery. These studies include a review of current knowledge of stress physiology in mammals, a necropsy program to examine dolphins killed during purse-seining operations, a chase-recapture experiment, and various analyses of existing (historical) data which have led to ongoing studies of fishery effects on mother-calf pairs, ETP dolphin reproductive biology, and analyses of dolphin school composition. The effect of noise has not been addressed directly in these studies, but potentially contributes to fishery-related stress in terms of initiating the significant and prolonged evasion response typical of dolphin schools reacting to tuna purse-seiners in the ETP. Although studies completed to date have not provided a definitive answer to whether fishery-induced stress is a significant factor in the lack of dolphin stock recovery in the ETP, it is possible that at least some adults, and probably many young dolphins, are negatively affected by interactions with tuna purse-seine fishing operations.

Dolphins in the eastern tropical Pacific Ocean (ETP), particularly spotted (*Stenella attentuata*) and spinner (*Stenella longirostris*) dolphins, are frequently chased and encircled by tuna purse-seiners intent on capturing the large yellowfin tuna often found associated with dolphin schools in this area of the Pacific Ocean. The set procedure involves using helicopters to search for the disturbances caused by tuna schools feeding in association with dolphins and seabirds (National Research Council, 1992) or for bird flocks over the horizon. Once an associated tuna school has been located and determined large enough to invest the time and effort in capture, the seiner begins to set the net while 4-5 speedboats with large outboard engines are dropped off the back of the vessel to separate dolphins associated with tuna and chase them into the closing purse-seine. In an association unique to the eastern tropical Pacific Ocean (ETP), the tuna remain associated with the dolphins during the chase and capture, so that the closed and pursed seine then contains both the yellowfin tuna and the dolphins. Once the net is entirely closed

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and pursed at the bottom, a specific maneuver by the vessel ("backdown") creates a long finger of small-mesh net (the "backdown channel") on the side of the seine opposite the vessel. Many dolphins have learned to expect this maneuver (Santurtun & Galindo, 2002) and gather near the appropriate area of the seine, waiting for the channel to form. The dolphins then escape over the submerged far end of the backdown channel and quickly leave the area (Chivers & Scott, 2002).

ETP dolphins respond to an impending set by beginning to flee as soon as the tuna seiner, the helicopter, or the speedboats are perceived (National Research Council, 1992). Because the initial response tends to occur several kilometers from the vessel (Au & Perryman, 1982; Hewett, 1985), initial perception appears to be acoustic rather than visual. The dolphins respond by moving closer together and increasing their swim speed from about 1-2 m/sec to 2-3 m/sec (Chivers & Scott, 2002; i.e., doubling to tripling their previous swim speed and thereby increasing their swimming power requirement by a factor of 8 to 27 times the power required for non-chase swim speeds (Edwards, 2006)).

The chase portion of the set typically lasts 30-40 minutes (with a small percentage of chases lasting up to about 80 minutes), encirclement lasts 30-60 minutes (with a very small percentage of encirclements lasting up to about 75 minutes), and length of confinement lasts another 40-60 minutes (with a small percentage lasting up to about 90 minutes) (Myrick & Perkins, 1995), so that time from initiation of chase to release typically ranges between about 1.5 and 2.5 hours (with a potential maximum in a few sets of about 4 hours). Once the dolphins perceive that the backdown channel is ready, they swim out quickly and continue their escape by swimming at even higher speeds (3-4 m/sec) for about 90 minutes before reverting to pre-chase behaviors (Chivers & Scott, 2002). Thus, each purse-seine set experience may disrupt normal ETP dolphin behavior for at least 30-40 minutes, if the dolphin manages to escape prior to capture, and for 3-4 hours (occasionally up to 5.5 hours) if the dolphin is captured in the seine and then released.

During the early 1960s, when the seining practice originated, several hundred thousand dolphins died in tuna purse-seine nets each year, reducing the populations spotted and spinner dolphins in the ETP by 70-80% (Wade, 1994). Improvements in fishing practices and introduction of individual vessel mortality limits, as well as apparent learning by the dolphins (currently, only about 4% of encircled dolphins need assistance leaving the net during backdown (Santurtun & Galindo, 2002)), have drastically reduced dolphin deaths in tuna nets, to less than 5000 dolphins annually (thought to be a biologically insignificant level) since the early 1990s (Inter-American Tropical Tuna Commission, 2004).

However, despite this dramatic decrease in purse-seine mortality, at least two stocks, northeastern offshore spotted and spinner dolphins, have not been recovering as expected (Gerrodette & Forcada, 2005). Because fishing effort on dolphins remains high (10,000-14,000 purse-seine sets per year (Inter-American Tropical Tuna Commission, 2004)), with each spotted dolphin being chased about 11 times and captured about 3 times per year, on average (Reilly et al., 2005), it is hypothesized that indirect effects of the fishery may adversely impact ETP dolphins. This potential for ongoing adverse fishery interactions has led to a variety of research projects addressing the possibility that fishery effects (interactions) may be contributing to the lack of population recovery through unobserved effects on dolphin survival or reproduction.

Although the issue of adverse fishery effects (in addition to direct mortality) on ETP dolphins has been of concern since the early days of the fishery (e.g., Stuntz & Shay, 1979; Cowan & Walker, 1979; Coe & Stuntz, 1980) research through the early 1990's focused primarily on reducing directly-observed mortality in the purse-seines. Once the current low level of purse-seine mortality had been achieved, research focus turned to investigating other types of fishery effects.

A major series of research projects was initiated between 1997 and 2002, in accord with mandates of the International Dolphin Conservation Program Act (IDCPA), an amendment to the US Marine Mammal Protection Act (MMPA) (Reilly et al., 2005). IDCPA-mandated fishery effects studies focused on the question "is the fishery having a significant adverse impact on ETP dolphins?" and included four related projects broadly characterized as stress studies. These included 1) a review of current knowledge of stress physiology in mammals, with emphasis on marine mammal physiology, 2) a necropsy program to examine dolphins killed during purse-seining operations, 3) a chase-recapture experiment *in situ* using a chartered purse-seine vessel, and 4) various analyses of existing (historical) data (Reilly et al., 2005). The effect of related noise was not specifically investigated as a stressor in these studies, but contributes to fishery-related stress in terms of initiating the significant and prolonged evasion responses typical of dolphin schools chased and encircled by tuna purse-seiners in the ETP (Au & Perryman, 1982; Hewitt, 1985; Chivers & Scott, 2002). The IDCPA research program also included a suite of studies to estimate current abundances, monitor environmental associations and their potential effects, and assess status and trends of these dolphin populations. Results of those studies are not covered here.

This paper summarizes results from completed studies and presents status reports for ongoing and proposed studies addressing the question of whether fishery interactions may be negatively affecting population recovery of ETP dolphins.

Completed Studies

Research Prior to the IDCPA Program

Limited data were collected prior to the IDCPA program, although the potential for fishery-related stress was recognized early in the fishery, primarily based on observations of passive-sinking behaviors by dolphins in the purse-seine nets (Coe & Stunz, 1980). These unusual behaviors suggested the possibility of "capture myopathy" (a degenerative muscle condition which can lead to delayed death, thus creating unobserved fishery-related mortality; Stunz & Shay, 1979). Subsequent examination and sampling of *Longissimus dorsi* and hypaxial muscle from 65 dolphins killed in ETP tuna purse-seines found "no evidence of myopathy" (Cowan & Walker, 1979), but this sample size is too small to definitively eliminate the possibility of capture myopathy affecting ETP dolphins at the population level. Another study suggested that examination of adrenal glands might provide a measure of fishery-related stress (Myrick & Perkins, 1995).

IDCPA Program Research

The stress literature review summarized current knowledge about the effects of physiological and behavioral stress in mammals, and related that information to potential effects on dolphins chased and encircled by tuna purse-seiners (Curry, 1999; St. Aubin, 2002a). The review concluded that tuna purse-seine fishing activities entail well-recognized stressors in other mammals, especially wild animals, including prolonged heavy exertion, social disturbance, and disruption of normal activities such as foraging. Typical mammalian responses to such disturbances include changes in metabolism, growth, reproduction, and immune status, any of which, alone or in combination, could significantly affect survival and reproduction. Of particular concern for ETP dolphins was the observation that prolonged heavy exertion in other wild mammals can lead to capture myopathy. Although specific response levels to specific stressors differ in detail between different mammals and environments, the review found that in general, the types of stressors presented by tuna purse-seine activities may affect dolphin survival, but quantitative estimates of the magnitude of these effects are not available (Curry, 1999; Reilly et al., 2005).

The necropsy study examined various physical characteristics of dolphins accidentally killed during tuna purse-seine operations. Due to logistic difficulties, only 56 dolphins were sampled during the 3-year study, far fewer than the desired minimum (for statistical power) of 300 dolphins per stock. However, although the small sample size precluded population-level conclusions, results provided revealing snapshots of physiological conditions and characteristics of dolphins killed in the nets. Various diseases unrelated to the fishery, but characteristic of normally healthy populations of wild mammals, were found in the majority of the dolphins (Cowan & Curry, 2002). Lymph nodes indicated normal, active lymphoid systems (Romano, Abella, Cowan, & Curry, 2002a). Heart, lungs and kidney contained lesions directly linked to death by asphyxiation, possibly resulting from an overwhelming alarm reaction leading to death by cardiac arrest (Cowan & Curry, 2002). Tissue abnormalities presenting as patchy fibrous scars in heart muscle and associated blood vessels may have formed previously in response to excess secretion of stress hormones, possibly indicating prior stress responses (e.g., possibly to fishery activity or predation attempts), although the direct cause and physiological consequences of the lesions could not be determined (Cowan & Curry, 2002). Opportunistic samples of skeletal muscle showed cell damage similar to that in heart muscle, indicative of a degree of capture myopathy that could lead to unobserved mortality in some cases (Reilly et al., 2005).

The Chase Encirclement Stress Study (CHESS) examined physiological and behavioral responses of ETP dolphins to repeated chase and encirclement (Forney, St. Aubin, & Chivers, 2002). During a two-month period, schools of spotted and mixed spotted/spinner dolphins were located, chased and encircled by a chartered tuna purse-seine vessel using fishery-typical techniques (Forney et al., 2002). Individual dolphins were sampled, tagged and subsequently released with the rest of the captured dolphins. Radio-tagged focal dolphins were followed by a NOAA research vessel, and attempts were made over the following days to recapture the focal dolphin(s) and any associates. CHESS studies included analyses of blood parameters (standard veterinary blood panels, with particular focus on exertion-related enzymes and stress hormones), immune function, thermal condition, behavior, and reproductive parameters, with the intention of determining serial changes through time with repeated recaptures. Initial (first capture) samples were collected from several dozen dolphins, but recaptures were limited because tagged dolphins generally separated from their original school rather than remaining associated. Blood was obtained from 61 dolphins, 53 of which were assumed to be first captures; the remaining 8 samples were collected from dolphins recaptured 1-3 times. In general, these limited sample sizes precluded drawing population-level conclusions about effects of chase and capture. However, a number of important observations relevant to the basic objective were made, and these are summarized below.

Immune function was normal in all blood samples, with no notable abnormalities in the captured or recaptured dolphins (Romano, Keogh, & Danil, 2002b). Hormone and enzyme analyses provided strong evidence for activation of an acute stress response and muscle injury due to exertion (St. Aubin, 2002b). Samples from animals chased for 20-30 minutes exhibited mild muscle damage (consistent with lesions observed in the Necrospy Study samples) (St. Aubin, 2002b). Blood changes were not sufficient to cause life-threatening capture myopathy in any of the animals examined, but individuals differed greatly in overall stress response (St. Aubin, 2002b). Some dolphins showed much more dramatic elevations in hormones, enzymes, and other metabolic indicators, implying a wide variety of responses in the natural population (St. Aubin, 2002b).

The potential for heat stress, particularly in pregnant females required to maintain blood flow to the uterus, placenta and fetus regardless of body temperature, was evaluated by examining thermal photographs of skin surface temperatures after chases of more than 75 minutes (Pabst, McLellan, Meagher, & Westgate, 2002). Heat flux increased during chase for one of two tagged individuals, but core body temperatures were stable for all but one of 48 sampled dolphins, indicating that ETP dolphins are able to regulate body temperature despite elevated swim speeds during chase.

As observed in previous studies (e.g., Scott & Cattanach, 1998), dolphin school dynamics were highly fluid so that associations of individual dolphins were quite variable (Chivers & Scott, 2002). The passive-sinking behavior seen during the 1970s (Coe & Stunz, 1980) was not evident, although rafting behavior (vertical position with head out of the water) still occurred in some dolphins (0 to 8.5 % of the individuals in the net) at some times prior to backdown (Santurtun & Galindo, 2002). In 77% of sets, dolphins were observed circling outside the purse-seine, and overall, it was evident that ETP dolphins are now familiar with the purse-seine procedure and can anticipate backdown for release from the net (Santurtun & Galindo, 2002).

With extremely limited data, it was impossible to determine any effect of capture or recapture on reproduction. No fetal loss was observed, although there were modest decreases in levels of progesterone and testosterone in the two animals analyzed after successive recaptures (St. Aubin, 2002b). Nine females with relatively large calves were captured during at least one set. Three females originally captured with relatively large calves were recaptured with the same calf in subsequent sets, including one pair chased seven times and recaptured four times, and two pairs chased and captured twice. These recaptures indicate that larger calves are capable of remaining associated with their mothers during sets. However, developmental issues indicate that smaller calves (less than 1 year postpartum) may have more difficulty remaining associated with the mother during fishery activities (Noren, Biedenbach, & Edwards 2006; Noren & Edwards, 2007; Noren, Biedenbach, Redfern & Edwards 2007).

Historical biological data were examined in a number of ways, including: 1) to determine whether dolphin behavior differs relative to level of recent fishing effort (Mesnick, Archer, Allen, & Dizon, 2002); 2) to compare the demographic and reproductive parameters of spinner dolphins schools in 1988-1993 vs. 1998-2000 based on aerial photographs taken during NMFS research cruises (Cramer & Perryman, 2002); 3) to estimate the energetic cost to dolphins of purse-seine set evasion (Edwards, 2002); 4) as contributing data for a review of all available information on physiological and behavioral development in dolphin calves (Noren & Edwards, 2007); and 5) to compare the number of lactating females versus the number of nursing calves killed in the same sets (Archer, Gerrodette, Chivers, & Jackson, 2001; Archer, Gerrodette, Chivers, & Jackson, 2004). The results of the latter studies have led to the current focus on fishery effects on ETP dolphin mother-calf pairs and reproductive biology.

Mesnick, Archer, Allen, & Dizon (2002) found that spotted and spinner dolphins (the target species) exhibited more ship evasion and avoidance than did non-targeted dolphin stocks in areas with greater fishing effort. Chivers & Scott (2002) found that escape from tuna purse-seine sets involves prolonged and high-speed swimming (at least 90 minutes at 3-4 m/sec) in addition to the typical 60-100 minutes involved in chase and encirclement (Myrick & Perkins, 1995), bringing the total time of typical set involvement to 3-4 hours, including 2-3 hours of elevated swim speeds. Cramer & Perryman (2002) found that the proportion of calves in schools was not related to the species composition or number of conspecifics in the school, but was significantly lower in more recent years compared to earlier years. Edwards (2002) found that that additional energy costs of evading purse-seine sets are probably not important for adult ETP dolphins, but may present a significant burden to small nursing calves (and potentially their mothers). Archer et al. (2001) found far fewer calves than expected from the number of lactating females killed in tuna purse-seine nets, suggesting that at least some of the calves become separated from their mothers during tuna purse-seine sets in the ETP and that subsequent unobserved calf mortality is a potentially important issue. Noren & Edwards (2007) found that physical limitations of small dolphin calves coupled with behavioral independence of mothers may cause mother-calf separation during tuna purse-seine set evasion, particularly with calves less than a year postpartum.

Despite limited sample sizes, IDCPA studies identified a number of fishery-related effects on ETP dolphins that could be contributing to stress-related injury and/or unobserved mortality (Reilly et al., 2005). These include 1) moderately elevated stress hormones (catecholemines) and enzymes in live-captured dolphins, indicative of muscle damage; 2) evidence of past (healed) muscle and heart damage in necropsy specimens (dolphins killed in the fishery), 3) fatal heart damage in virtually all necropsy specimens, possibly related to elevated catecholamines, 4) prolonged response to set activities, including post-release as well as during chase and capture, and 5) separation of mothers and calves. Although the effects observed in live-captured animals were all sub-lethal, differences in individual reactions to stressors could lead to more critical responses in some animals compared to others (St. Aubin, 2002b).

Research Subsequent to the IDCPA Program

Following discovery of the significant discrepancy between mortality of lactating females and nursing calves (Archer et al., 2001), additional research quantified the “calf deficit”, determining that 75-95% of lactating females killed in tuna purse-seine sets are killed without an accompanying calf (Archer et al., 2004). Given the importance of the mother-calf bond to calf survival, and the potential for mating failure, fetal resorption or abortion in response to fishery activities, research subsequent to the IDCPA has focused on effects that fishery interactions may have on ETP dolphin mother-calf pairs, reproduction and calf survival.

Mother-calf research has focused on factors that can be expected to affect the proximity of mothers and calves during attempted evasion of purse-seine sets, with particular emphasis on the swimming behavior known as drafting in echelon position whereby the calf positions itself slightly above and behind the mother’s midsection (Norris & Prescott, 1961). Mathematical and aerodynamic modeling of movement forces (Weihs, 2004; Weihs, Ringel, & Victor, 2006) and empirical kinematic analyses of swimming motions of bottlenose dolphin mothers and calves from birth through two years postpartum (Noren et al., 2006, Noren et al., 2007) both confirmed and quantified the significant hydrodynamic advantages (decreased cost of swimming and/or increased velocity) enjoyed by dolphin calves swimming in echelon, as well as the hydrodynamic disadvantages (decreased swim performance and increased swim effort) suffered by dolphin mothers (Noren, 2007). Mother dolphins swimming in echelon swim only about half as fast at mothers swimming independently (Noren, 2007), while 0-1 month calves in swimming echelon experience a 28% increase in average swim speed, 22% reduction in fluke stoke amplitude, and 19% increase in distance per stoke compared to calves swimming independently (Noren et al., 2007). Neonate dolphin calves can gain up to 90% of the thrust needed to move through the water alongside the mother at speeds up to 2.4 m/sec (Weihs, 2004), while mean and maximum swim speeds of 0-1 month old calves swimming independently were only 37% and 52% of adult speeds, with adult levels not achieved until at least one year postpartum (Noren et al., 2006). Stroke amplitude and distance covered per stroke were also significantly lower than adult levels for independently swimming calves during the first year postpartum. Lower size-specific swim speed in 0-3 month olds compared to calves older than 10 months indicated that factors other than size (e.g., underdeveloped physiology) act synergistically with small body size to limit independent swim performance in dolphins during ontogeny (Noren et al., 2006). The modeling studies also revealed the importance of precise positioning for effective drafting, and included an observation of disrupted drafting when a neonate calf lost coordination during a respiratory leap attempted during escape-speed swimming in the ETP (Weihs, 2004). The importance of drafting for remaining associated with adults is illustrated by energetics modeling of swim speed duration capacity of independently-swimming (non-drafting) ETP spotted dolphins. Neonate spotted dolphins require 3.6 times more power per kilogram of muscle than an adult, to swim the same speed, and have a burst maximum speed of about 3 m/sec compared to an adult's 6 m/sec (Edwards, 2006). Even at two years of age, spotted dolphin calves must produce about 40% more power per kilogram of muscle than an adult to swim a given speed. Loss of the drafting advantage due to high-speed, fast maneuvering swimming during evasion of tuna purse-seine sets appears to be a significant and plausible source for the observed calf deficit.

Ongoing swimming kinematics research, not yet completed, includes estimation of the cost to mother dolphins of swimming with near-term pregnant morphology. Future modeling work should include estimation of the limits to drafting by dolphin calves in terms of speed and maneuvering during evasion of tuna purse-seine sets. Ongoing research on reproduction and survival includes development and application of methods to determine pregnancy rates of ETP dolphins from progesterone analyses of blubber biopsies taken *in situ*, and estimation of fetal mortality rates in ETP dolphins, based on biological samples collected during the 1980s from fishery-killed specimens.

Conclusion

In general, studies of fishery effects on ETP dolphin physiology, behavior, and population dynamics indicate that adult dolphins chased, encircled, and released during tuna purse-seine sets experience acute, intense stress during the event but most appear to recover from this experience, though some may develop long-term sequelae such as vascular and muscle lesions, reproductive failure, or reduced survival. Because even a relatively small fishery-induced decrease in reproduction or survival could lead to the observed failure of population recovery for ETP dolphins (e.g., Gerrodette & Forcada, 2005), it is possible that fishery effects on adults remain an important factor in the observed lack of population recovery The estimated calf deficit suggests that the purse-seine fishing procedure may be disrupting mother-calf associations in the ETP, and the studies of calf physiology, behavior, and swimming characteristics suggest that nursing calves not reunited with their mothers are not likely to survive. Incorporating age-based likelihoods of calf separation and subsequent mortality into population dynamics models that include age-specific fishery encounter rates is being investigated as a tool to evaluate these potential effects of fishery activity on calf survival and subsequent population dynamics.

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The Long-term Consequences of Short-term Responses to Disturbance Experiences from Whalewatching Impact Assessment

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Studies often use behavioral responses to detect the impact of given disturbances on animals. However, the observation of these short-term responses can often lead to contradicting results. Here we describe studies focusing on the impacts of whalewatching to show how the biological relevance of short-term responses can be inferred from contextual information. They showed that short-term behavioral responses could have long-term consequences for individuals and their populations using information about variation in response magnitude with exposure levels, long-term population biology data, and multiple response variables. They showed that the added energetic constraints of the responses can impair life functions and lead to influences on vital rates with the potential to affect population viability. Individuals will manage disturbances as another ecological variable and will assess its costs in relation to other energetic trade-offs associated with the occupancy of the habitat in which the disturbance takes place. This can lead to rapid shift in tactics to cope with the disturbance, such as shift from short-term avoidance tactics to long-term habitat abandonment. When individuals cannot elude proximity to the disturbance, their fitness is reduced as observed through reduced reproductive success. These studies provide mechanisms to inform the US National Research Councils' Population Consequences of Acoustic Disturbance framework in which the influence of noise impact of on marine mammal conservation can be studied.

Many studies are now highlighting that what we perceive as short-term responses to disturbances can have unforeseen consequences for the life history of individuals exposed to those disturbances and the dynamics of their populations (Coltman et al., 2003; Cooke & Schramm, 2007; Lusseau, Lusseau, Bejder & Williams, 2006a; Proaktor, Coulson, & Milner-Gulland, 2007). These consequences can occur at an ecological scale with for example added energetic constraints from the responses influencing the homeostasis of individuals. They can also occur at an evolutionary scale. For example, selective harvesting can influence the genetic make-up of populations by selectively removing individuals with similar traits that are highly heritable (Coltman et al., 2003). These impacts influence the viability of populations, either by decreasing their fitness or by decoupling the populations from the environment in which they evolve because disturbances become a driving force for the life history of individuals at either of the temporal scales.

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In excess of 700 to 1000 cetacean populations routinely interact with tour boats (Hoyt, 2001). The potential impact of interactions between cetaceans and tourist vessels has been studied for more than 20 years (Baker & Herman, 1989; Corkeron, 2004). Over this period a wide variety of short-term effects has been detected on many species (Au & Green, 2000; Bejder, Dawson, & Harraway, 1999; Blane & Jaakson, 1995; Hastie, Wilson, Tufft & Thompson, 2003; Lusseau, 2006; Nowacek, Wells, & Solow, 2001; Williams, Trites, & Bain, 2002). These include changes in respiration patterns, variation in path directedness and other short-term behavioral alterations resulting from apparent horizontal and vertical avoidance tactics (Frid & Dill, 2002). However, it has been difficult to move from the description of short-term changes, which sometime appeared contradictory, to a more comprehensive understanding of the biological relevance of these impacts (Corkeron, 2004). Indeed interpreting behavioral responses outside the biological and ecological context in which they are studied has been shown to be uninformative (Beale & Monaghan, 2004; Bejder, Samuels, Whitehead & Gales, 2006a; Gill, Norris, & Sutherland, 2001).

Recent studies show that these short-term avoidance tactics can lead to biologically significant effects which can have long-term consequences for individuals and their populations (Bejder, 2005; Bejder et al., 2006a; Bejder et al., 2006b; Foote, Osborne, & Hoelzel, 2004; Lusseau, 2005; Lusseau, Slooten, & Currey, 2006b; Williams, Lusseau, & Hammond, 2006). These latter studies have taken a multi-contextual approach to elucidate the mechanisms linking short-term avoidance tactics to long-term impacts. Using comparisons between control and impact sites and long-term life history data they have revealed how whalewatching disturbance, a chronic intermittent stressor, had short-term effects on the lives of cetaceans which lead to long-term consequences for the viability and fitness of individuals and their populations. Whalewatching refers here to interactions between vessels and both dolphins and whales. Here we use three examples to highlight these mechanisms. We argue that this work is paving our understanding of principles governing the impacts of human activities on cetaceans. In particular, research in the effects of whalewatching can contribute significantly to a better understanding of the transfer functions in the Population Consequences of Acoustic Disturbance (PCAD) model (National Research Council, 2005).

Methods

We undertook studies on bottlenose dolphins (*Tursiops* sp.) at two sites: Shark Bay, Australia (Bejder et al., 2006a) and Fiordland, New Zealand (Lusseau, 2004). We will also present work carried out in collaboration with other authors on killer whales (*Orcinus orca*) off Vancouver Island, Canada (Williams et al., 2006). In Shark Bay, immediate responses to controlled vessel approaches were evaluated at both control and impact sites, depending on whether whalewatching occurred at those sites or not. Observed effects were related to long-term dolphin photo-identification records, reproductive rates and cumulative exposure measures to vessels (Bejder, 2005; Bejder et al., 2006a; Bejder et al., 2006b). In a similar fashion, we measured immediate behavioral responses of individuals and schools of bottlenose dolphins to boat interactions in Fiordland in two populations that were exposed to different levels of boat interactions. These two populations, one residing in Doubtful Sound and another whose home range centers on Milford Sound, are exposed to similar ecological conditions but are distinct. We then related these responses to long-term habitat use and reproductive success in relation with the rate of exposure to these disturbances (Lusseau, 2003a; Lusseau, 2003b; Lusseau, 2004, 2005; Lusseau et al., 2006a; Lusseau et al., 2006b). The Fiordland study also benefited from a natural experiment in that we made predictions regarding the consequences of increased tourism levels in Doubtful Sound following the results of the study (2000-2002) that were tested after tourism intensity did increase in subsequent years (2003-2007).

Results

Shark Bay, Australia

In Shark Bay, dolphin abundance was compared within adjacent tourism and control sites, over three consecutive 4.5-year periods wherein tourism levels increased from zero (1988-1993), to one (1993-1998), to two (1998-2003) dolphin-watching operators. As the number of tour operators increased from one to two, there was a significant average decline in dolphin abundance (14.9%; 95% CI = -20.8 to -8.23), approximating a decline of one per seven individuals in the tourism site. In contrast, abundance in the adjacent control site, which was not used by tour boats, did not change significantly (Bejder et al., 2006b).

Additionally, the behavioral response of dolphins to experimentally controlled boat interactions was quantified at two sites: the impact site mentioned above, and another control site, located 17km away from the impact site, that had similar ecological features. The movement of dolphins became more erratic during interactions and dolphin schools tightened. However, the effect size was smaller at the impact site (Bejder et al., 2006a), which traditionally would have been explained as a sign of “habituation”. However, in the light of the abundance study, it is more parsimonious to infer that individuals left at the impact site could afford to respond as much as others at the control site, because of reduced fitness. Indeed, the reproductive success of females in this area was linked to their cumulative exposure to boat interactions (Bejder, 2005).

Fiordland, New Zealand

The Milford Sound population was exposed to approximately seven times more tourism traffic than the Doubtful Sound population (Lusseau, 2004). Interactions affected behavioral budget in a similar fashion in both fiords leading to significant increased time spent travelling and decreased time spent resting (Lusseau, 2003a, 2004). They also increased the duration of travelling bouts, leading to added energetic challenges for individuals with less relative energetic stores (i.e., females and especially females with calves or pregnant). These added costs were apparent in that females tended to have different avoidance strategies than males, undergoing vertical avoidance strategies only when the boat interaction intrusiveness was such that it was highly likely to lead to injuries to non-avoiding individuals (Lusseau, 2003b).

While tourism exposure was much higher in Milford Sound than Doubtful Sound, the time spent interacting with boats in both fiords was similar (Lusseau 2004). This was linked to an avoidance of Milford Sound by dolphins during seasons with high tourism traffic (boat traffic was the only oceanographic predictor of residency pattern: $r = –0.814$, $p = 0.021$, Lusseau, 2005). In addition, when dolphins visited the fiord they avoided location with high boat traffic at peak traffic hours ($r =–0.888$, $p = 0.0018$, Lusseau, 2005). There was a linear relationship between boat traffic and dolphin-boat interaction pattern until the average time elapsed between two interactions reached 68 minutes (Lusseau, 2004; Lusseau et al., 2006b). Beyond this point, dolphins switched from a short-term behavioral avoidance strategy to long-term avoidance strategy (habitat displacement) because the former strategy was no longer beneficial (Lusseau, 2004). Tourism activities affect only a portion of the home range of the Milford Sound population. Therefore, habitat displacement is a possible tactics for the individuals to manage the impacts. In contrast, tourism activities are pervasive throughout the home range of the Doubtful Sound population. We predicted that if boat interactions were to intensify and pass the 68-minute threshold, the population could only cope by decreasing its reproductive success (Lusseau et al., 2006b). Once boat traffic increased beyond the 68-minute threshold, the population suffered a dramatic decline in abundance (Currey, Dawson, & Slooten, in press; Lusseau et al., 2006b), passing from 67 to 56 individuals in a very short period. There was also a drastic significant decline in reproductive success with an increase in neonatal/stillbirth deaths (1994-1999: stillbirth presence: 2/5 years, stillbirth rate: 0.13 stillbirth/year; 2000-2007: 6/7 years, 0.34 stillbirth/year; randomization tests respectively: p=0.044 and p=0.043 (Lusseau et al., 2006b) and overall calf survival rate (Currey et al., submitted). This decline in calf survival could explain solely the population decline (Currey et al., submitted).

Vancouver Island, Canada

This study showed that boat traffic was also significantly affecting the behavioral budget of northern resident killer whales (Williams et al., 2006). They reduced foraging opportunities and increased travelling time. However, a simple bioenergetic model showed that while the behavioral effect size was greater for travelling than for foraging, the loss in foraging opportunity was leading to a greater energetic cost, by decreasing energy intake by 18%. In contrast, the added energetic cost of increased activities was only leading to a 3 to 4% increase in energy output for individuals (Williams et al., 2006). This showed that the biologically significant impact of boat interactions principally focused on food intake for this population. Such studies can help us prioritize management actions to minimize the biological significance of the impact. In this example, preventing boat interactions while whales are foraging will have a disproportionately greater influence on the overall impact of whalewatching than other restrictions would. Therefore establishing no-boat zones around foraging hotspots would be an ecologically and economically sensible measure (Lusseau & Higham, 2004).

Discussion

Results presented here indicate biologically significant impacts of an apparently benign human activity, i.e., watching whales and dolphins. The success of detecting population level effects was based on long-term population monitoring and the availability of information on the variation in vessel exposure between individuals, sites, and populations. The influence of these impacts on population viability can be inferred using the dose response relationships these studies describe. Early individual-based models show that these impacts are highly likely to endanger the viability of small populations which have restricted immigration/emigration because of the increased cumulative exposure they incur (Lusseau et al., 2006a).

The consequences of energetic challenges

The published studies we present here show that increased energetic challenges, either as added travelling costs or reduced foraging opportunities, can lead to reduced fitness for individuals. If such challenges occur too often, individuals shift into long-term avoidance strategies when possible by avoiding the degraded areas. However, such long-term decisions have to be balanced with other costs and benefits to leave a habitat degraded by whalewatching or leave a school exposed to whalewatching. These trade-offs lead to non-linear relationships with a rapid shift into long-term strategies when short-term tactics are no longer beneficial. This highlights that these behavioral systems, like other complex systems, can be shifted from one basin of attraction to another quite rapidly (van Nes & Scheffer, 2007). Individuals that cannot leave degraded habitat have reduced fitness leading to, at least, reduced reproductive success. This shows that at the population-level these shifts in basin of attraction may not always lead to evolutionary stable solutions.

Modeling population-level consequences

This described link between whalewatching disturbance exposure and reproductive success and survival probability can be used in agent-based simulations to define the likelihood that these effects can endanger the viability of exposed cetacean populations (Lusseau et al., 2006a). More importantly, the uncertainty surrounding the estimated dose-response curves can be incorporated in these models, so that its influence on the likelihood populations will remain viable can be accounted (Lusseau et al., 2006a). Agent-based simulations provide a tool to disturb artificial individuals in a population in a realistic manner because the rules of interactions (timing, duration, number of interactions, temporal variation) can be informed by empirical data. Unsurprisingly, these models illustrate how small populations, with restricted immigration and/or emigration, are less likely to survive even low levels of whalewatching exposure (Lusseau et al., 2006a). That is because such features increase the cumulative exposure to disturbance per capita. In addition, once the population starts to decline, restricted immigration means that exposure per individual intensifies, precipitating the population in an extinction vortex (Lusseau et al., 2006a).

Insights for the PCAD model

These studies provide templates to inform the PCAD model (Figure 1). The highlighted studies bring valuable insight into the three transition functions of the PCAD model. They show that repetitive short-term behavioral change can influence life functions by imposing additional costs to the energetic budget of individuals. The resulting impact on individuals will vary with the life history of the targeted species. In some instances, decreased energy intakes will predominantly drive the impact of the responses, while in others it may be the added energetic cost of transport.

Impacts on life functions can affect vital rates. These studies show that the influence of these changes on vital rates is non-linear, their impact shifting abruptly around a threshold. At this stage, whalewatching studies only provide a mechanistic function in an energetic framework. Other life functions may be impaired, such as socializing, and those impacts can also have influences on vital rates, such as reproduction rate. Much work is needed to understand the principles governing these mechanisms that will be highly species-specific.

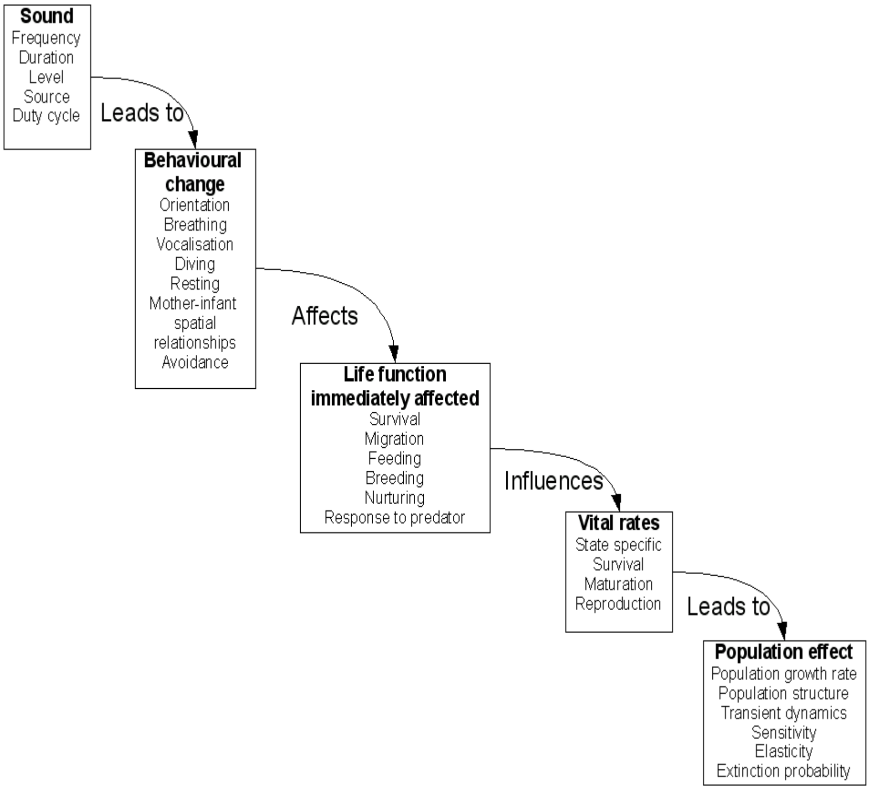

Figure 1. Modeling population-level consequences. Printed as modified from the Population Consequences of Acoustic Disturbance model developed by the US National Research Councils (National Research Council, 2005) with permission from the National Academies Press, Copyright 2005, National Academy of Sciences.

Finally, as it has been shown in the case of other anthropogenic impacts (Slooten, Fletcher, & Taylor, 2000), the alteration of vital rates can lead to influences on the viability of populations. This will depend on the resilience of the population's carrying capacity and therefore small, closed population are highly likely to be more prone to extinction under these scenarios.

Conclusion

We have shown here that there is high propensity for individuals to have context-specific responses to disturbances. It is also expected that human activities will have disproportionate influences on different individuals depending on their current fitness and life history strategy (Lusseau, 2003b; Munch & Conover, 2003; Perez-Tris, Diaz, & Telleria, 2004). If the impacts of these activities are significant enough to select against sensitive individuals, these disturbances may also influence the evolutionary dynamics of populations since the predisposition for risk-taking behavior may be heritable in many species (Brick & Jakobsson, 2002; van Oers, Drent,, de Goede, & van Noordwijk, 2004). This population-level adaptation could result in lower observed effect size of disturbance. Such variation can be interpreted as the population “habituating” to the disturbance when in fact the population is reacting to this disturbance in several dimensions. This conclusion highlights the need for contextual information to define the biological relevance of observed short-term effects and the danger of interpreting these effects out of context.

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Adaptive Management, Population Modeling and Uncertainty Analysis for Assessing the Impacts of Noise on Cetacean Populations

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Population modeling is now widely used in threatened species management and for predicting the impacts and benefits of competing management options. However, some argue that the results of models must be used with caution, particularly when data are limited. This is important, as even the simplest models would generally require more data (and knowledge) than are available in order to have complete confidence in model predictions. In particular, population models often suffer from a lack of data on demographic rates, spatial distribution, dispersal, management responses, habitat correlations and the magnitude of temporal variations. A number of authors identify behavioral and physiological responses of animals to anthropogenic noise. Assessing population level impacts of noise on cetacean populations is essential to understanding how noise impacts on the future viability of marine mammal populations. This assessment will be particularly challenging due to the difficulties associated with identifying a clear link between behavioral responses of animals and physiological impacts, observing and measuring changes in cetacean population parameters and the long lag-times over which population changes manifest in long-lived species. The urgency of the conservation situation for many of these socially important species demands immediate action, despite pervasive uncertainty. Adaptive management provides a coherent framework for action and continuous improvement under uncertainty. I review the elements of adaptive management and discuss the role of population modeling in that context. I discuss Bayesian approaches to enhancing inferential power and reducing uncertainty in model parameter estimation. I then review approaches to characterizing irreducible uncertainty with Monte Carlo methods and sensitivity analysis and conclude with a brief discussion of formal decision tools available to assist with decision making under severe uncertainty. I propose that urgently needed action should not be postponed due to uncertainty and that adaptive management provides a coherent framework for instituting immediate action with a plan for learning.

Of primary interest to conservation practitioners is the degree to which human activities (such as anthropogenic noise) induce physiological and behavioral responses (e.g., a prolonged stress response) that ultimately manifest in changes to population dynamics such as reduced yearly survival and fecundity (collectively referred to as *vital rates*), and metapopulation dynamics such as immigration and emigration rates. More specifically, it is possible that anthropogenic noise may impact on marine mammal populations through direct physiological impacts leading to reduce survivorship and fecundity, or indirectly through changed behavior such as interrupted or altered foraging, mating or migration patterns (see Bateson, this issue; Beale, this issue; Deak, this issue; Lusseau, this issue; Romero & Butler, this issue; Wright et al., this issue, a. There

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is mounting evidence that anthropogenic noise will result in population level impacts on marine mammal species, but substantial uncertainty about exactly how anthropogenic noise impacts will manifest. This is a common situation in conservation and natural resource management. In most situations we lack information about the magnitude of anthropogenic impacts and the efficacy of ameliorative actions on vital rates and metapopulation dynamics, as well as how they interact with environmental influences. Data on 'natural' demographic rates are also often lacking making inference about the population-level impacts of noise particularly challenging.

While such uncertainties are pervasive in conservation science, attempts at dealing with uncertainties in decision making have been largely ad-hoc and few applications utilize formal decision theory. However, some principles of decision making under uncertainty are articulated in the literature (Holling, 1978; Walters, 1986; Walters & Holling, 1990) and coherent approaches to management and decision making under uncertainty have recently emerged (Dorazio & Johnson, 2003; Nichols & Williams, 2006). Bayesian approaches to dealing with uncertainty due to imperfect knowledge and data have long been available but are only now becoming more widely used by ecologists and conservation biologists (Dorazio & Johnson, 2003; Ellison, 2004; McCarthy, 2007). There are a rising number of practical examples of formal decision making in conservation and natural resource management (Gerber et al., 2005; Hauser, Pople, & Possingham, 2006; Johnson & Williams, 1999; McCarthy & Possingham, 2007; Moilanen & Wintle, 2006; Regan et al., 2005), and the number of people trained to implement formal decision techniques is increasing. The synthesis of adaptive management principles, Bayesian approaches to characterizing and reducing uncertainty, and formal decision protocols may provide the basis for improved transparency, efficiency and robustness of conservation management under uncertainty. However, there are few examples of the successful integration of these approaches in practical applications of adaptive conservation management. Here I review aspects of uncertainty analysis and experimental management of threatened species populations and propose a framework for learning about the population-level impacts of noise-related stress effects.

Management under uncertainty: The adaptive management framework

Because uncertainty is pervasive in conservation management it is not appropriate to use uncertainty as an excuse for inaction (Bruntland, 1987), as inaction often results in deleterious environmental and biodiversity outcomes (Stern, 2007). Postponing decisions and changes to management because evidence for environmental harm is inconclusive or because impacts are not yet perfectly measured may be a highly sub-optimal strategy for conservation and should be weighed against the costs and benefits of various alternative actions. Adaptive management has been proposed as a paradigm for management under uncertainty and continuous improvement (Johnson et al., 1997; Linkov, Satterstrom, Kiker & Bridges, 2006a; Walters, 1986; Walters & Holling, 1990). Adaptive management can be loosely defined as management with a plan for learning. Under adaptive management a range of management actions are prescribed at each time step that have the dual purpose of achieving management goals and facilitating learning about the system under management and the relative performance of management strategies. Adaptive management may be described in four steps (Figure 1);

i) identification of management goals, constraints and performance measures;
ii) specification of management options;
iii) identification of competing system models and model weights; and
iv) allocation of resources, implementation of management actions and monitoring of management performance.

The integration of 'implementation of management actions' and 'monitoring' emphasizes that monitoring is central to management and not an optional extra.

Modern interpretations of adaptive management based on adaptive optimization encourage an iterative approach to decision making (also known as 'state-based' decision making; Nichols & Williams, 2006). The act of determining management actions (strategies) for a discrete period of time that are optimal with respect to one's belief and uncertainty about the state of the system, as well as one's predictions about how the system will respond to management is intuitive though not always simple to achieve (see Allan and Curtis, 2005; Stankey et al., 2003, 2005). Indeed, it is not necessary that managers adopt formal optimization methods when implementing adaptive management as long as there is a plan for learning and a willingness to adapt management decisions in light of evidence that is collected through management experiments. Adaptive management is appealing in that it explicitly acknowledges that the decision being made is subject to substantial uncertainty and may change in the next time step depending on what is discovered (learnt) in the intervening period. It doesn't require the completion of an experiment before a change to management can be instituted; rather it identifies the best decision to be taken now, based on what is believed about the state of the system and what has been discovered to date through previous monitoring and research. Adaptive management is well suited for managing systems in which changes take a long time to become apparent and definitive experiments are not possible in reasonable timeframes. Formal adaptive management helps to identify an immediate course of action despite substantial uncertainty. It also helps to clarify the role of monitoring as a process for reducing uncertainty and ranking the performance of management in ameliorating impacts.

One of the most challenging aspects of decision making in natural resource management is the process of identifying and setting management objectives, especially when multiple stakeholders hold conflicting or competing objectives (Step **i** in Figure 1). Environmental management requires decisions makers to integrate heterogeneous technical information with values and judgment. Methods for eliciting and reconciling competing objectives, such as multi-criteria decision analysis (MCDA; Figueira, Greco, Ehrgott, 2005) provide a basis for tackling this challenge. MCDA also provides a coherent way of integrating various forms of uncertainty (epistemic uncertainty, subjectivity, semantic ambiguity; Regan et al., 2001) with social preferences in the decision process. The methods and tools reviewed in the paper (adaptive management, Bayesian approaches, population modeling) are important tool for characterizing and reducing uncertainty that feed into the decision making process. However, they do not make decisions *per se* because decision making is, necessarily, a social process that involves competing decision priorities. The common purpose of MCDA methods is to evaluate and choose among alternatives, based on multiple criteria using systematic analysis that overcomes the limitations of the unstructured individual or group decision making (Figueira et al., 2005). The aim of MCDA is to facilitate decision makers' learning about and understanding of the problem as well as about organizational preferences, values and objectives. MCDA can guide decision makers in identifying a preferred course of action through exploring these issues in the context of a structured decision analysis framework. MCDA framework may be integrated with adaptive management (Linkov et al., 2006a, b) as well as with Bayesian methods and population models. A detailed review of MCDA and associated methods is beyond the scope of this article. Here I focus primarily on approaches to characterizing and where possible, reducing uncertainty with efficient modeling and learning strategies. I recognize that these are aspects of the larger problem of dealing with uncertainty and social preferences in decision making.

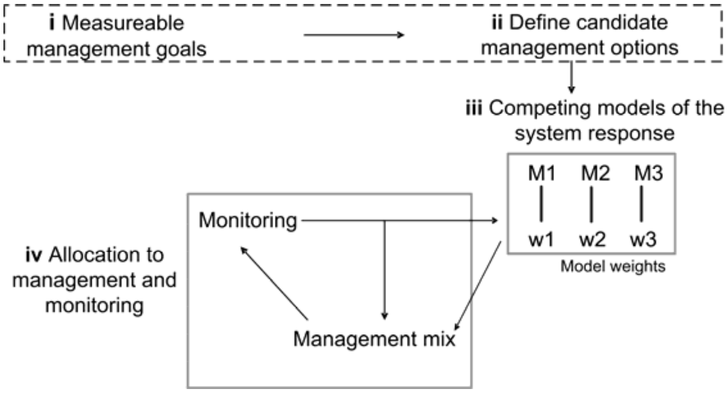


Figure 1. Adaptive management (reproduced from Figure 1, Duncan & Wintle, 2008, © with kind permission of Springer Science+Business Media); an approach to management under uncertainty with a plan for learning. The dashed-line box indicates steps that require elicitation of social preferences. Updating of models can include updating of individual model parameters (e.g. Dorazio & Johnson, 2003) and/or updating of model weights (e.g. Box 2, Johnson et al., 1997).

Population models, impact assessment and adaptive management

Adaptive management of threatened species requires the specification of a model (or competing models) of species' responses to impacts and management intervention. The role of models in adaptive management is twofold. Firstly, models help to characterize uncertainty and formalize competing views about population dynamics, and the manner in which populations respond to anthropogenic influence and interact with natural environmental processes. Secondly models are useful for making predictions about the likely impacts of future (or proposed) management actions, allowing managers and stakeholders to rank competing management options. Under adaptive management, competing models are iteratively assigned credibility based on the observed response of species to management over time. Population models have been used in both terrestrial and marine systems to evaluate the long-term population consequences of competing management options (Box 1; Akcakaya, Radeloff, Mladenoff & He, 2004; Taylor & Plater, 2001; Wade, 1998; Wintle, Bekessy, Pearce, Veneir & Chisholm, 2005).

Box 1. The use of population modeling to rank management options: The wedge-tailed eagle and plantation conversion in northeastern Tasmania, Australia.

Bekessy et al. (in review) utilized dynamic landscape metapopulation models (DLMP: Akcakaya et al., 2004; Wintle et al., 2005) to assess the landscape-level impacts of plantation conversion on the viability of the wedge-tailed eagle in the north-east region of Tasmania. DLMP were fitted in the software package RAMAS Landscape (Akcakaya et al., 2004). The process of developing DLMP models may be broadly described in 4 steps (Wintle et al., 2005): (1) building a habitat model; (2) developing a model of population dynamics; (3) linking these models in a metapopulation model; and (4) building a forest-dynamics model and linking it to the metapopulation model to evaluate management options.

Bekessy et al. (in review) were able to use the DLMP framework to provide predictions about the future (160- year time horizon) wedge-tailed eagle population size in north eastern Tasmania under a range of forest management and plantation conversion scenarios including: (1) no logging (only 'natural fire disturbance'); (2) native forest harvesting only; and (3) native forest harvesting with extensive plantation conversion (~50% of total forest extent). Results of DLMP models were summarized using the expected minimum population size (EMP: see main text). The results of the DLMP risk assessment process indicated that all anthropogenic disturbance scenarios generated an EMP that was approximately half that of the no-logging scenarios (Fig. 1.1), but that there were no appreciable differences between native harvest-only and conversion scenarios for this particular species. This was thought to be because the primary limiting resource for the species was the availability of nesting habitat that only occurs in old, relatively undisturbed forest on sites with large trees, and that these conditions were approximately equally compromised by native forest harvesting and plantation conversion.

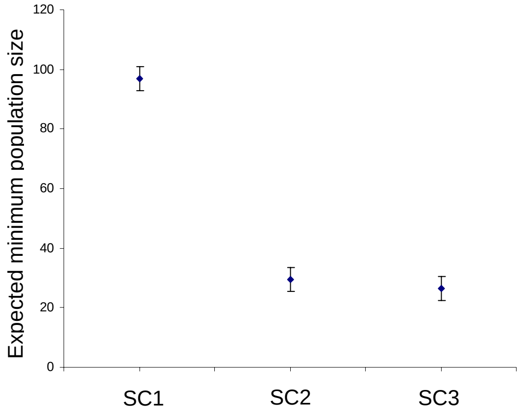


Figure 1.1. Expected minimum wedge-tailed eagle population sizes over a 160-year time horizon under three management scenarios (SC1 = no logging or plantation conversion, SC2 = only native forestry logging with natural regeneration, SC3 = native forestry with natural regeneration and approximately 30% plantation conversion). Error bars represent the 95% confidence interval on the mean EMP (this should not be confused with a 95% prediction interval for EMP). EMP may be interpreted as there being a 50% chance of the population falling below the stated level at some time over the next 160 years.

However, predictions of population models are subject to substantial uncertainty in parameter estimates (Ludwig, 1996). The standard approach to quantifying and representing such uncertainty is through Monte Carlo simulation. Monte Carlo methods are widely used for simulating the behavior of various physical and mathematical systems. Monte Carlo simulation of population models involves randomly sampling parameter values from a distribution of possible values over a number of 'iterations'. For example, when conducting Monte Carlo simulations for a population model, the value of the adult yearly survival parameter at *each time step* might be selected from a beta distribution with a mean set at the best estimate of yearly survival and a variance determined by analyzing long-run variation in yearly survival of the species. Often it is the variance of such parameters that is hardest to determine. A single iteration of the model provides a single possible trajectory for the species. Over numerous iterations, a distribution of predictions is derived that represents the predictive uncertainty in expected population trajectory attributable to parameter uncertainty and the more general effects of environmental stochasiticity. For more information about Monte Carlo sampling in population models, see Burgman, Ferson & Akçakaya (1993).

In order to test the sensitivity of model predictions to particular assumptions, one may conduct a sensitivity analysis. There are several different approaches to conducting a sensitivity analysis including random sampling or systematic perturbation of parameter values and analysis of how variation in a given parameter influences model predictions. A common approach to sensitivity analysis involves systematically adjusting individual parameters by a set amount (e.g. +/- 20%), while keeping all other parameters at their estimated mean value, and observing the magnitude of change in model predictions that arise. If the predicted change in expected population size is substantial for a small change in a particular parameter, then the model is said to be 'sensitive' to that parameter. Sensitivity analysis may be used to assess sensitivity of tail risks as well as expected population sizes. Sensitivity analysis is may be used to priorities research into vital rates or environmental parameters to which population projections are most sensitive.

McCarthy & Thompson (2001) proposed the now widely used metric 'expected minimum population size' (EMP) as an appropriate quantity of interest derived from population viability analysis. EMP is calculated by taking the mean of the smallest population size that occurred at over the simulation period for each Monte Carlo iteration of the model. The EMP is useful in ranking scenarios as it provides a good indication of the propensity for population decline but is less sensitive to model assumptions than the metrics *risks of decline* or *risk of extinction* (McCarthy & Thompson, 2001). One particularly useful property of EMP is that it can be used to delineate between management options for species that have almost no probability of going extinct under any option. The sensitivity of the model to a particular parameter, or the sensitivity of the species to a particular management option may be defined in terms of EMP (Wintle et al., 2005):

$S_i = (\mathrm{EMP}_\mathrm{i} - \mathrm{EMP}_b)/\mathrm{EMP}_b \times 100,$

where S_i is the sensitivity of model i (the model being investigated), EMP_i is the expected minimum population size of the model i, and EMP_b is the expected minimum population size of the base model. The base model usually represents the model for which parameter estimates are all 'best' estimates or the model representing the default (or current) management. Sensitivity calculated in this way provides an indication of both the magnitude and direction (positive or negative) of the change in EMP.

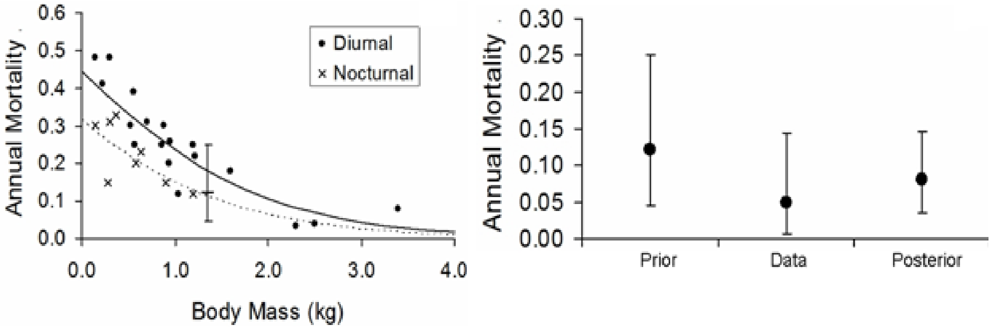
Despite the prevalence of substantial uncertainty, modeling may be useful in challenging stakeholders and managers to clearly state their belief about species population dynamics and the magnitude and mechanisms of anthropogenic impacts. Models represent testable hypotheses that may be improved and updated as new data or knowledge comes to hand. As data are gathered, updated models may begin to provide predictions that are more broadly trusted by managers and stakeholders. In data-poor situations, it is important to make the most of available expertise or 'collateral' data. That is the topic of the next section.

Bayesian approaches to inference

Ecological data are often expensive, time consuming and difficult to collect. Unlike in the physical sciences, the design of the definitive experiment that proves or disproves a theory can seldom be achieved in ecology and conservation. Ecological inference is largely a process of synthesizing disparate data and the results of inconclusive experiments to update knowledge and make the best possible decision. Ecological inference is primarily concerned with estimation of parameters and the weighting of competing hypotheses (models) rather than the rejection or acceptance of null-hypotheses (Anderson, Burnham & Thompson, 2000; Burnham & Anderson, 2002; Ellison, 2004; Johnson, 1999). Bayesian approaches to inference are particularly well suited to the synthesis of disparate information, parameter estimation and multi-model inference (Ellison, 2004; Harwood, 2000; McCarthy, 2007; Wintle, McCarthy, Volinsky & Kavanagh, 2003). Multi-model inference and iterative updating of knowledge (beliefs) are strengths of the Bayesian approach to inference. Ferson (2005) provides an excellent review of the criticisms of Bayesian approaches to inference and decision making, focusing on the use of prior information that is central to the Bayesian method. He identifies concerns about the contraction of uncertainty that arises when highly divergent distributions (i.e. prior and data) are combined with Bayes theorem. There are non-Bayesian alternatives to integrating multiple sources of information (e.g. meta-analysis; Sutton, Jones, Abrams, Sheldon & Song, 2000) and conducting multi-model inference (Burnham & Anderson, 2002), though they are regarded as theoretically less coherent by some authors (Link & Barker, 2006). A full review of the philosophical and practical differences between Bayesian and alternative analytical methods is beyond the scope of this paper. I also consider that the 'controversy' over Bayesian and non-Bayesian methods to be somewhat over-played and to be largely irrelevant here. However, warnings about Bayesian methods should not be ignored because, as is the case for all statistical methods, naïve applications of Bayes theorem can be dangerous. In the following two sections I discuss two important functions of Bayesian inference in model-based management of threatened species. In the first section I discuss Bayesian approaches to reducing uncertainty through integration of alternative data sources and expert knowledge. In the second section I describe the role of Bayesian updating for iteratively assigning plausibility to competing management models under adaptive management.

Bayesian approaches to reducing uncertainty with prior data and expert opinion

Under adaptive management of noise-effects on cetaceans it is necessary to generate hypotheses and models that describe both the impacts of noise on cetacean population parameters as well as the value of proposed noise mitigation or management strategies. This can be particularly challenging in the absence of definitive studies or models that measure such processes, as is currently the situation with the case in point. McCarthy (2007; pg 134) provides an excellent example of how to develop informative prior information about the value of a poorly measured parameter (in this case, the yearly mortality rate of powerful owls in southeastern Australia). McCarthy utilized a regression of body mass on mortality rate using data for a range of (better studied) raptors from around the world. In his analysis McCarthy demonstrates the use and value of a model-based prior when making inference based on an extremely sparse data (in this case, one observed mortality in 35 observation years: Figure 2).



a. b.

Figure 2. a) Annual mortality of raptors versus body mass for diurnal (solid line) and nocturnal (broken line) raptors. The prediction and prediction interval for the powerful owl, based on the regression for other owls, is shown as the dashes and vertical bar. b) Annual mortality of powerful owls showing the prior based on other species' mortality estimates (a), the data on powerful owls and the posterior estimate (circles are means and dashes delimit 95% CIs) [reproduced with permission of Michael McCarthy and Cambridge University Press].

Box 2. Using Bayes' theorem to assign credibility to competing models with monitoring data; the management of Mallard ducks.

Models that predict a system response to management actions are needed to optimize management decisions (Nichols & Williams, 2006). Typically, multiple competing views (opinions, hypotheses) about how a system will respond to management exist and these views can be formalized as competing models. The plausibility of competing models may be assessed by comparing their predictions to data obtained from monitoring. In developing an adaptive management strategy for Mallard duck harvest, Johnson *et al*. (1997) describe a process of updating belief about the plausibility of competing models based on Bayes' theorem, such that the plausibility of a given model given the newly observed data (D) is:

$$\Pr(M_i \mid D) = \frac{\Pr(D \mid M_i)\Pr(M_i)}{\sum_{j=1}^{s} \Pr(D \mid M_j)\Pr(M_j)}, \qquad \text{(eq 1)}$$

where $\Pr(M_i| D)$ is known as the 'posterior probability' or 'weight' of model M_i (i.e. the degree of belief in M_i *after* considering the available data). $\Pr(D|M_i)$ is the likelihood that a given set of data would be observed if M_i were true, $\Pr(M_i)$ is the prior probability assigned to model M_i and the denominator represents the sum across the products of prior probabilities and likelihoods for all competing models including model M_i.

Models describing duck population responses to hunting pressure are central to the sustainable management of duck harvests. Managers of Mallard ducks use equation 1 to iteratively update their belief in competing models as yearly monitoring data are collected (Johnson et al., 1997; Johnson & Williams, 1999; USFWS, 1999). Various scientists and stakeholders hold alternative views about how duck hunting impacts on duck population dynamics. Debate focused on whether population growth would compensate for harvest mortality (compensatory mortality vs. additive mortality) and whether reproductive success would be strongly or weakly linked to habitat availability (strong vs. weak density dependence). In developing an adaptive management system for duck hunting, competing views were summarized as four models of duck hunting population response: 1) additive mortality (am), strong density-dependent recruitment (sdd); 2) additive mortality, weak density-dependent recruitment (wdd); 3) compensatory mortality (cm), strongly density-dependent recruitment; and 4) compensatory mortality, weak density-dependent recruitment (USFWS, 1999).

The implication of strong density dependence and compensatory hunting mortality is that higher hunting quotas may be sustainable. More conservative harvesting may be warranted if density dependence is low and hunting mortality is not compensated by increased reproductive success and a reduction in other forms of mortality. Table 2.1 shows how model probabilities were updated with duck population monitoring data over the years 1995 - 1999. Note that prior to the collection of monitoring data in 1995, all models shared equal prior probability [i.e. $\Pr(M_i) = 0.25$]. As monitoring data were collected and compared against the predictions of the four competing models, it rapidly became apparent that the compensatory mortality hypothesis was not supported by the data as hunting had a substantial impact on overall survivorship estimates. The data provided slightly more support for strong density dependence than weak.

Table 2.1
Trends in probabilities for competing hypotheses of Mallard population dynamics taken from USFWS (1999) [model probabilities have been rounded to two decimal places].

Year **Model** (defined above)	'95	'96	'97	'98	'99
1 (am, sdd)	0.25	0.65	0.53	0.61	0.61
2 (am, wdd)	0.25	0.35	0.46	0.39	0.38
3 (cm, sdd)	0.25	0.00	0.00	0.00	0.00
4 (cm, wdd)	0.25	0.00	0.00	0.00	0.00

The above example illustrates how it is possible to derive parameter estimates where little or no data are available. Approaches to eliciting Bayesian estimates of parameters from experts where no data can be obtained are analogous to those described in this simple example (see Martin et al., 2005; McCarthy, 2007 on soliciting subjective priors). A similar analysis might be initiated to develop parameters that describe the survival and fecundity of species in other situations, such as whales under various noise exposure/management scenarios. The approach outlined above is a logically coherent approach to extrapolating, for example, noise-related impacts from other mammals to cetaceans. The degree to which this approach works depends on whether the responses in question (e.g., behavioral, physiological, psychological, etc.) are highly conserved between species. For example, stress response physiology does appear to be highly conserved between species (see Deak, this issue; Romero & Butler, this issue) and thus would be a good candidate for this approach.

Bayesian updating in adaptive management. Adaptive management encourages a formal process of iteratively updating degrees of belief in competing hypotheses (models) in light of evidence collected through monitoring. There is usually substantial uncertainty about how a species will respond to management intervention, or indeed, the ecological/biological processes that mediate that response. It is common for different experts to support qualitatively different models of ecological processes. Qualitatively different management strategies usually imply different views about how species and environmental processes interact with human and natural disturbances. When appropriate experts support qualitatively different models, it implies substantial uncertainty about the best approach for achieving desired management outcomes. When such uncertainty exists (and is acknowledged), there is value in implementing management options that will facilitate learning about the relative merits of competing models and ultimately the best long-term strategies for achieving management goals. In some instances, data and expert opinion may favor some models over others. When this is the case, formal methods for weighting competing models may be utilized (Box 2; Burnham & Anderson, 1998; Wintle et al., 2003). Competing model weights may be used to assist in the allocation of effort between competing management options. If there is no substantial evidence in favor of one model over another, then uninformative (equal) model weights may be appropriate until further evidence arises that provides support for one model over others (Box 2).

Conclusions

At first glance, the range of tools and the technical aspects of formal decision making may serve as a disincentive to engage in adaptive management. Here I have focused on techniques for making predictions, characterizing uncertainty, and learning about effective ways to manage threatened species. There are substantial components of the decision making process, such as reconciling competing objectives and social utilities that I have not dealt with in detail. While there are technical challenges to all decision analysis methods, the advantages gained in terms of transparency, repeatability and stakeholder trust far outweigh the technical overheads. In short, dealing with uncertainty in conservation and natural resource management is a difficult challenge that necessitates sophisticated methods. The number of examples of adaptive management and formal decision theory applications occurring in conservation and environmental management are gradually increasing, though much un-chartered territory remains. A systematic method of combining quantitative and qualitative inputs from scientific studies of risk, cost and cost–benefit analyses, and stakeholder views has yet to be fully developed for environmental decision making (Linkov et al., 2006a). Management of threatened cetacean populations and the acute and chronic impacts of noise will involve numerous sources of uncertainty. This highlights the need for systematic approaches to learning and decision making. I encourage cetacean conservation managers to embrace the principles and tools of adaptive management as a means to efficient use of scarce conservation resources and better long-term conservation outcomes.

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Anthropogenic Noise as a Stressor in Animals: A Multidisciplinary Perspective

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Consequences of extreme noise exposure are obvious and usually taken into some consideration in the management of many human activities that affect either human or animal populations. However, the more subtle effects such as masking, annoyance and changes in behavior are often overlooked, especially in animals, because these subtleties can be very difficult to detect. To better understand the possible consequences of exposure to noise, this review draws from the available information on human and animal physiology and psychology, and addresses the importance of context (including physiological and psychological state resulting from any previous stressor exposure) in assessing the true meaning of behavioral responses. The current consensus is that the physiological responses to stressors of various natures are fairly stereotyped across the range of species studied. It is thus expected that exposure to noise can also lead to a physiological stress response in other species either directly or indirectly through annoyance, a secondary stressor. In fact many consequences of exposure to noise can result in a cascade of secondary stressors such as increasing the ambiguity in received signals or causing animals to leave a resourceful area, all with potential negative if not disastrous consequences. The context in which stressors are presented was found to be important not only in affecting behavioral responses, but also in affecting the physiological and psychological responses. Young animals may be particularly sensitive to stressors for a number of reasons including the sensitivity of their still-developing brains. Additionally, short exposure to stressors may result in long-term consequences. Furthermore, physiological acclimation to noise exposure cannot be determined from apparent behavioral reactions alone due to contextual influence, and negative impacts may persist or increase as a consequence of such behavioral changes. Despite the lack of information available to managers, uncertainty analysis and modeling tools can be coupled with adaptive management strategies to support decision making and continuous improvements to managing the impacts of noise on free-ranging animals.

Physiological responses to stressors and the consequences for an individual or a population have been debated in various arenas, partly because they are studied by scientists from widely different disciplines. Here we summarize the knowledge acquired over the recent decades in different disciplines ranging from animal physiology to human psychology. Noise is a ubiquitous stimulus with the potential to act as a stressor, which has been growing in intensity in the oceans over recent decades. Paradoxically however, the effects of noise on the health and wellbeing of humans, terrestrial animals and, most recently, marine animals remain controversial. This paper provides an overview of the physiological responses to various stressors in humans and animals across various scientific fields and their consequences. We also summarize the current state of knowledge about these responses with specific regard to noise in humans and laboratory animals. Then, we extrapolate from this overview to fill some of the gaps concerning the physiological responses induced by noise in humans and free-ranging animals, highlighting marine species as they often rely heavily on acoustical communication as light does not travel far in water (Hatch & Wright, this issue). The importance of the context in which stressors are presented is also emphasized. Finally, we attempt to identify how and to what extent noise affects the health, wellbeing and viability of wildlife populations. Working definitions of several terms related to “stress” used throughout this paper are presented in Wright & Kuczaj (this issue).

Noise levels and exposure to those levels are measured differently in air and water. The reasons for this are varied, complex and beyond the scope of this paper. More information can be found in Clark & Stansfeld (this issue) and Hatch & Wright (this issue).

Physiological Stress Responses

Pathways of response

Two major systems are known to be involved in stress: the sympathetic nervous system (SNS) and the hypothalamic-pituitary-adrenal (HPA) axis. These systems are activated very rapidly and have broad impacts on diverse aspects of physiological functioning. The concerted effort of these and other critical endocrine and neural systems ultimately comprises an organism's response to a stressor (see Deak, this issue; Romero & Butler, this issue). Indirect measures of SNS activation (e.g., increased heart rate, blood pressure, or hyperthermia) or direct measures of SNS output from the adrenal medulla (plasma concentrations of catecholamines – epinephrine and norepinephrine) and HPA activation (corticosteroid concentrations in plasma, tissue or excrement) are often collectively or individually used to indicate the severity of a stressor. Importantly, "stress responses" can also occur to stimuli that are merely arousing, such as sexual activity (see Deak, this issue). Thus to avoid misinterpretation of physiological and behavioral measures observers should take into consideration baseline information and should verify the presence of a threatening context to determine whether the observed changes actually reflect a stress response and not arousal *per se*.

The SNS response to stressors can be detected within seconds of the perception of a punctate stressor (i.e., one with a sharp onset). However, many stressors are not punctate but rather develop over a long period. In the cases of these building stressors, the SNS activation is often described as a steadily escalating "tone" where general SNS activity increases relatively slowly over the course of hours, days or months, leading to escalated metabolic demand and gradual wear-and-tear on physiological systems that may eventually culminate into physiological failures (see Deak, this issue). These contrasting SNS responses make it particularly difficult to identify a causal relationship between anthropogenic noise and SNS response because anthropogenic noise arises across a wide range of time frames. Noise can be punctate, such as occurs in seismic survey blasts, or noise can gradually increase over a given area and persist for extended periods (if not permanently), such as is the case with the increase in ambient noise throughout the world's oceans resulting from shipping traffic. In the latter situation, the major stressor is unlikely to be the noise itself, unless levels cross some threshold of tolerability, but rather the increasing masking (i.e., the "drowning out" of a signal in the noise) of mating calls, social communication, echolocation of prey and other important signals.

Development of the response by the HPA axis is somewhat slower than that of the SNS response, but its impact is just as profound, albeit on a somewhat more protracted timeline. Immediately upon perception of a stressor a chain of events in the HPA axis triggers the production of glucocorticoids (GCs: e.g., corticosteroid) by the adrenal cortex (see Deak, this issue; Romero & Butler, this issue). The stress hormones are then quickly released into the bloodstream (usually within 3-5 min after activation by stressor onset) where they are rapidly distributed throughout the body to initiate a systemic response to the threat (Romero & Butler, this issue; Sapolsky, Romero, & Munck, 2000). This can be problematic for researchers as it limits the time during which they can gain valid information on GC levels, as an animal's blood GC levels rises very quickly after the individual perceives the threat of capture, regardless of whether it is yet in hand or not.

In general, the more intense the stressor, the greater the amount of GC released. Once the stressor ends, GC levels return to baseline concentrations as a consequence of both the ending of the stimulus and GC negative feedback on the pituitary gland and hypothalamus (see Romero & Butler, this issue). If the stressor persists or occurs at frequent intervals the animal becomes chronically stressed (how frequent depends upon the stressor). This is generally manifested as a long-term increase in GC secretion due to two mechanisms: repeated secretion in response to repeated stressors and a failure of GC negative feedback (Dallman & Bhatnagar, 2001).

Consequences of the stress response

GCs (both independently and in combination with other components of the stress response) cause a variety of behaviors in free-living animals that are heavily context dependent (see Deak, this issue; Romero & Butler, this issue). However, the broad effects of GCs are to shift the animal away from normal life-history behavior to emergency behaviors (see Romero & Butler, this issue). Examples include increasing activity, the scattering of a group, shifting behavior from reproduction to feeding, and abandonment of breeding territories. These behaviors are adaptive in natural environment in the short-term, but may become maladaptive in response to novel human disturbances and/or repeated or chronic exposures.

Detrimental physiological effects can also appear if the stressors remain, or additional stressors are presented, prolonging the GC response over an extended period. A number of pathological effects appear after 2-3 weeks, which are very consistent across species studied (mainly in captivity: see Romero & Bulter, this issue). These include, but are not limited to, diabetes, immune suppression and reproductive malfunction. In fact, the assault on reproductive function is threefold, involving prolonged behavioral changes, such as reorientation of the individual's behavior away from reproduction, psychological effects, such as decreases in libido, and physiological impairment of reproduction (see Deak, this issue; Romero & Butler, this issue). Interestingly, in many human couples seeking artificial conception, the underlying infertility is induced by being stressed (Homan, Davies & Norman, 2007; Wischmann, 2003).

Other long-term consequences of persistent high GC levels include accelerated aging and a slow disintegration of body condition (see Romero & Bulter, this issue). It is clear that accelerated aging in combination with decreased reproductive function presents a double-blow to the fitness of an individual. There are obvious implications for the population if such effects are widespread, but more subtle consequences also exist (see Deak, this issue; Romero & Butler, this issue). For example, if cultural exchange from one generation to the next is limited by the shortened lifespan and premature death of the older generation, certain skills or valuable information (e.g., regarding a reliable watering hole in times of drought in elephants) may be lost.

One further example of the consequences of persistently elevated GC levels is psychosocial dwarfism (Green, Campbell & David, 1984), a rare but documented inhibition of growth in human children due to altered growth hormone function (see Romero & Butler, this issue). It appears possible (although speculative at this point) that prolonged high levels of GCs may explain why sperm whales (*Physeter macrocephalus*) in the Gulf of Mexico (GoM) are significantly smaller than others elsewhere in the world (Jaquet 2000). Humans have very extensively used the Gulf ever since the discovery of the Mississippi River: activity that has continuously intensified.[1] The apparent dwarfism in the resident sperm whales might be a symptom of the heavily stressed state of the animals due to that activity. This condition would probably not be the result of exposure to noise alone, but rather the cumulative action of noise with various other stressors such as reduced prey availability and contaminants. Genetic differences and other factors might also be involved.

GCs can also have toxic consequences for neurons (i.e., cause neuron death) in the very young brain, which is probably why GC responses to stress are attenuated during the perinatal period (Sapolsky, 1992). Only severe stressors elicit GC release by the newborn during this time, such as parental deprivation or neglect, possibly as a consequence of parental/alloparental poor health (for any reason), or maternal separation, perhaps due to increased foraging times. The period of attenuation extends up to about a week or two postpartum in rats, but its length is not known in many other species, including marine mammals. If the mother is exposed to severe stressors however, GCs may be passed to the offspring through the placenta or in milk, circumventing this attenuating mechanism. The damage caused by exposure of the young brain to GCs produced by the mother alone can have profound and permanent consequences for the offspring, including sensitizing them to stressors, that is increasing their GC response, later in life (Kapoor, Dunn, Kostaki, Andrews & Matthews, 2006). Such changes can last at least to young adulthood and may be permanent, introducing the specter of potential generational effects.

Once this attenuation period ends, the still developing brain may then be very susceptible to neurological damage and re-programming as a result of exposure to high GC levels, whatever the source. Consequently, while reasonably mild stressors can lead to mild and temporary stress responses in adult animals, similar exposure in very young animals, either directly (e.g., brief handling of neonates, for not more that 2-3 minutes per day) or indirectly (e.g., through a “stressed” mother), has the potential to elicit long-term, if not permanent, consequences for the individuals resilience to stressors.

Long-term consequences of a prolonged or repeated stress response may also be present in individuals of any age due to ways that GCs instigate changes in

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[1] For more information on human activity in the GoM see the EPA Gulf of Mexico Program website (http://www.epa.gov/gmpo/about/facts.html#maritime), Lynch & Risotto (1985) and Melancon, Bongiovanni & Baud (2003).

the body. In order to have any effects GCs, like other steroids, must first pass through the cell wall. Once inside the cell nucleus, GCs bind with their receptor and they rewrite protein construction priorities (i.e., reprogram the expression of various genes). These revisions can persist long after high GCs levels have ceased circulating in the blood, thus long after the removal of the stressor. This persistence combined with the rapid activation of both the SNS and HPA axis responses means that many of the delayed and/or long-term consequences of stressor exposure are induced as a direct consequence of the initial perception of even a brief punctate stressor.

Effects of combining stressor types

The brain appears to classify threats as being processive (psychological) or systemic (physiological) in nature (see Deak, this issue). Psychological stressors include threats like predators, while physiological stressors include immediate and severe threats to physiological homeostasis, such as hypoglycemia (low blood sugar, specifically glucose). Importantly, some stressors appear to activate brain systems involved with both classes of stressors and it is these “compound” stressors that appear to produce the most direct outcomes for CNS functioning and overall health (see Deak, this issue).

Either exposure to a single very intense acute stressor, or the cumulative impact of numerous stressors across time, can ultimately lead to expression of sickness-like behavior, which is thought to be a symptom of neuroinflammation (Deak, this issue). For example, separation of a young guinea pig from its mother produces psychological stress (separation anxiety) and the offspring immediately begins to run around and vocalize. However, after an hour of exertion (physical stress), the young guinea pig stops that behavior, shuts it’s eyes, curls up and looks sick (Schiml-Webb, Deak, Greenlee, Maken & Hennessy, 2006). This response can be reversed by giving drugs with potent anti-inflammatory properties (Schiml-Webb, Deak, Greenlee, Maken & Hennessy, 2006). It is possible that the stress response and illness may have co-evolved as both are responses to threats (see Deak, this issue).

Normal aging is associated with greater expression of pro-inflammatory factors in the CNS (see Deak, this issue), so that risk of neuroinflammation increases with age. Repeated stressor exposure also leads to inflammatory responses as well as to accelerated aging as discussed above, creating an escalating combination of effects that can lead to increased incidence of neurodegenerative disorders and other critical problems that normally only arise later in life (see Deak, this issue).

Maladaptation of the stress response

Generally speaking, physiological responses to acute stressors promote survival in the face of diverse threats and are therefore viewed as being adaptive. Survival is promoted principally through a preferential re-allocation of resources (blood flow, glucose utilization, cognitive and sensory acuity, etc). The increase in catecholamines associated with the acute fight-or-flight response has distinct energetic and immune consequences for the individual. The effects of GCs are more prolonged in nature and probably evolved as a mechanism to sustain behavioral and physiological responding to stressors of longer duration. The transient expression of sickness-like behavior after stressor cessation probably represents an adaptive period of recuperation that is necessary to reinstate normal levels of cognitive and behavioral function to pre-stress levels (Deak, this issue). With prolonged or repeated stressor exposure, however, neuroinflammatory consequences of stress can become maladaptive, leading to compromised neuronal function, greater susceptibility to infection (Dhabhar & McEwen, 1997), and ultimately reduced reproductive fitness (see Deak, this issue).

Likewise, failure to mount a GC response can lead to the inability of the animal to continue to respond appropriately to a stressor, subsequently resulting in death (see Romero & Butler, this issue). This failure might be due to over-stimulation from either chronic or intense acute stressors that could have shutdown GC production through negative feedback, and possibly also depleted some of the various precursor molecules and biosynthetic enzymes necessary to produce the GC molecule. Alternatively, a prolonged response or exposure to a persistent stressor, such as pollutants, may have caused damage to the adrenocortical tissue where GCs are produced (Hontela, Rasmussen, Audet, & Chevalier, 1992; Martineau, this issue). Functional abnormalities of chronic stress are not restricted to GC effects. They can also result from catecholamines. For example, long-term activation of the fight-or-flight response across the life span can lead to coronary dysfunction and disease (see Romero & Butler, this issue), an effect that may involve vascular inflammation as an intermediate mechanism (Black, 2002, 2003).

In general, the physiological stress response and the consequences thereof described above are highly conserved between species, including fish, birds and mammals, although the exact basal levels of GCs and other stress hormones are fairly variable from one individual, population or species to another (see Deak, this issue; Martineau, this issue; Romero & Butler, this issue). However, not all stimuli are actually stressors. The distinction is largely a matter of perception by the animal/human. Experience immediately prior to a stimulus plays an important role in the nature and intensity of an animal’s response to that stimulus. For example, a very slowly increasing stimulus is easily acclimated to and only becomes a stressor once it exceeds some threshold. Similarly, the stress response is initiated only when events are worse than those expected by an animal (Levine, Goldman & Coover, 1972). Conversely, if a stimulus decreases in frequency or magnitude, the individual perceives an improvement in situation and the stress response will decline, even if the individual is still being subjected to an unpleasant stimulus. Complicating the matter further, the expectation of an unpleasant stimulus may in itself initiate the stress response. Furthermore, acute stressors that normally last a short time (such as predator attacks, dominance interactions and storms) may become chronic stressors if they occur often enough or persist.

Context is thus extremely important in the overall expression of a response to a potential stressor. Innumerable factors combine to form the context: environmental factors, such as season; recent history of incidence of the particular stimulus including intervals (i.e., prior experience); maturity, age, sex and other life history factors; inter- and intra-specific variation (genetic and propensity) including individual sensitivities, resilience and personality; condition (e.g., well-fed or hungry); other stressors currently acting upon an individual (e.g., infection, chemical exposure, etc.); predictability of stressor exposure; behavioral context (e.g., what the animal is doing when subjected to the stimuli); current psychological state (e.g., anxious, optimistic); and social structure.

Behavioral responses as an indicator for stress effects

While many of the above contextual factors may influence the onset and/or magnitude of a physiological stress response, the response itself is reasonably consistent once activated. However, an observed response does not necessarily reflect the magnitude of the impact actually experienced by the animal (Beale, this issue; Beale & Monaghan, 2004; Bejder, Samuels, Whitehead & Gales, 2006; Gill, Norris & Sutherland, 2001; Harrington & Veitch, 1992; Lusseau 2004; NMFS, 1996; Stillman & Goss-Custard 2002; Todd, Stevick, Lien, Marques & Ketten, 1996).

For instance, behavioral reactions may be influenced by the psychological state of the individual. All behavioral decisions (whether conscious or not) are the product of information processing systems within the animal’s brain. Stressors, including noise, and their associated emotional states, such as anxiety and depression, may influence this processing in a number of ways. First, anxiety is essentially an early warning system for the fight-or-flight response, and as such is associated with a suite of adaptive changes in cognition. Attention shifts towards awareness of possible threats and ambiguous information is interpreted more pessimistically (see Bateson this volume). These effects may be subtle and reversible, but may significantly affect the actions of an animal while they persist. For example, captive European starlings (*Sturnus vulgaris*) exposed to the stressor of being housed in barren cages may become more pessimistic and risk-averse in their interpretation of cues associated with food rewards. This pessimism is seen in a shift towards preferring safe foraging options, avoiding riskier but potentially more rewarding sites (Bateson & Matheson, 2007; Matheson, Asher & Bateson, 2008). Similar biases induced by other stressors could therefore result in changes in the spatial or temporal pattern of foraging behavior, with knock-on consequences for the fitness of the animals exposed. These changes in behavior also have the potential to place animals in situations where additional stressors could occur, such as food deprivation, or arrival in a novel environment due to avoidance efforts.

Physical condition can also influence behavioral responses. For example, well-fed animals may take fewer risks than their hungry counterparts, preferring a certain food reward over a more variable (i.e. risky) alternative (Caraco et al., 1990). Consequently, these individuals may also appear to be more sensitive to disruption, fleeing from a disturbance source at much greater distances. Conversely, a starving or sick animal may not display any observable response, as they may simply not be able to afford to react behaviorally: this is the only good feeding habitat in the area. Similarly, the well-fed animal may eventually be forced to return to its foraging ground when it becomes hungry, regardless of the potential threats. In this case, the change in behavior reflects a change in the physiological status of the animal.

However, such apparent increases in tolerance have often been used to argue that animals are “habituating” to the source and are thus no longer impacted by it (see below). On the contrary, any individuals (such as the hungry animal described above) remaining in a location in the face of potential danger may be subjected to one or more potential stressors. They may therefore display a number of physiological and epidemiological responses consistent with a stress response. For example, kittiwakes (*Rissa tridactyla*) in Scotland show an increase in heart rate in response to human disturbance. This cardiac reaction has been estimated to increase daily energy expenditure by around 7.5-10% for some individuals, despite a long history of exposure to disturbances in the area (see Beale, this issue). This increase in daily energy expenditure is sufficient to result in eventual abandonment of nesting attempts once energy reserves drop below a critical level.

In summary, a lack of behavioral response could be either because there is no stress felt, or because the animal can’t afford, or is not able, to respond overtly. Likewise, a strong behavioral response to a stressor, or a high level of observed response in a population, may mean that the stimulus is a particularly horrible stressor that is to be avoided at all costs, or it may imply that there is very little, if any, cost of responding to the stimulus, even though it may amount to no more than a minor irritation. Thus, given that animals make decisions (consciously or subconsciously) about how and/or whether or not to respond to a stimulus on the basis of their current context, this context must be known to biologists in order to accurately interpret the response intensity to a given stressor. As acquiring this knowledge is fraught with enormous difficulties in practice, it may not be possible at all to make such a determination simply from behavioral observations (see Beale, this issue). However, if such information is cautiously coupled with additional data (e.g., through the application of resource-use models), behavioral measures may allow the absolute minimum cost associated with responding to a stressor to be assessed (see Beale, this issue). Also, behavioral reactions observed in longitudinal studies can be, to some extent, placed in the context in which they occur (such as population abundance trends, residency patterns, season, etc.: e.g., Bejder et al., 2006; Lusseau 2005). These multi-scale approaches can also provide a framework to infer the synergistic costs of multiple stressors (natural and anthropogenic).

Likewise if the context in which decisions are made is not changed between two stressor exposures, behavioral measures can be used directly to measure the relative degree to which the stressors affect individuals (see Beale, this issue). However, maintaining similarity of context is challenging. Many factors, such as passing predators, changes in prey abundance and distribution (even on a very local scale), and recent experience of any and all other stressors, can be difficult to measure especially in the marine environment. If such experimental approaches are not feasible, these contextual factors need then to be included as model co-factors or accounted for in other ways. One exception occurs if the behavioral responses to a given type of stimulus remain great regardless of the context, which would indicate unambiguously that the species involved attempts to avoid that type of noise at all costs.

Acclimation

The term “habituation” is often used loosely to describe animals “getting used to” a stimulus, with various broad implications. However, “habituation” is often invoked without reference to the literature and seemingly in conflict with the use of the term in the biomedical or psychological literature (see Bejder et al., 2006). To avoid confusion, we shall use the term “acclimation” or “acclimatization”, meaning that an animal no longer produces a physiological stress response in reaction to a stimulus (Romero, 2004; Wright & Kuczaj, this issue and references therein). Animals can only truly acclimate in this way to stimuli that they perceive to be the same from one instance to the next, as well as non-life threatening (Romero, 2004; Wright & Kuczaj, this issue and references therein).

Acclimation is more likely to occur with frequently repeated, predictable exposures and can be lost if enough time passes between exposure events. This may explain why laboratory results for acclimation are more consistent than observations in the wild, as what appears to be repeated exposure in the “real world” may not be predictable or perceived as precisely the same by the animal. Chronic stimuli obviously meet the exposure frequency criteria required for an animal to acclimate, however animals may still lose acclimation if the exposure ends and there is enough time before the next exposure begins. The magnitude of exposure is also a consideration, because, in general, the greater the stress response initiated by a stressor, the less likely an animal is to acclimate to it, to the point where animals never acclimate to serious stressors.

In summary, animals will acclimate quicker to stimuli that are perceived to be smaller potential threats than those representing larger possible threats. However, acclimation only eliminates or reduces the stress response. It does not prevent other effects produced by a stimulus, such as hearing loss and masking that result from noise, as well as any stress response that these effects might subsequently induce. Similarly, acclimation also opens the possibility for sensitization, where the animal may produce an enhanced stress response when exposed to a new or different stressor.

Additionally, some uncertainties remain even within the narrower definition of “acclimation” as some humans can continue to perceive a noise as annoying or stressful without physiological responses or vice versa. Also, it’s not clear exactly how similar a sound must be for animals to cease to be able to tell them apart: e.g., different boats may sound very different.

Determining Cumulative Effects

We have already discussed above the potential for one stressor to influence the impacts of a subsequently applied stressor through the alteration of the context of exposure. Accurate prediction of all the potential cumulative and synergistic effects requires a reasonable knowledge of all the various contextual factors for each exposure and is thus not an easy proposition. However, at the most basic level it seems reasonable to conclude that the addition of new stressors is likely to increase the stress response, a concept that has some support in the literature (see review by Dallman & Bhatnagar, 2001).

The cumulative effects of multiple stressors can be estimated in this way through use of the concept of allostasis (see summary in Wright & Kuczaj, this issue; and discussion in Romero, 2004: Box 1 and references within), which suggests that all the various energetic demands that would be placed on an individual can be added up to see if that individual would be able to cope with them (i.e., maintain an allostatic load) or not (i.e., go into allostatic overload). Allostasis is currently a contentious idea in the biomedical world, a debate that goes beyond the scope of this paper. Suffice to say that the use of the concept of allostasis to investigate the cumulative effects of various stressors requires a working knowledge of the size of the energetic demands generated by each stimulus, which is clearly lacking for many species. This is not to say that energetic models cannot be useful in the management of the cumulative effects of various stressors on species where such data are limited, for example marine mammals (e.g., Lusseau, 2004). Rather energetic models are indicators of minimum possible energetic costs because of the various assumptions involved and the limited knowledge of the possible non-linear synergistic interactions between stressors.

Initial efforts to begin considering such non-linear synergistic interaction could be based on the two broad categories of stressors defined earlier, psychological, or processive, and physiological, or systemic, stressors. These categories should be considered because the simultaneous exposure to stressors belonging to each category increases the likelihood of having a severe impact on the individual. For instance, rats exposed to either simple restraint or hypoglycemic challenge show no evidence of neuroinflammation, while rats exposed to both challenges showed profound neuroinflammation (Deak, Bordner, McElderry, Bellamy, Barnum, & Blandino, 2005). Given that neuroinflammation may be a harbinger of adverse long-term health outcomes of stressor exposure, these data indicate that a categorically distinct, synergistic response can be provoked when otherwise innocuous events are combined. This may have profound implications for animals in captivity, which may be exposed to a wide variety of both physiological and psychological stressors such as confinement in a small environment, handling (especially in marine species, where handling is often accompanied with at least partial removal from water), and the noise and activities of the public, staff, and/or researchers.

Even if both the different types of stressors and their cumulative energetic demands are accounted for, it may still not be possible to predict the overall effect of multiple stressors on an individual because lab-based studies have shown that multiple stressors interact in unpredictable ways to alter GC release, either increasing or decreasing circulating GC levels (see Dallman & Bhatnagar, 2001). Context or the influence of context may also vary unpredictably. Consequently, efforts to determine cumulative and synergistic effects of multiple stressors on animals, though important to pursue, should be undertaken cautiously.

Noise-Induced Stress Responses

Some of the known effects of noise in animals include audiogenic seizures and increases in serum cholesterol levels (Clough, 1982), intestinal inflammation (Baldwin, Primeau, & Johnson, 2006), and increased adrenal weights due to overproduction of adrenal hormones caused by a prolonged stress response (Ulrich-Lai, et al., 2006). Stress responses induced by loud or sharp noises have even lead to cannibalism of neonates, as well as a generally decreased reproductive performance in mice (Michael Rand, pers. comm.).

The stress response with its various effects and impacts has been studied to some extent in rats and humans exposed to noise. For example, laboratory rats exposed daily to short periods of white noise exhibited a variety of conditions consistent with the onset of a physiological stress response after around 2 weeks, becoming more pronounced at 3 weeks (Baldwin, this issue). These conditions included inflammation of the intestinal mucosa and the mesenteric microvessels, degranulation of mast cells in the intestinal mucosa, migration of eosinophils into the wall of the intestine, and oxidative damage. Additionally, exposed rats groomed excessively and had redness around eyes and neck. After a recovery period of 3 weeks, the noise-exposed rats displayed some characteristics similar to unexposed controls, but other characteristics remained similar to pre-recovery conditions, indicating that some pathological effects continued to persist even after removing the noise exposure (Baldwin, this issue).

In humans, noise causes a number of predictable short-term physiological responses such as changes in hormone levels. However, little is known about how these might combine to have long-term consequences on health (see Clark & Stansfeld, this issue). Furthermore, specific evidence of chronic noise effects on adrenaline, noradrenaline and cortisol levels in humans is weak and inconclusive, suffering from various experimental difficulties (see Clark & Stansfeld, this issue). However, there is stronger evidence for a positive association between chronic noise exposure and both hypertension (i.e., raised blood pressure) and coronary heart disease (CHD), including some significant increases in myocardial infarction (i.e., heart attacks) associated with exposure to occupational, road traffic and aircraft noise.

There are indications that some of these effects on health may be mediated through annoyance, itself a psychological stressor (see Clark & Stansfeld, this issue). In addition, noise exposure (or the annoyance it causes) has been associated with increased reporting of psychological and somatic symptoms in affected populations, but not with more serious clinically diagnosable psychiatric disorders such as anxiety and depressive disorders. This suggests that noise is probably not associated with serious psychological illness, but may affect well-being and quality of life (see Clark & Stansfeld, this issue). However, there have been no longitudinal studies in this area.

Noise may disturb sleep in humans as well, which may in turn have consequences for performance, mood and health. However, it appears that, with regards to sleep disturbance, naïve exposure (i.e., no prior experience) is a very important factor. Regardless of the mechanisms involved, these various effects may contribute to the increase in mortality observed in one study of industrial noise, with additional job-related stressors potentially acting cumulatively with the noise (see Clark & Stansfeld, this issue).

The greater expression of noise-related impacts in workers with higher job-related stressors is one example of the importance of contextual factors and cumulative exposure on the strength of response and ultimate outcomes from exposure to noise or any other stressor. Various other contextual factors are also important in humans in ways that are similar to the influence of prior experience on the physiological stress response of animals (see Clark & Stansfeld, this issue). For example, individuals with poor psychological health prior to exposure to noise reported greater annoyance (Tarnopolsky, Barker, Wiggins, & McLean, 1978), showing that individual psychological traits determine how annoying noise is.

Children may be more vulnerable to the effects of environmental stress as they have less cognitive capacity to understand and anticipate environmental stressors, in addition to lacking well-developed coping repertoires (Stansfeld, Haines, & Brown, 2000). Studies have consistently found that chronic noise negatively affects children's learning and cognitive abilities, and are beginning to indicate an effect on hyperactivity, although evidence for an increase in psychological symptoms is mixed and inconclusive (see Clark & Stansfeld, this issue). Recovery of some of these deficits may be possible if noise exposure ends, but noise could potentially impair child development, resulting in lifelong effects on both educational attainment and health. Longer exposures are known to cause larger and more persistent effects on physical health and are also likely to generate larger cognitive deficits and bigger effects on psychological health (see Clark and Stansfeld, this issue). Furthermore, the consequences for educational attainment are more likely to be long-lived or permanent if exposure overlaps with the closure of any learning window or opportunity (e.g., until a child leaves school).

Acclimation to noise

Given the above considerations on acclimation to stressors in general, apparent behavioral tolerance of noise cannot be automatically interpreted as true physiological acclimation. Instead, apparent behavioral tolerance could be the result of different contexts, such as an overwhelming need for an individual or a population to remain in the area, the absence of alternative habitats, the prohibitive costs associated with avoidance, or even that the animal might already have reduced hearing at the frequencies of the stimuli. Learning alone (i.e., without an associated reduction in physiological response) might also simulate acclimation to noise. In addition to the above mechanisms, an apparent increase in behavioral tolerance at the population level can arise if the most sensitive animals in the population have already left the area (e.g., Bejder, Samuels, Whitehead, & Gales, 2006). One other possibility is that rapid "natural" selection may have taken place, through the death of either the most sensitive individuals and/or the ones that are most prone to maladaptive alarm/escape responses (for some possible examples of these in marine mammals see Wright et al., this issue, b). The possible long-term costs and benefits of behavioral tolerance as a result of any of these mechanisms are unknown, although the action of either selection or emigration will clearly reduce the number of animals in the local population.

If an animal spends a considerable amount of time reacting to human disturbance, it may be fatigued and not willing or able to evade a potential threat and thus may appear to have acclimated when in fact it has not. Likewise, the apparently quick development of tolerance to disturbances in humans (e.g., aircraft noise in most people sleeping near airports) may not translate into free-ranging animals because animals must remain aware of predators, while humans in contrast are largely spared threats of this kind. Humans also benefit from prior knowledge that the noises can be reliably associated with passing aircraft or road traffic and that these things are unlikely to indicate an imminent threat.

The matter is complicated further still by the concept of "tuning out", a type of filter for chronic, but changing, noise as is seen in humans (see Clark & Stansfeld, this issue). Consider that many patrons in a bustling restaurant largely filter out the general noise of employee activity and the conversations of other diners. This filtering does not prevent other effects, such as masking and hearing loss. Furthermore, it is not clear how much people or animals might perceive the noise as changing. For example, many of the abovementioned diners would look up if they hear a waiter breaking a plate or a glass.

Masking, psychology and behavior

Acoustic signals become ambiguous when they are hard to discriminate from other sounds. Increased environmental noise thus augments the ambiguity of incoming information by either reducing hearing capacity through hearing damage (temporary or permanent) or through masking by increasing background noise levels. Hearing damage persists after exposure (even if only temporarily) and affected animals can do little to compensate for the loss during that time. On the other hand, animals can employ several strategies to limit the ambiguity created by masking (see Bateson, this issue).

One option, physical avoidance, is to leave the noisy area for somewhere quieter. Avoidance strategies are not likely to be feasible for the majority of chronic or high-incidence noises. This is especially true for marine life exposed to ambient noise generated by shipping, which dominates background noise at low frequencies in many of the world's oceans, particularly in the northern hemisphere.

A second option, available if noise is not continuous, is to cease communicating during periods when noise levels are highest. For example, urban European robins (*Erithacus rubecula*) switch to nocturnal singing in areas with high daytime noise (Fuller, Warren & Gaston, 2007). However, such evasive behaviors could again place animals in situations where they will encounter new stressors. In the above example, nocturnal singing could lead to an increased risk of predation by exposure to, or attraction of, nocturnal predators. In any case, temporal and special avoidance strategies can only be employed if the temporal distribution of the noise is predictable.

A third tactic available to animals is to change one or more characteristics of their acoustic signals, such as length, frequency, amplitude, or other acoustic features, to increase their transmission probability in a noisy environment. Beluga whales (*Delphinapterus leucas*) for instance can increase the amplitude of their signals in response to increasing background noise, a response known as the Lombard effect (Scheifele, Andrew, Cooper, Darre, Musiek, & Max, 2005). Humans speaking loudly in noisy situations are employing this option, but will eventually become hoarse and may temporarily lose their voice. It is not known what kind of consequences long-term use of signal-change strategies may have for animals, however increasing the amplitude of a sound uses more energy and therefore carries some additional cost.

The fundamental ability of an animal to actually alter its signals may also be limited, physiologically, anatomically, or by age. Many songbirds, such as the chaffinch (*Fringilla coelebs*), have a narrow window of time in early life in which their brains are particularly receptive to acquisition of new vocal patterns such as song. A few species, such as mockingbirds (*Mimidae*) and European starlings, continue to learn new vocal patterns after this period, while other singers show only limited variation from the parental song after early learning (for a review see Catchpole & Slater, 1995). Similarly, there are indications that bottlenose dolphins (*Tursiops truncatus*) may be able to learn at any time (e.g., Watwood, Owen, Tyack, & Wells, 2005) and male humpback whales (*Megaptera novaeangliae*) are known to change their songs repeatedly throughout their lives (see Noad, Cato, Bryden, Jenner & Jenner, 2000; Payne, Tyack, & Payne, 1983). However, very little is known about the abilities of most other marine species, especially marine mammals that use low frequencies, to acquire new vocal patterns throughout their lifetimes.

In any case, while altered signals may propagate further or be more distinct in the face of increases in ambient noise than unaltered ones, the potential usefulness of signal alteration is limited by the extent to which signals continue to be recognized by the intended receiver. This is especially important when the calls are involved in species recognition, perhaps for mating or maintaining social structure, which may further reduce the extent that these calls can be changed. Alteration of signals may also be problematic in species that communicate over long distances (such as mysticetes – baleen whales), because two animals may be subjected to very different ambient noise profiles. This means that the optimum signaling strategy in the immediate acoustic environment of the signaler may be very different from the best option given the noise profile in the immediate area of the signal receiver.

Signal alterations are also not an option for animals that hunt using passive acoustics (i.e., eaves-dropping on their prey). Consequently, there will be many occasions when the only option available to an animal will be to alter its responses to incoming sounds. For example, animals can alter their thresholds for responding to incoming sounds that they receive, be they communication signals or sounds made incidentally by prey, predators, or con-specifics (see Bateson, this issue). If increases in masking noise make it harder to discriminate important signals from other irrelevant sounds, then animals may adapt to this situation in different ways, including:

1) Lowering their threshold for a sound to be identified as a particular type of signal, thus increasing their probability of falsely identifying signals as related to mates, prey and/or predators. Possible results include chasing after objects or organisms that are neither prey nor a mate, or fleeing from things that are not a predator (or other threat). This has consequences in terms of increased energetic costs.
2) Increasing their threshold for a sound to be identified as a particular type of signal, thus decreasing their probability of identifying a signal related to a mate, prey and/or a predator. Possible results include increased missed opportunity costs (e.g., passing up on possible prey and potential mates) or increasing the risk of predation if predators are missed.

In summary, animals have a range of options available for mitigating the adverse effects of environmental noise on their use of acoustic information. However, it is important to assess the potential fitness costs of any observed adaptation. Costs may arise from increased energetic expenditure, increased risk of predation, or lost opportunities for feeding or mating. All of these sources of cost could potentially be associated with increased risks of a physiological stress response occurring as animals struggle to adapt to function in a noisy environment.

Management Issues

The stress effects from noise that are of the greatest interest to managers are those that ultimately have consequences for survival and fecundity rates (*vital rates*). Population level impacts are potentially catastrophic but highly uncertain, providing some grounds for a precautionary approach. However, as uncertainty is pervasive in ecology and conservation management, various tools have been developed that attempt to characterize and deal with such uncertainty in decision making processes (see Wintle, this issue). In particular, adaptive management and Bayesian modeling approaches offer some promise (see below and Wintle, this issue).

Management under uncertainty: A general framework

Adaptive management can be loosely defined as management with a plan for learning (Wintle, this issue). The sequential actions in the process of adaptive management should have the dual purpose of achieving management goals and facilitating learning about both the system under management and the relative performance of management actions. Effective adaptive management requires simultaneous implementation of multiple competing hypotheses and/or management actions that are iteratively updated through concurrent assessment and evaluation with monitoring data. Hypothesis generation and modeling may be based on existing data and/or expert opinion.

Adaptive management is appealing as it explicitly acknowledges that the decision being made is subject to uncertainty and may change in the next time step depending on what is discovered (i.e., learned) in the intervening period. Notably, the completion of an experiment is not required before a change to management can be instituted. This allows a more rapid response that is particularly well suited for managing systems in which changes take a long time to become apparent.

Population modeling and scenario analysis

Adaptive management of anthropogenic impacts on any species requires the construction of a model (or competing models) of species' responses to those impacts and any management intervention. Population models have been used in both terrestrial and marine systems to evaluate the long-term population consequences of competing management options (Akçakaya, Radeloff, Mladenoff & He, 2004; Taylor & Plater, 2001; Wade, 1998; Wintle, Bekessy, Pearce, Veneir, & Chisholm, 2005). Predictions of population models must be treated with caution as most population models require numerous assumptions and are themselves subject to substantial uncertainty. Despite the prevalence of uncertainty, modeling may be useful in challenging stakeholders and managers to clearly state their belief about species population dynamics and the magnitude and mechanisms of anthropogenic impacts. Models represent testable hypotheses that may be improved and updated as new data or knowledge comes to hand. As data are gathered, updated models may begin to provide predictions that are more broadly trusted by managers and stakeholders. In data-poor situations, it is important to make the most of available expertise or "collateral" data.

Bayesian approaches to inference

It is not easy or cheap to collect ecological data and definitive results are rare. Bayesian inference provides a coherent approach to synthesizing and making the most of disparate ecological data and/or expert opinion. McCarthy (2007 and summarized in Wintle, this issue) utilized a novel Bayesian approach to estimate the mortality rate of powerful owls (*Ninox strenua*) by combining very sparse observation data with predictions from a regression of body mass on mortality rate data for a range of other raptors. This approach provides a sound template for analyses of other species that are characteristically difficult to study, including marine mammals. Expert opinion can (and should) be used in ecological studies, however it is very important that it is integrated in analyses appropriately (see Martin, Kuhnert, Mengersen, & Possingham, 2005 and McCarthy, 2007 on soliciting subjective priors for Bayesian estimates).

Once parameters have been estimated, population models may then be used to evaluate the long-term population consequences of competing management options (Akçakaya, Radeloff, Mladenoff, & He, 2004; Wintle, Bekessy, Pearce, Veneir, & Chisholm, 2005). However, any predictions arising from such a model would, at first, be compromised by substantial uncertainty in the parameter estimates. To address this, sensitivity analyses should be undertaken to identify the parameters and assumptions in the model that most strongly affect its predictions. These assumptions should then become the focus for adaptive management plans for learning.

Conclusions

It is clear that the debate surrounding physiological stress responses, behavior, welfare and anthropogenic noise are going to continue for some time. To provide some focus we offer the following points as particularly noteworthy findings and recommend that scientists and managers take them into consideration when planning research and in assessments of environmental impact of noise.

1. Noise can act as a stressor. A single source of noise can result in a range of interwoven stressors. The various potential impacts of signal masking by noise illustrate this. The cascade of interwoven stressors that can be triggered by noise and masking includes separation anxiety, anxiety arising from ambiguous information, and hypoglycemia from loss of foraging opportunities, which can all in turn lead to other consequences as discussed earlier. Even when the noise itself may not lead directly to effects arising from the stress response, animals may create their own stressors through maladaptive efforts to avoid the noise. Similarly, physical injuries resulting from noise exposure may also act as additional stressors.

2. Short-term stress responses cannot be presumed to have only short-term consequences, especially when considering cumulative effects.

3. There is great potential for synergistic effects to arise through exposure of an animal to noise cumulatively with other stressors.

4. Context, especially the predictability of the stimulus and available response choices, is a very important (and possibly the most important) factor in mediating the overall stress response. For example, very young animals and fetuses are likely to be particularly susceptible to stressors, due to the effects of stress hormones on the developing brain. Thus, while

single or infrequent exposures alone may not produce long-term effects in adults, they may produce long-term consequences in young, still-developing animals. Unfortunately, such impacts will be very hard to detect in wild animals, especially in species that are hard to observe constantly, such as marine mammals.

5. It is impossible to determine the physiological and psychological responses of an animal to a stressor based on behavioral observations alone. Changes in an individual animal's behavior (or lack thereof) cannot be related to actual physiological and psychological impact without extensive investigation of the context. Behavioral changes in context are best understood and controlled in captive situations where exposure rates, environmental conditions and other factors are documented over long periods of time. However, the extrapolation of results from captive animals to the responses of wild animals should be done very cautiously given the large contextual differences (i.e., captivity and training vs. wild and free ranging) and the potential for high ambient noise levels to alter the baseline in the captive environment. Such contextual information is not generally available when assessing the possible correlations between acoustic stimuli and behavioral change in the wild. Collecting this information presents a considerable challenge, especially in the marine environment, although it is not impossible. Impact assessment studies need to specifically incorporate long-term and large-scale contextual information in their experimental design. Current short-term studies are generally failing to correctly assess the impacts of noise. Studies that have incorporated contextual information have led to a better understanding of disturbance impacts in other human-wildlife interactions. Without such contextual information it cannot be assumed that lack of a behavioral response means that no physiological stress response has occurred, or conversely that a behavioral response indicates the occurrence of a physiological stress response. In the latter case there may still be negative consequences for the animal if the behavioral response is maladaptive, involves a detrimental increase in energetic expenditure or exposes it to other threats.

6. By definition, acclimation requires consistency between non-severe repetitive exposures (including context) to sounds that are (near-) identical as perceived by the receiver. Conversely, repetitive exposure to different types of sounds (in frequency, intensity and other acoustic characteristics) cannot result in acclimation. Furthermore, animals cannot and will never acclimate to (contextually) severe stressors as these always, by definition, represent a threat. These reasons probably explain why few studies have shown acclimation occurring in the wild. Therefore, it should be assumed that animals have not acclimated to a sound, until proven otherwise. Although humans might be able to "tune out" more generalized noise sources such as road noise, health effects of exposure to such noise can

still arise (see Clark & Stansfeld, this issue). Tuning out can have its own detrimental consequences as individuals may over-generalize that ability to other sources, which may result in that individual ignoring sounds that are important to them, such as those produced by a predator.

7. While physiological acclimation to noise in the wild appears likely to be uncommon, it is clear that many animals have the capacity to learn to react behaviorally in a specific way to a generalized set of sounds. For instance, a whale might learn not to react behaviorally to noise from all types of engines because they are have proven to be non-threatening to date. As the specific repeated experience required to induce physiological acclimation has not occurred, the whale may still initiate a stress-response to the sounds of a passing ship, priming the animal to react in the case that this particular noise is different. To date, however, the evidence that non-human animals have genuinely learned to reduce or eliminate behavioral responses to human disturbance is largely anecdotal. Regardless, generalized learning may also explain similar reductions in behavioral responsiveness to a given stressor at the population level. However, it is difficult to separate the action of such learning from a number of other possible mechanisms, including the mortality or displacement of the most susceptible individuals, gradual changes in the context in which a population find itself, and selection for adaptive responses occurring over several generations.

8. The considerable effects of relatively short periods of noise in the lab must be taken into consideration when interpreting the results of experiments undertaken with animals in captivity (see Baldwin, this issue). Most animals in captivity will have been exposed to relatively high levels of noise on a regular basis, due to feeding or other husbandry activities, machinery noise or other general facility operations. These effects, in addition to the increased sensitivity of developing brains to the effects of GCs, may partially explain why attempts to breed some animal species in captivity have not been successful.

9. Epidemiological studies in humans have been more consistent in demonstrating effects of noise on health and psychological wellbeing than on the physiological stress response. This might be explained if the epidemiological effects arise from cumulative effects over a long timeframe. Also, inconsistencies in the studies of the human physiological stress response to noise exposure may be due to (unknown) contextual elements that have not been accounted for.

10. Managing the impacts of noise on animal populations is likely to require an adaptive strategy to address the substantial uncertainties arising from a poorly understood stressor, especially in data-poor species such as many marine mammals. In situations of severe uncertainty, models can be useful

decision tools, not only because they make assumptions explicit, but also as they allow the stakeholders to explore the importance of those various assumptions. Adaptive management of noise impacts should be accompanied by well-planned long-term studies that address key uncertainties about the population level impacts of noise on the species concerned. Careful extrapolation of data from other species using appropriate analytical methods may provide a basis for developing actions to reduce noise impacts. Such actions would be refined as better, species-specific data come to hand.

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Do Marine Mammals Experience Stress Related to Anthropogenic Noise?

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Sound travels much further than light in the marine environment. As a result, marine mammals, especially cetaceans, rely heavily on sound for many important life functions, including breeding and foraging. This reliance on sound means it is quite likely that exposure to noise will have some detrimental effects on these life functions. However, there has been little application to marine mammals of the knowledge available in other species of stress responses to noise and other stressors. In this paper we begin to integrate what is known about marine mammals with the current knowledge gained in terrestrial mammals about stress physiology, specifically considering physiological and psychological context and thus also cumulative and synergistic impacts. We determined that it is reasonable to extrapolate information regarding stress responses in other species to marine mammals, because these responses are highly conserved among all species in which they have been examined to date. As a result, we determined that noise acts as a stressor to marine mammals. Furthermore, given that marine mammals will likely respond in a manner consistent with other species studied, repeated and prolonged exposures to stressors (including or induced by noise) will be problematic for marine mammals of all ages. A range of issues may arise from the extended stress response including, but not limited to, suppression of reproduction (physiologically and behaviorally), accelerated aging and sickness-like symptoms. We also determined that interpretation of a reduction in behavioral responses to noise as acclimation will be a mistake in many situations, as alternative reasons for the observed results are much more likely. We recommend that research be conducted on both stress responses and life-history consequences of noise exposure in marine mammals, while emphasizing that very careful study designs will be required. We also recommend that managers incorporate the findings presented here in decisions regarding activities that expose marine mammals to noise. In particular, the effects of cumulative and synergistic responses to stressors can be very important and should not be dismissed lightly.

As sound travels much better than light in the ocean (Urick, 1983) many marine animals, including marine mammals, use sound instead of light to gain information about their environment (Popper, 2003; Richardson, Greene, Malme & Thomson, 1995; Tyack & Miller, 2002). Cetaceans (whales, dolphins and porpoises) in particular are heavily dependent on sound to find food, communicate (including for reproduction), detect predators and navigate. Increasing mechanized use of the sea, such as for shipping, military activities, oil and gas exploration, and recreation (including cruises and pleasure boating), is increasing the amount of noise that humans introduce into the oceans, sometimes over very large distances (for details and discussion, see Hatch & Wright, this issue).

As cetaceans (as well as other marine mammals) are primarily acoustic animals, it appears likely that they will suffer more from exposure to noise than other species, including rats and humans - both species for which there is some information available about the consequences of noise exposure. It is reasonable to assume that marine mammals' reliance on sound has led to the evolution of a number of adaptive mechanisms to deal with natural noise, but whether those mechanisms are sufficient to compensate for the comparatively recent advent of anthropogenic ocean noise is uncertain (see Bateson, this issue; Weilgart, this issue). For example, cetaceans may have developed various strategies that are better than those employed by terrestrial species at averting or handling the problems created by masking (i.e., the drowning out of a signal of interest by noise). Regardless, their ability to cope with noise will still have limits. Indeed, anthropogenic underwater noise is a novel environmental element for marine mammals and some species have been exposed to it for only one generation (e.g., bowhead whale, *Balaena mysticetus*). This is a very short period in terms of evolutionary time, making it very unlikely that any marine mammals have developed appropriate coping mechanisms (Rabin & Greene, 2002).

Here we attempt to increase our understanding of the effects of sound on marine mammals through the application of the current state of knowledge about noise, physiological stress and the influence of context, as outlined in Wright et al. (this issue, a) and detailed further in the other papers in this issue. Wright et al. (this issue, a) and the references therein should thus be considered the source for information included in this document unless other sources are cited. Working definitions for the terminology related to 'stress' are provided by Wright & Kuczaj (this issue).

Review of known effects of noise in marine mammals

Marine mammals have demonstrated various responses to specific noise exposures ranging from changes in their vocalizations (shifts in frequency, becoming silent, etc.) and displacement or avoidance (including shifting their migration paths) through alterations in their diving, swim speed, respiration or foraging behavior, to hearing damage and strandings (see Appendix 1). Weilgart (this issue) provides a summary of the known effects and the references therein offer additional details.

Hearing damage is not discussed here, as this is not a result of a noise-induced stress response. However, it should be noted that ear damage and other physical injuries would, if not immediately fatal, act as a variety of stimuli/stressors in their own right, each with the potential for producing a stress response. Thus, sound may generate both auditorily-mediated (i.e., heard) stimuli/stressors and non-auditory (i.e., those not directly resulting from sound perception through the ear) stimuli/stressors.

Noise and Stress in Marine Mammals

Two studies to date have investigated the physiological stress response to noise in captive marine mammals. Thomas, Kastelein & Awbrey (1990) exposed four captive beluga whales (*Delphinapterus leucas*) to playbacks of drilling noise but found no changes in blood adrenaline and norarenaline ("stress hormones", also known as epinephrine and norepinephrine) levels measured immediately after playbacks. Romano et al. (2004) exposed captive bottlenose dolphins (*Tursiops truncatus*) and a beluga whale to sounds from a seismic water gun and (for the bottlenose dolphins only) 1 s, 3 kHz pure tones and observed detrimental changes in some of the various hormones in the blood (for more details, also see Weilgart, this issue). However, the small sample sizes of these studies, their use of captive animals and other technical limitations mean that extrapolation of their results to wild animals should be done with caution (as recommended by Thomas, Kastelein & Awbrey, 1990). Additionally, there may have been some level of response to background noise levels that were not accounted for in the baseline measurements (see Baldwin, this issue).

It should also be noted that the epidemiological studies undertaken in humans examining physiological effects such as hypertension and coronary heart disease have been more consistent and conclusive than those considering the various stress hormones (see Clark & Stansfeld, this issue). Accordingly, it appears to be possible for noise to cause effects consistent with prolonged exposure to a stressor, such as hypertension and coronary heart disease, without necessarily displaying a consistent increase in stress hormones, such as glucocorticoids (GCs), and other metrics.

Three specific examples of the effects of sound on marine mammals are considered here in greater detail: the stranding of beaked whales (*Ziphiidae*) in association with military sonar exercises; the effects of shipping noise on beaked whale foraging and communication; and the various effects on the energy budget of odontocetes (toothed cetaceans) from disturbance due to whalewatching activities. Disruptions caused by whalewatching are likely to result from a combination of the actual presence of the whalewatching vessels as well as their noise. However, the effects of whalewatching and those of noise from moderately distant shipping are similar in many respects (see Lusseau & Bejder, this issue; Weilgart, this issue), suggesting that noise is probably the predominant source of impact of whalewatching. Furthermore, playback experiments have demonstrated that vessel noise alone can elicit responses in at least some species (e.g., manatees, *Trichechus manatus*: Miksis-Olds, Donaghay, Miller, Tyack & Reynolds, 2007).

Beaked whale strandings

Beaked whales have repeatedly mass-stranded a few hours to days after naval maneuvers during which military ships used midrange frequency sonar (Fernandez et al., 2005; Hildebrand, 2005)[1]. These whales were consistently affected by a new syndrome, never described in marine mammals prior to these events, consisting of extensive fat and gas bubble emboli: an ensemble of lesions most similar to decompression sickness in human divers (Fernández et al., 2005; Jepson et al., 2003). It is clear that the severity of emboli is the direct cause of death and that the constant temporal and spatial coincidence with naval exercises involving sonar designates these exercises as the cause of this new syndrome (Fernandez et al., 2005; Hildebrand, 2005). Recent studies have qualified beaked whales as the deepest diving mammals (down to 1.8 km: Tyack, Johnson, Aguilar Soto, Sturlese & Madsen, 2006) and have shown that these animals typically

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[1] With regards to the debate over the frequency of strandings coincident with such activities, it should be noted that the discovery of just one dead body from a wild population is widely accepted in terrestrial biology to be always indicative of a wider problem, as it is easy to miss carcasses (p14-15 in Wobeser, 1994). This is likely to be even more true with marine mammals, where dead animals can be quickly scavenged upon, carried away by strong currents, or sink beneath the waves if they float at all. Deep diving marine mammals, such as beaked whales, that die at depth may be prevented from rising to the surface at all due to inhibition of decay-induced floating by the increased hydrostatic pressure (Allison, Smith, Kukert, Deming & Bennett, 1991). There are also fewer potential observers that are much more widely scattered than in terrestrial environments.

(although not always) follow a highly stereotyped diving pattern. This pattern consists of a deep dive followed by progressively shallower dives, apparently similar to the decompression stops used by human divers to avoid decompression sickness, although this is not necessarily their function (Tyack et al., 2006). Tyack et al. (2006) instead argued that the collapse of the whales' lungs at depth alleviates the need for such decompression dives.

In either case, behavioral disturbances, such as a startle or flight response, that disturb this highly stereotyped diving pattern, may overwhelm or circumvent the normal nitrogen buffering physiology of beaked whales and trigger the formation of nitrogen bubbles (i.e., 'the bends'), with the ultimate outcome being death from gas embolism and/or hemorrhage (see Cox et al., 2006; Tyack et al., 2006). While this remains the predominant theory, the physiological processes by which it occurs are still unknown (Cox et al., 2006) and other causes of death have also been suggested (see review by Rommel et al., 2006). For example, it has been hypothesized that instead of or in addition to indirect action via behavior disturbance, the navy maneuvers may directly induce the formation of nitrogen bubbles through a process termed "rectified diffusion" (Crum & Mao, 1996; Houser, Howard & Ridgway, 2001).

Additional support for the flight hypothesis is found in the similar response to novel sounds observed in other cetacean species. For example, Nowacek, Johnson & Tyack (2004) exposed foraging North Atlantic right whales (*Eubalaena glacialis*) tagged with a Digital Acoustic Recording Tag (DTag: Johnson & Tyack, 2003) to vessel noise, whale social sounds, silence, and a synthetic signal designed to alert the whales to the presence of vessels and thus reduce ship-strikes. Five out of six whales exposed to the alert signal responded by abandoning their foraging dive prematurely and executing a shallow-angled, high power (i.e., significantly increased fluke stroke rate) ascent and continued to swim at shallow depths, surfacing only to breathe, for the duration of the exposure: an abnormally long surface interval. This response was elicited by alarm sounds at received levels as low as 133 to 148 dB re 1 µPa at 1000 Hz. None of the whales exposed to ship noise playbacks responded at all.

There is also some indication that a stress response may be at least partly involved in reactions of beaked whales to military exercises involving sonar. Intracellular globules composed of acute phase protein have been found in the cells of six out of eight livers examined from beaked whales stranded in association with such exercises (tissue decay prevented detailed examination in nine others; Godinho/Fernandez, unpublished data). The globules are also found in the cytoplasm of hepatocytes in a range of examined cetacean species that stranded for many different reasons, including animals that are known to have died in 'very stressing' circumstances (e.g., anthropogenic interactions, such as bycatch; pathologies; or heat shock; Godinho et al., 2005). For example, globules have been seen in 26 of the 27 livers examined from bycaught harbor porpoises (*Phocoena phocoena*) in one study, with the only negative result being a neonate, possibly because of its immature metabolism (Godinho et al., 2006). Furthermore, only 7 of the other 11 examined porpoises that stranded for other or unknown reasons were positive (Godinho et al., 2007; Godinho, unpublished data). It is acknowledged that live stranding itself is also likely to be an intense stressor.

The mechanism for the accumulation of acute phase proteins and the function that they have in the organism are not clear and there are various theories. For example, one hypothesis is that the vascular compromise (e.g., resulting from live-stranding) leads to acute liver congestion, which has been observed in 17 different cetacean species, that could in turn prevent the proteins from leaving the cell, where they thus accumulate and the globules are formed (Godinho et al., 2005; Godinho/Fernandez, unpublished data). However, for reasons not yet known, the globules in the above study vary both within and between species, as shown by electron microscopy and inmumohistochemistry (Godinho et al., 2007).

Hypoxia may also become a compounding issue for any marine mammal exposed to a stressor at depth, because oxygen consumption increases dramatically with increased heart rate as a result of release of catecholamines (adrenalin/epinephrine and noradrenalin/norepinephrine) through activation of the sympathetic nervous system (SNS: see Deak, this issue, Romero & Butler, this issue). The increase in heart rate is usually associated with a corresponding increase in respiration; however this is not possible at depth. This additional oxygen demand during pronounced SNS activation could therefore be particularly problematic for deep divers that are already living right on the physiological edge. Beaked whales are thought to be diving beyond their aerobic limits (Tyack et al., 2006; Aguilar Soto et al., 2006) so additional oxygen demands could force them to cut their dives short. Regardless, the combination of a psychological stressor (extreme noise that is perceived as threatening) with a more direct physiological stressor (fat and gas emboli or hypoxia) may have some potentially deleterious consequences (see Deak, this issue). Such a combination may have contributed to beaked whale deaths recorded in the mass strandings or unobserved at sea, as well as negatively affecting the health and fecundity of survivors of the events.

Although it is possible that a stress response contributed directly in some way to the lethal consequences resulting from exposure of beaked whales to military exercises involving sonar, it remains most likely that the fatalities resulted from the whales' flight response. In understanding this subtle difference, it is useful to consider the three successive stages of adaptation to insult (i.e., a stressor) presented by Selye (1946): alarm reaction; stage of resistance; and stage of exhaustion. An animal may respond at the very initial stages of a stress response (alarm) by fleeing (i.e., flight arising from the SNS response). If this action removes the animal from exposure to the stimulus then it may only lead to a short GC response (resistance), if any at all (see Deak this issue, Romero & Butler, this issue). However, if the flight response is lethally mal-adaptive, as appears to be the case with beaked whales and military sonar exercises, the exposure may still result in death, just not as a consequence of 'stress' *per se* (as in 'chronic stress' – exhaustion). It might also be possible that flight responses are increased if a stimulus is not only psychological, but also noxious (i.e., painful) by the direct effect of the noise pressure on the tissues and/or ear.

Shipping and masking of signals of importance for cetaceans

Shipping is most likely the main overall source of man-made noise in the marine environment (NRC, 1994, 2003) and masking has been identified as the primary auditory effect of vessel noise on marine animals (Southall, 2005). Most concern on this subject has traditionally focused on mysticetes (baleen whales), which communicate at the low frequencies typically associated with shipping noise (e.g., Payne & Webb, 1971). Consequently, it is noteworthy that ambient noise levels in the deep ocean at low frequencies have increased by 10-15 dB over the past 50 years due to motorized shipping (see Hatch & Wright, this issue, a and references therein). However, there is increasing evidence that modern ship noise can reach higher frequencies (e.g., up to 30 kHz: Arveson & Venditis, 2000; up to 44.8 kHz: Aguilar Soto et al., 2006) at distances of at least 700 m (Aguilar Soto et al., 2006). For example, there is a recording of a passing vessel on a DTag attached by suction cups to a Cuvier's beaked whale (*Ziphius cavirostris*) that demonstrates clearly that ship noise can mask ultrasonic vocalizations of odontocetes (Aguilar Soto et al., 2006). The high-frequency components of shipping noise may also be increasing due to the trend toward faster ships (Southall, 2005), because broadband cavitation noise (including the higher frequencies) generally increases with vessel speed (Arveson & Venditis, 2000).

Masking predominantly results from noise at similar frequencies to the signals of interest, although there may be some masking effects from "out-of-band" frequencies. Considering only in-band masking, the measured increase of up to 15 dB in low frequency noise due to shipping will greatly reduce the maximum functional range for signals in that band (Au, 1993). Similarly, calculations made be Aguilar Soto et al. (2006) demonstrated that the maximum communication range at frequencies used by Cuvier's beaked whales would be reduced by 82% (to 18% of its normal value) when exposed to a 15 dB increase in ambient noise at these frequencies, as was observed in the above-mentioned recording of a passing vessel. They also determined that the effective detection distance of echolocation clicks would also be reduced by 58% (to 42% of their normal range). Furthermore, if the current trend observed at low frequencies were applied to the higher frequencies component of ship noise, leading to a further increase of 15 dB by 2050, beaked whale communication at those frequencies would be reduced by 97% (to only 3 % of their 1950 maximum range) with each passing vessel (Aguilar Soto et al., 2006).

It is important to note that these calculations are based on observed increases in noise at high frequencies from a single passing vessel, that noise profiles from ships are highly variable and that high frequency noise attenuates much more rapidly than low frequency noise (see Hatch & Wright, this issue), limiting the area over which Cuvier's beaked whales would be affected. However, the trend towards faster boats, producing more cavitation and thus noise at higher frequencies, should also be considered. Furthermore, marine mammals that predominantly use low frequencies (e.g., baleen whales) may suffer similar reductions in the effective range of communication and other signals over much larger areas with additional reductions nearer a passing vessel. At the very low frequencies used by many mysticetes (e.g., under 200 Hz), masking may occur in the majority of the oceans, especially in the northern hemisphere (see Hatch & Wright, this issue). Consequently, it would not be possible for these species to employ an avoidance strategy (see Bateson, this issue; Wright et al, this issue, a) because of the omnipresence of increased background noise from ships.

This reduction in effective distances for communication will almost certainly be associated with an increase in the ambiguity of information received. The reception of ambiguous signals can act as a stressor and/or potentially lead to consequences such as missed mating opportunities and unidentified predators (see Bateson, this issue). These consequences can be especially problematic for animals that are already compromised in some way (see Wright et al., this issue, a). For example, a whale that is already in a state of chronic stress is more likely to interpret ambiguous information pessimistically and act accordingly, such as not chasing as many possible prey items or wasting energy avoiding more possible predators.

Whalewatching and energy budgets

Interactions between boats and cetaceans are known to have a number of effects on marine mammals, although they may not even be consistent among different groups within the same species (see Lusseau & Bejder, this issue). For example, in Doubtful Sound, New Zealand, female bottlenose dolphins (*Tursiops* spp.) responded linearly to increased disturbance intensity (increased intrusiveness of boat interactions) by increasing dive duration (Lusseau 2003). Conversely, the males almost immediately adopted an avoidance strategy by substantially increasing their dive duration, but then did not increase it further with increasing interaction intrusiveness. There are a number of possible reasons for this difference between males and females, including the fact that energetic demands and consequences differ between the sexes (e.g., reproduction). Whatever the reason, it may be that the males' avoidance strategy spares them from higher noise exposure and disturbance rates, limiting their physiological stress response. Alternatively, the males may be falling into an ecological trap and the females may be better off if the physiological stress response is actually quite limited and they can still continue to forage effectively.

Although difficult, it is possible to estimate the energetic consequences of behavioral alterations and other avoidance strategies (see Lusseau and Bejder, this issue). For example, increases in time spent traveling and decreases in time foraging in northern resident killer whales (*Orcinus orca*) in response to disturbance by whalewatching traffic led not only to a relatively small (although not necessarily inconsequential) estimated increase in energetic demands of 3%, but also to a estimated reduction in energetic intake of 18% (Williams, Lusseau & Hammond, 2006). It should be noted that these are minimum estimates, as any costs associated with a stress response (physiological or psychological) or as a consequence of masking would be in addition to these figures.

Dolphins have been observed apparently shifting from short-term avoidance (local behavioral) to long-term avoidance (habitat displacement) strategies in response to passing a threshold of disturbance from tourist boats (see Lusseau & Bejder, this issue). Presumably, at the point where this behavioral switch occurred, the dolphins determined in some way that the various costs associated with remaining in the disturbed habitat had become larger than the potential benefits. Consequently, when either habitat value is very high or habitat displacement is not an option (e.g., because boat interactions occur throughout the home range of the population), the costs of short-term avoidance strategies can accumulate and have serious implications for the population's viability. Alternatively, habitat displacement can also be very costly, as new habitats may have to be found or fought for, and knowledge of the area (e.g., prey locations) may have to be learned anew, the reduced habitat awareness potentially acting as a stressor in the meantime.

In either case, the various changes in the energy budget of an animal can, in turn, have a number of additional consequences. If the animal is still consuming more energy than it is using, it can continue to survive and grow, although unquestionably it will be less able to deal with anything that places additional energetic demands upon it, such as disease, migration and reproduction. As any remaining energetic surplus diminishes, a number of significant effects may begin to appear. For example, if the energy and resources available to a parent limits natal and/or parental investment, there will be various consequences for the health of the offspring (see Wright et al., this issue, a). Ultimately, if the animal is not able to consume enough energy to meet the increased demands, then it will begin to metabolize its lipid stores before it slowly starves to death or is forced to leave the area. In marine mammals the largest lipid store is the blubber layer, the mobilization of which will concurrently lead to an increase in contaminant levels in the blood (see Cumulative and Synergistic Effects). It should also be noted that hypoglycemia is a very powerful threat to homeostasis (i.e., a large stressor) that leads to rapid activation of stress responsive systems.

Something akin to the above may be occurring in both Shark Bay, Australia and Doubtful Sound, New Zealand. In Shark Bay a significant 15% decline in the relative abundance of dolphins was observed in an area where dolphin-watching activities occur, while a similar decline was not observed in an adjacent control site free from whalewatching activity (Bejder et al., 2006). In Doubtful Sound, the rate and frequency of perinatal deaths have significantly increased and the population abundance has decreased concurrently with a significant and substantial increase in the number of boats as well as the number of trips per boat (Lusseau, Slooten & Currey, 2006). The costs associated with boat interactions are such that females have to maintain homeostasis by reducing energetic investment in the only extrinsic factor they can manipulate: reproduction. It is not known how the males are faring in comparison.

Cumulative and Synergistic Effects

If context is important in controlling how noise induces stress responses in marine mammals and the various potential consequences thereof, it is crucial to consider the other potential stressors and anthropogenic activities that may be influencing marine mammals at any given time. We will not go into detail about the various possible additional anthropogenic stressors here, as the U.S. Marine Mammal Commission (Reeves & Ragen, 2004) provided an effective summary of the majority of other threats to marine mammals. Its annual reports also provide more information (MMC, 2007 and previous).

The following threats will almost certainly contribute in one way or another to a reduction in the condition of individuals (i.e., an increase in the “allostatic load”), which might, among other things, make them more susceptible to other potential stressors, including noise. As mentioned above, a reduction in the overall condition can also influence the psychological outlook of an animal (see Bateson, this issue). Although acting primarily on individuals, the impacts of these stressors may filter up to the population level if they affect an individual’s survival or fecundity. These threats include:

- climate change and other ecosystem-wide change;
- habitat loss or degradation through coastal and offshore development, fishery activity (including due to a reduction in available prey), inland development (that results in material washing downriver either immediately or over an extended period as a consequence of a change in land-use, such as clearing forests), etc.;
- disease;
- toxic algal blooms ; and
- contaminants (especially adrenocorticotoxic contaminants: see Martineau, this issue).

Several other threats may also induce stress responses in individual marine mammals. However, they generally result in removal of an individual from the wild (either through mortality or permanent capture). Consequently, these other threats do not usually contribute to any existing stress response an animal may be experiencing prior to an exposure to noise, but are more likely to act cumulatively with noise-related stress effects at the population level. These include:

- fisheries bycatch;
- ship strikes;
- whaling; and
- dolphin drives.

It is also possible for exposure to noise (through a stress response or other means) to make individuals more susceptible to any of the above additional threats, including the generally lethal ones. For example, Nowacek et al. (2004) concluded that the alarm stimuli mentioned previously were poor options in attempts to mitigate vessel collisions with North Atlantic right whales, since the reaction of most animals in the study likely placed them at greater risk of vessel collision. Consequently, it is very important for managers to consider this conclusion when making decisions regarding the introduction of other novel sounds into the habitat of this highly endangered and declining species (Carretta et al., 2007), especially as the entire range for the species (the coasts of southern Canada to northern Florida) is an area that has a high concentration of shipping traffic.

Additionally, marine mammals, especially deep divers, are often thought to be pushing their physiological and anatomical limits as part of their normal behavior. They often subject themselves to considerable pressures as well as large changes in pressure on a regular basis, all while holding their breath for prolonged periods. The hypothesized anaerobic diving in beaked whales discussed above is one example of this. Another would be the bone damage seen in sperm whales (*Physeter macrocephalus*), which is thought to be a manifestation of the "bends" (Moore & Early, 2004). Such extreme conditions and related injuries could potentially be acting as additional injury stressors in their own right and might thus make marine mammals more susceptible to cumulative effects with other stressors, especially those thought to be mainly psychological in nature (see Deak, this issue).

Although information is generally lacking about how exposure to noise may ultimately affect marine mammals, it is possible to draw from the available information on how they respond to exposure to other stressors. Consequently, the following discussions examine the various effects of two of the most common threats to marine mammals: contaminant loads, with examples from pinnipeds and belugas; and interactions with fisheries, with an example from tuna-dolphin sets. These examples also provide some insight into the possible physiological and psychological condition that marine mammals might be in when exposed to noise (i.e., context), thus indicating potential pathways for cumulative interactions with noise exposure.

Contaminants

Marine mammals are especially susceptible to the effects of contaminants due to their high trophic level in the food web, long-life span, relatively late maturity and low reproductive potential. Many contaminants (or their metabolic products) bioaccumulate, meaning that they are found at increasing concentrations in the tissues of animals that occupy higher trophic positions. This process can lead to very high concentrations in long-lived adults or in newborns, when lipophilic contaminants are transferred from the mother through milk (see Martineau, this issue). This is because much of the contaminant load is stored in the blubber layer, which is partially metabolized for milk production (see Martineau, this issue). In many marine mammals, the first offspring stands to receive the highest dosage as the mother might have been bioaccumulating for many years before the first offspring is born, while only accumulating contaminant loads for a year or two in between pregnancies (Beckmen, Blake, Ylitalo, Stott & O'Hara, 2003). The blubber layer is also metabolized during periods of fasting or starvation (including times of migration, such as in mysticetes, or reproduction, such as in many pinnipeds), delivering the contaminant load to the fasting animal.

While contaminant loads compromise animals and are often associated with increased occurrences of various pathological conditions, different contaminants can have very different effects. For example, some organochlorine compounds (OCs), such as dioxin-like polychlorinated biphenyls (PCBs), can cause apoptosis (i.e., self-destruction) of T-cells in the same way that a GC stress response does. Dioxin-like PCBs (and their metabolites) are also known to interfere with the size and effectiveness of the GC response (see Martineau, this issue). Other OCs metabolites, such as DDT's, are known to damage the adrenal cortex (see Martineau, this issue), which is also involved in the stress response.

Many substances (or groups of substances) may have a range of effects (see Kakuschke & Prange, this issue). For example, studies have linked high metal burdens with a large variety of impacts in marine mammals ranging from lower resistance to diseases, through harmful influences on the liver, kidney, central nervous system and reproductive system, to stillbirths. Metals also impair immune cell function through a number of mechanisms. Depending on the particular metal, its chemical bond, concentration, bioavailability and a host of other factors (including the age of the animal), the result can either be immunosuppression or immunoenhancement leading to hypersensitivity and autoimmunity (see Kakuschke & Prange, this issue). Studies on marine mammals from the North Sea have demonstrated a relationship between pollutant exposure and infectious disease mortality (Jepson et al., 2005). Higher levels of contaminants were also found in seals that died during the Phocine distemper virus epizootic that interrupted the increase of the harbor seal (*Phoca vitulina*) population in the Wadden Sea (Hall et al., 1992).

One population that may be particularly at risk from cumulative effects of noise and contaminants is the beluga whale population of the St Lawrence estuary. These beluga may already be quite compromised as they live in a historically highly polluted area (Fox, 2001; Lebeuf & Nunes, 2005; Lebeuf, Noëla, Trottier & Measures, 2007; Martineau, Béland, Desjardins & Lagacé, 1987; Muir et al., 1996; Muir, Koczanski, Rosenberg & Béland, 1996). For example, immunosuppressive contaminants most likely led to a high susceptibility to infections by opportunistic bacteria (i.e., bacteria that are part of the usual bacterial load in many animals and are not usually pathogenic) reported in the population (Martineau et al., 1988). High levels of shipping activity in the area is also exposing the whales to noise, with the imminent construction of a liquefied natural gas (LNG) terminal and planned natural gas exploration in the estuary set to raise noise levels further. As stressors related to contaminant loads are predominantly physiological and those related to noise are likely to be mostly psychological, increasing exposure to either also increases the risk of sickness-like conditions developing in the whales (e.g., neuroinflammation: Deak, this issue).

Tuna-dolphin fishery

The yellowfin tuna (*Thunnus albacares*) purse-seine fishery targets dolphins in the eastern tropical Pacific Ocean (ETP), as the tuna schools are associated with the dolphins. It should be noted that this makes it a somewhat unusual example of fisheries interactions, as marine mammals are not often targeted directly. However, there are a relatively large number of studies into the effects of the ETP tuna fishery upon the dolphins, which is why it was selected as an example here.

Edwards (this issue) describes the process of chase, capture and release that the ETP dolphins are subjected to by the fishery. High mortality rates in the early days of the fishery (see Edwards, this issue) substantially reduced abundance in the two dolphin species most often involved (northeastern offshore spotted, *Stenella attenuata*, and eastern spinner, *S. longirostris*) to 20% - 30% of pre-fishery (1960) levels (Wade, Reilly & Gerrodette, 2002). Despite the substantial reduction of mortality rates to sustainable levels in 1990 due to the implementation of new fishing procedures, the populations do not appear to be recovering (Edwards, this issue; Gerrodette & Forcada, 2005).

Fishery-related stress responses (e.g., acute stress responses, “heat stress”, etc.) became a suspected limiting factor in both of the most commonly targeted species, as the number of sets (i.e., the number of times dolphins are disturbed, chased and potentially captured) has not decreased (see Edwards, this issue). The role of capture myopathy (a disease complex involving muscle damage that is associated with the combination of intense physical exertion and physiological stress effects of capture or handling, and which can in some cases have immediate or delayed fatal consequences: Spraker, 1993) in the lack of recovery is yet to be fully determined for a number of reasons (see Reilly et al., 2005). However, it seems possible that detrimental sub-lethal consequences arising from each individual’s stress response are playing an important role at the population level, at least through the more sensitive animals (see Edwards, this issue).

Great concern also surrounds the separation of calves from their mothers during fishery evasion, as the subsequent potential for unobserved calf mortality if not reunited promptly with their mother is quite high (Noren & Edwards, 2007). Even if calves are reunited, or do not suffer separation in the first place, there may still be serious consequences resulting from the experience. Neonates and young calves will be particularly sensitive to GCs because their brains are still developing, like all young mammals with immature nervous systems (see Romero & Butler, this issue). The purse-seine set experience, which appears to represent a severe but intermittent stressor to the ETP dolphins, may therefore have quite significant non-lethal effects on young calves. These would result from the double dose of GCs arising from the massive influx transmitted to them via the mother’s milk as a consequence of her physiological stress response, combined with those produce by their own stress responses. These excessive stress-chemical loads have the potential for generating both acute neurological damage and long-lasting neurological re-programming in any nursing calves involved in evasion of a tuna purse-seine set in the ETP (see Sapolsky, 1992).

The various studies investigating fishery-related stress effects in ETP dolphins (e.g., changes in blood and muscle chemistry; damage to various organ systems, etc.: Reilly et al., 2005) illustrate the wide variety of impacts that can accompany an escape response (possibly acoustically-initiated) to an impending threat. At the present time, it is impossible to determine whether physiological effects of the whole chase/capture/escape experience are either short- or long-lived.

In general, physiological effects related to the stress response are likely to be reasonably short-lived for otherwise healthy adults in situations where even fairly intense natural stressors (e.g., predation attempts) occur only once every few weeks (see Dallman & Bhatnagar, 2001). Although the rate of occurrence may be similar in the ETP dolphins (see Edwards, this issue), surviving calves and fetuses in utero may still suffer a range of long-term impacts as they are exposed to maternal cortisol (if not also their own) each time their mother has been stressed during the chase-hunt, as discussed above. Some of these impacts may persist until the animals are adults and can include the development of an abnormal stress response system (e.g., Kapoor, Dunn, Kostaki, Andrews & Matthews, 2006). However, adults could also be affected as the chase process is characterized by an intensity and duration never encountered in nature (e.g., predators get tired and remain silent in contrast to motor vehicles). The set attempts likely involve both physiological and psychological stressors, such as noise and intense exercise, which may lead to sickness-like conditions in the exposed individuals (see Deak, this issue). Furthermore, the extent to which the stress response is involved in the initiation of capture myopathy has not yet been identified (see Reilly et al., 2005). The potential also exists for some serious cumulative impacts in dolphins of any age if they are in any way compromised prior to attempted purse-seine sets.

Acclimation in Marine Mammals

There is very little (if any) evidence of acclimation (as defined in Wright & Kuczaj, this issue) in marine mammals in the wild, although this does not mean that it does not occur. Many references to “habituation” have not demonstrated that the observed reduction in behavioral response is associated with a reduction in the physiological stress response and processes other than acclimation may explain the results (see Wright et al., this issue, a). For example, the observed reduction in behavioral responses of ETP dolphins when in the purse-seine net (i.e., originally they appeared to panic, but now seem to wait relatively passively until released), could indicate acclimation, but more likely indicates learning, and/or natural selection instead. It is important to recognize that these processes can change behavior in adaptive ways that nevertheless continue to be accompanied by a full internal physiological stress response.

Thus, apparent behavioral tolerance of noise in marine mammals cannot be automatically interpreted as acclimation (see Beale, this issue). However, there has been little opportunity for adaptation to noise to occur through natural selection in many marine mammals because of their long lifespans (except if there are lethal consequences of exposure to the stimulus: see below). This is especially true in large whales, as the increases in noise in the oceans may have occurred in a single lifetime. Consequently, an observed reduction in behavioral responses in marine mammals may often reflect a learning process, whereby repeated exposures to a stressor leads to reduced or altered behavioral responses, but not necessarily reduced physiological responses. The animals learn either how to behave to reduce any negative effects or that the stressor is not as noxious as it first appeared. However, the stimulus is still perceived as a stressor. It is then possible that this information and any associated behaviors are conveyed to the next generation through cultural transmission.

With regards to the apparent acclimation in ETP dolphins to capture by the purse-seine the tuna-dolphin fishery, it is important to separately consider the capture by itself, as well as the whole purse-seine set experience collectively. It is unlikely that physiological acclimation to the whole purse-seine set activity occurs for several reasons. First, most ETP dolphins are only chased about once per month (and captured less often still; see Edwards, this issue) which is probably not often enough to lead to acclimation given the probable size of the stressor involved (although these catch frequency estimates are merely averages: some dolphins will evade sets more often, some will evade less often). Second, the dolphins still respond to capture efforts by fleeing immediately upon perception of an impending set (which, as an aside, is the cause of capture myopathy in free-ranging ruminants: Spraker, 1993). Third, they still engage in prolonged escape behavior after getting out of the net (also involved in capture myopathy: Spraker, 1993). Fourth, ETP dolphins in the more heavily fished areas exhibit escape reactions in response to all approaching big boats while responding less to vessels not approaching them directly (Au & Perryman, 1982; Hewitt, 1985), even though the combination of sounds that signal an approach are unlikely to be identical due to vessel and engine variety. Fifth, the number of ETP dolphins has been severely reduced. Finally, the social structure of the dolphins appears to have changed since the onset of the fishery as the average school size has decreased. Although the last two pieces of evidence do not necessarily reduce the likelihood that acclimation is at work, they suggest that other explanations for any tolerance displayed may be more likely, such as half a century of selective pressure (approximately four generations in these species: Myrick, Hohn, Barlow & Sloan, 1986).

It may be that the dolphins have acclimated somewhat to their temporary capture in the purse-seine nets, although the frequency of exposure remains a major issue (i.e., it may not occur frequently enough for acclimation to take place). Consequently, it appears more likely that the dolphins' relatively calm behavior reflects learning or selection, rather than acclimation. Furthermore, the dolphin's prolonged escape response after release from the net also implies that the animals have not acclimated to either capture or the full set experience. For example, it may be that, having experienced enough sets to realize that there is nothing they can do until the backdown maneuver (see Edwards, this issue), the dolphins may have learned to behave more calmly in the net, although they are very likely not internally calm at all. In comparison, learning to ignore the chase is unlikely as the result is uncertain: there is the possibility of either escape or capture.

As mentioned above, selective pressures may also be involved, fuelled by variation in individual susceptibilities to in-net mortality, the stressors of chase and capture, and possibly also capture myopathy. These factors, in combination with the fact that fishermen actively target larger schools, may have very quickly selected for dolphins that aggregated in smaller groups and behaved most appropriately to the sets. Consequently the reduction in apparent agitation in the net could be a result of the massive and efficient loss of the more sensitive individuals (potentially through unobserved capture myopathy in addition to direct mortality in the net). Given the dramatic reduction in abundance, it appears reasonable that the remaining dolphins are those best ‘suited’ to surviving purse-seine sets.

Similar processes are also at work in modern fisheries. Observed effects include a reduction in the average size of collected fish, due to slower growth rates (within any given species), because only larger fish are big enough to be legally captured (see Conover & Munch, 2002). Under those conditions, fish that mature at a smaller size (either by growing slower or maturing earlier) have a selective advantage. However, smaller breeding animals may also have less resources and energy available to invest in reproduction, which could explain the associated reduction in egg size (Conover & Munch, 2002).

North Atlantic right whales

There are several possible explanations for the reactions of North Atlantic right whales to shipping noise and alarm sounds as discussed above (Nowacek et al., 2004). Two of the most likely are: 1) the whales have not learned to react to ship noise sounds appropriately (i.e., by swimming away), while they do not distinguish alarm sounds from those emitted by possible predators, such as killer whales; and 2) the whales have acclimated, wrongly, to continuous ship noise so that they do not react even at levels likely indicating danger of collision, while they do react to novel noise sources such as alarm sounds.

It is therefore no surprise that the following statements (which we demonstrate below are likely incorrect), with their associated management ramifications, are common in attempts to further understand why right whales do not appear to use sound to avoid ship strikes: 1) North Atlantic right whales appear to have “habituated” to ship noise, thus increasing the numbers and/or types of vessels in their coastal habitat does not constitute a potential threat to this endangered species; and/or 2) North Atlantic right whales have “habituated” to ship noise thus introduction of other industrial sounds to their coastal habitat does not constitute a potential threat to this endangered species.

If indeed right whales have actually acclimated to the constellation of low-frequency dominant sources in their environment, then the probability of a stress response occurring as a direct result of repeated exposure to industrial and vessel noise may be decreased. However, masking and signal discrimination would continue to create problems for right whale communication efficiency (and thus may indirectly lead to a stress response). In fact, the occurrence of ship strikes and entanglements in right whales may indicate that there is so much noise (or the noise has caused enough hearing damage) that the whales are unable to hear or locate anything except the loudest of sounds.

If acclimation is not occurring and a repeated and/or continuous stress response is being maintained by right whales due to a high incidence of exposure to acoustic and other stressors, then the observed lack of behavioral response in right whales may be due to various other factors. First, their physiological response to vessel noise exposure may not result in changes in behavior. Second, the animals may be less likely to respond if they are in poor overall health, perhaps as chronically stressed individuals (see Beale & Monaghan, 2004). Third, any changes in behavior that do occur may be too subtle to have been detected, or have not been correctly identified (and thus recorded) by researchers due to a lack of understanding regarding the context for those changes. Finally and perhaps most likely, the whales just can't afford to react to ship noise as it happens all the time in the area they have to be in, so they carry on regardless (e.g., they have learned not to respond to the noise).

Given the lack of evidence for acclimation in this situation and in studies of other animals, as well as the discussion of acclimation above and in Wright et al. (this issue, a), it seems quite unlikely that North Atlantic right whales have acclimated, as defined, to loud sources of low frequency sound in their environments,. Consequently, the likelihood that the apparent tolerance is due to one or more of the other possible reasons needs to be considered in efforts to manage anthropogenic impacts on the species.

Conclusions

It is clear that noise can act as a stressor to marine mammals. If marine mammals react in a similar manner to other animals (including mammals) that have been studied in controlled circumstances, repeated and prolonged exposures to stressors (including or induced by noise) will be problematic for marine mammals of all ages. The resulting extended stress response may then lead to a range of issues including, but not limited to, suppression of reproduction (physiologically and behaviorally), accelerated aging, and sickness-like symptoms. Acclimation to such exposures seems unlikely for a number of reasons, including differences in the perceived stimuli, changing context, time-scales, etc. Examples of apparent "habituation" may instead indicate selection, or learning without acclimation. Learned responses, like acclimation, are highly dependent on the predictability of stimuli. However, learned responses, like other possible mechanisms of adaptation but unlike acclimation, may or may not reduce the magnitude of the physiological stress response.

Regardless, acclimation or some other apparent tolerance of a noise may have various pernicious effects, such as limiting the ability of the animals to react to actual threats. These may, in some cases, have lethal consequences (e.g. right whales' lack of reaction to ship noise, possibly resulting in collisions), but the majority of knock-on outcomes are likely to be physiological (e.g. dolphins approaching acoustic pingers, risking receiving noise levels with the potential to cause temporary hearing impairment, also known as a temporary threshold shift – TTS) or psychological (e.g., annoyance) effects that are not immediately lethal. However, physical injuries and other consequences of noise exposure may then act as additional stressors upon marine mammals. For example, if masking leads to increases in information ambiguity, or group or mother-calf separation, animals may suffer from anxiety as a result. Masking by increasing noise levels would be roughly analogous to a human trying to see through increasingly dirty glasses. Eventually, the lack of reliable acoustic information prevents marine mammals, especially cetaceans, from 'seeing' their environment, essentially leaving animals blind. Confounding the issue further, maladaptive efforts to avoid a noise can also indirectly lead to detrimental outcomes for marine mammals.

In addition to the myriad possible affects from noise exposure that can all interact together, it is important to consider the potential cumulative effects of multiple anthropogenic stressors. For example, should the energy balance of a marine mammal become negative (due to disturbance or disease, etc.) lipids and the lipophilic contaminants stored within them are mobilized from the blubber. The release of these contaminants into the circulation not only constitutes *de facto* a second exposure to the individual concerned during a period of nutritional challenge, but mothers also expose newborns through transfer in milk (Martineau, Béland, Desjardins & Lagacé, 1987; Tornero et al., 2005; Wells et al., 2005). Affected animals would then be less able to respond sufficiently or appropriately to any additional stressors.

Further contextual complications may be involved in beaked whales and other deep diving marine mammal species, as their normal behavior may put them already at the limits of their physiological capabilities. Cumulative and synergistic effects can be assessed in different ways, but any such assessment should be undertaken very cautiously as synergistic effects can be very unpredictable. The following hypothetical chain of events illustrates the complexities of cumulative and synergistic effects in which noise-related stress may have deleterious consequences for a marine mammal.

A young male sperm whale in the Gulf of Mexico is exposed to nearby shipping noise and experiences a stress response. This response is more extreme than it would otherwise be as the young animal was exposed in utero and immediately after birth to high GC levels transferred through the placenta and milk from its mother, when she was undergoing a stress response. Despite a flight response sending the whale to the surface, the animal is lucky and avoids a potentially lethal ship strike. After repeated non-lethal exposures to that (or similar) sounds, the whale learns that the noise is not followed by any serious immediate consequences and so it stops responding behaviorally. Despite this, the animals GC levels remain high, because it has not acclimated to the passing ships and also because of its altered HPA axis. The resulting GC levels cause slow growth. If a ship passes nearby, the whale might experience TTS and/or the disruption of sleep, as well as interference in communication and foraging resulting from the masking. From time to time these problems annoy or agitate the whale and produce their own stress responses, depending on the exact situation.

As it ages, the sperm whale builds up a contaminant load over and above the dose it received as a calf from its mother. It also begins to suffer from bone damage related to diving. Frequent exposure to a variety of anthropogenic noise sources continues to disrupt foraging efforts and begins to directly affect its body condition and psychological outlook. A compromised immune system allows an infection to take hold and the whale begins to lose weight. Blubber is metabolized and the whale is exposed to the mobilization of its contaminant load. A seismic survey begins in the area and the resulting total exposure over the next several days exhausts the supply of components for GC production and pushes the combination of psychological and physiological stressors beyond a certain threshold, resulting in neuroinflammation and other sickness-like conditions. In the face of this worsening condition, the sperm whale beaches itself and dies with no particular cause of death apparent.

Many of the effects discussed in this paper can be incorporated into population viability assessments and other models used by managers in their decision making process. There are a small number of studies in marine mammals where controls have been appropriately established that are beginning to provide some of the information required for this. However, for the majority of marine mammals, accounting for these effects will require some assumptions about the implications of the various stress responses on fecundity and survivorship, as the data that concern these parameters are not available. Fortunately, extrapolation from data in other species (and possibly even from other animal groups) appears reasonable, because the physiological stress response is highly conserved across the many different species that have been studied to date.

In addition to the more general conclusions and findings offered by Wright et al. (this issue, a) pertaining to stress responses to noise, we suggest that the following findings and recommendations (presented in no particular order) are especially important with regards to marine mammals. We propose that marine mammal managers and scientists consider these findings and specific recommendations when planning research or management actions (e.g., in assessments of environmental impact).

Findings

1. "Stress" is a very important concept to consider in managing the impacts of anthropogenic activities on marine mammals, yet definitions vary greatly among specialists as well as laymen. There is also much confusion over the use of the related term "habituation" (see also Wright et al., this issue, a).

2. Given the physiological, psychological, behavioral and ecological information presented, considered and discussed in this issue, the conclusions that have been drawn from them, and the other findings presented here, it is reasonable to assume that anthropogenic noise, either by itself and/or in combination with other stressors, can reduce the fitness of individual marine mammals and decrease the viability of some marine mammals populations.

3. The physiological stress response is highly conserved among those animal species in which it has been studied (including a few marine mammal species: e.g., Martineau, this issue) and thus extrapolation to marine mammals is reasonable.

4. Very young individuals (and fetuses) are particularly sensitive to the neurological consequences of the stress response and can suffer permanent neurological alterations as a result. Similarly, deep diving marine mammals may be particularly sensitive to noise as a stressor given that many marine mammal species are thought to live close to their physiological limits.

5. Acoustic masking may act in several ways to induce stress responses in marine mammals. These may include but are not limited to: reducing the range of signals important for communication and finding of prey; reducing the clarity of received signals; and inducing anxiety and annoyance. These combine with potential effects on foraging efficiency and social cohesion, with possible subsequent effects on reproductive success and survivorship.

6. Scientists need to study stress responses in marine mammals and their epidemiological and psychological consequences. Most immediately, classical stress measures will be needed to marry the extrapolations from studies in other animals with observed behavioral responses. Such studies will be complex and require defining concepts such as “need” and “risk” in terms of the decision making process in the often highly developed brains of marine mammals. Adequate techniques to obtain physiological data (e.g., heart rates, cortisol levels, adrenal morphology and other information) are also required. Implicitly, these various techniques should be the least invasive as possible to minimize additional stressors. It is also very important to include a comparison or control group (i.e., mammals not exposed) or baseline data (i.e., data from animals before they became exposed). However it is acknowledged that non-exposed populations of marine mammals are likely to be quite rare.

Research Recommendations

1. Efforts should be made to collect information on the dynamics of stress-related chemicals (particularly cortisol) in cetaceans and other marine mammals. Collection from blood plasma may not currently be practical for assessing the effects of most stressors, given that animals would generally need to be captured, which is a complex task when handling large marine mammals. Currently available methodologies that do not require capture involve the collection of feces from free-ranging animals (either after visual detection or through the use of the canine sense of smell: Hunt, Rolland, Kraus & Wasser, 2006), or the collection of mucus expelled during exhalation (Hogg, Vickers, & Rogers, 2005). The time between exposure to a stressor and the increase in cortisol levels in the various samples need to be considered. The period from stressor exposure to increased cortisol levels is very short in blood samples. In contrast, cortisol levels in samples from feces will be averaged between bowel movements, and those from samples of respiratory mucus exhaled with a breath are likely to take 10-15 minutes or more to reflect the impact of a stressor. Cortisol levels in fecal and mucosal samples are likely to be more variable than in blood samples, but the less invasive collection methods are less likely to trigger a stress response of their own, allowing the techniques to be used to study the effects of other stressors, such as noise. Such investigations would need to be carefully constructed, with well-designed controls. Efforts should acknowledge that is not possible to distinguish between acute and chronic stress responses in blood, fecal and mucosal

samples without a time-series. It should also be noted that animals often expel fecal matter as part of a sympathetic response when they become stressed. In addition, GC levels are fairly variable from one individual to another, so baselines will be needed for each individual against which to measure relative stress levels.

2. Opportunistic collection of information about the level of stress-related chemicals from various tissues and stores in stranded and bycaught animals should also be undertaken. Investigations should also be made to see if it is possible to obtain these chemicals from skin and/or blubber. If so, the amounts in the blubber may be long-term average levels, providing indication of cumulative stress responses for marine mammals over the long-term. However, there is some active exchange between the blubber and the blood, so levels of stress-related chemicals in the different layers of the blubber may reflect shorter-term averages, although there may also be high variability both between and within species. Post mortem examinations of stranded marine mammals should also record other pathologic effects related to exposure to stressors. For example, the size and weight of, as well as the presence of any lesions on, the adrenal glands should be noted. Chronic stress leads to chronic stimulation of the adrenal cortex by adrenocorticotrophic hormone (ACTH). In turn, ACTH chronic stimulation results in adrenocortical hyperplasia (increased number of cells) or hypertrophy (increased size of cells) necessary to allow for sustained overproduction of GC and possibly catecholamines. These morphological changes are seen grossly as increased size and weight of the adrenal glands (Clark, Cowan & Pfeiffer, 2006; Dorovini-Zis & Zis, 1987; Lair, Beland, De Guise & Martineau, 1997; Nemeroff et al., 1992; Ulrich-Lai, Figueiredo, Ostrander, Choi, Engeland & Herman, 2006). Furthermore, the presence of acute phase proteins in different organs, such as the liver or skin, could indicate recent exposure to an intense stressor. This could also provide important information on “normal” background levels of the proteins in different species, which would be very useful in developing further studies on the evaluation of stress response in marine mammals.

3. Skin biopsies, sampled from live cetaceans with minimal disturbance, have yielded unique information about genetics and contaminants (Fossi et al., 2004; Hobbs et al., 1998). Not only is skin a major target organ for cortisol (and thus cortisol is present in the skin) but skin is also a site of cortisol synthesis (Slominski, Wortsman, Tuckey & Pau, 2007). Measurement of cortisol levels in skin biopsies carried out on free-ranging cetaceans should be explored, although the possible effects of any chase and handling required to obtain the samples needs to be considered. It may also be possible to obtain this information through collection of sloughed skin from the water in the wake of a whale, which could largely circumvent this problem.

4. Given that studies on cortisol in humans have generated mixed results, efforts should also be made to study epidemiological effects in marine mammals, especially in the wild.

A Strategy for Managing the Impacts of Noise on Cetaceans in the Face of Uncertainty

Based on the available evidence, a non-trivial negative impact of noise-related stress responses on vital rates is expected for many marine mammals, especially cetacean species, although there is still substantial research needed to determine the magnitude of impacts. The Bayesian approach outlined by Wintle (this issue) is likely to be viable, logical and coherent in quantifiably extrapolating noise-related impacts from other mammals to cetaceans, given the highly conserved nature of stress physiology.

There are clearly grounds to justify initiating an adaptive noise mitigation strategy based on the available evidence and theory concerning the impacts of both acute and chronic noise on humans and terrestrial mammals, as well as the sparse data available on cetacean noise impacts. Potential noise exclusion zones should be identified as a matter of urgency. However, in order to commence the learning cycle, it is essential to measure vital rates under both noisy and noise-excluded management conditions so that the specific benefits of noise exclusion/mitigation can be better understood. Until an adequately stratified study of cetacean vital rates under various levels of noise impacts can be established, the value of noise mitigation efforts will be clouded by uncertainty. It is acknowledged that this will be a difficult and lengthy task.

A detailed description of a suitable management and monitoring strategy to assess the impacts of noise and noise mitigation on cetacean vital rates is beyond the scope of this issue. However, some general recommendations to those managing the impacts of noise on marine mammals can be made. We recommend that:

1. An expert working group should be convened with the specific goal of identifying noise impacts on cetacean (or other marine mammal) vital rates, using all available data and systematically integrating knowledge of impacts from other species.

2. Areas suitable for broad-scale noise exclusion/reduction should be identified.

3. Where possible, environmentally similar areas that cannot have noise exclusions/reductions should also be identified.

4. Based on the results of expert working groups, models should be developed to predict likely population responses to noise mitigation strategies.

5. Levels of noise should be closely monitored and measurement of cetacean vital rates initiated in all locations.

6. The relationship between noise level and cetacean vital rates may then be updated and predictions about future gains modified to reflect the new information.

7. Monitoring of vital rates should be maintained to enable better decisions about future allocation of mitigation efforts.

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Appendix 1

The following table compares some of the scientific evidence for physiological, psychological and behavioral responses to various stressors with some of the known behavioral effects of noise in marine mammals and other species. It should not be considered an exhaustive list. It should also be noted that authors contributed predominantly to the rows in which they had expertise. This has given rise to different application of the columns "mechanisms', 'observations' and 'consequences'. For example, in some cases a physiological stress response is listed as a consequence, while in others the whole response is, or elements of it are, listed as either a mechanism and/or an observation. These inconsistencies highlight the diverse approaches in the various disciplines and may arise from the different methodologies available to the scientists in the various fields and from one species to another. They should therefore not necessarily be interpreted as inconsistencies in the actual results. Finally, some of the potential impacts resulting from noise exposure discussed in this and other papers in this issue have been added to many of the marine mammal entries as possible consequences. Items in italics are uncertain and those marked '*???*' are unknown.

Animal	Stimulus	Mechanisms	Observations	Consequences	Sources
General	Chronic/cumulating acute non-specific (e.g., contaminants, predators, etc.)	Chronic GC response.	Increased GC levels prior to eventual fall-off.	Chronic: Disregulation of glucose and metabolism; Stress-induced dwarfism; Behavioral changes (context dependant); Reproductive disruption (psychological and physiological); Immune-suppression.	McEwen & Goodman, 2001; Sapolsky, Romero & Munck, 2000
Guinea pigs	Maternal separation	*Probable increase cytokine expression?*	See consequences.	Initial anxiety followed by 'sickness'.	Hennessy et al., 2007
Lab rat	Footshock	Increase cytokine expression and microglial activation and CNS.	See consequences.	'Sickness' behavior, Neurodegeneration.	Deak, Bellamy & D'Agostino, 2003; Nguyen et al., 1998; Plata-Salaman et al., 2000; Shintani et al., 1995
Lab rat	White noise (experimental)	Release of corticosterone; Intestinal inflammation; Microvasular damage; Transient increase in blood pressure.	Redness around eyes and on back of neck. Also see mechanisms.	Non-selective molecular exchange intestine-blood stream leading to septicemia.	Baldwin, Primeau & Johnson, 2006; Baldwin & Bell, 2007; Burwell & Baldwin, 2006; Windle et al., 1998

Animal	Stimulus	Mechanisms	Observations	Consequences	Sources
Humans	Aircraft noise, road traffic noise, community/ambient noise and occupational noise	Physiological responses: Hypertension; Coronary heart disease (CHD).	Increased systolic BP or hypertension diagnosis; Increased rates of CHD.	Problems with hypertension leading to heart disease; CHD; Annoyance.	Babisch, 2006; van Kempen et al., 2002; Babisch, 2000
Humans	Aircraft noise, road traffic noise, community/ambient noise and occupational noise	Physiological responses in adults and children: Stress hormones in the endocrine system (cortisol, adrenaline, noradrenaline).	Increased levels of these hormones being measured in urine and saliva.	Evidence linking stress hormone levels to health impairment is lacking but raised levels may impact of peripheral vascular system; Annoyance.	Babisch, 2003 (meta-analysis)
Humans	Aircraft noise, road traffic noise, community/ambient noise and occupational noise	Sleep disturbance.	Increased awakenings due to noise exposure; Taking longer to fall asleep; Evidence that habituation (as defined by Clark & Stansfeld, this issue) to exposure occurs.	Performance effects; Mood effects; Health effects associated with sleep disturbance; Noise during sleep may also stimulate heart rate; Annoyance.	Basner & Samel, 2005; HCN 2004; Miedema & Vos, 2007
Humans	Aircraft noise, road traffic noise, community/ambient noise	Psychological health.	Dose-response relationships between aircraft noise and depressiveness in adults; Some child studies have found increase reports of poor psychological health but others haven't.	Poor psychological functioning, wellbeing, quality of life.	Haines et al., 2001; Haines et al., 2001; Hiramatsu et al., 2000; Lercher et al., 2002; Stansfeld et al., 2005
Humans	Aircraft noise, road traffic noise, community/ambient noise	Children's cognition.	Impaired reading and short-term and long-term memory.	Impact on children’s learning and schooling.	Clark et al., 2006; Haines et al., 2001; Haines et al., 2001; Hygge, Evans & Bullinger, 2002; Stansfeld et al., 2005
Wedge-tailed eagle	Forestry operations *(chainsaw noise??)*	Fleeing.	Nest abandonment.	Breeding failure (for that year).	Mooney & Holdsworth, 1991; Mooney & Taylor, 1996

Animal	Stimulus	Mechanisms	Observations	Consequences	Sources
Robin	Ambient Noise	*Masking?*	Nocturnal Singing.	Increased risk of predation; Sleep deprivation.	Fuller, Warren & Gaston, 2007
Starlings	Barren cages	Anxiety.	Risk averse foraging.	Reduced intake of food.	Bateson & Matheson, 2007; Matheson, Asher & Bateson, 2007
Turnstones	Human presence	'Decision' based on context.	Variable alert and evasive depending on context.	Probably minimal (in this case).	Beale & Monaghan, 2004a
Kittiwake	Human presence	*Sympathetic responses?*	Variable: Elevated heart rate; Sleep/Awake proportion.	Variable: Increase nest failure (debatable long-term impact).	Beale & Monaghan, 2004a, 2004b
Wood lark	Human presence	'Decision' based on context.	Variable: nest selection; Disturbance avoidance.	Complicated: Potentially population level effects.	Mallord et al., 2007
Seals	Pollutants	Immunmodulation by metal (pollutants); Activation and/or suppression of lymphocyte reactions; Influence on cytokine expression.	See consequences.	Immunological dysfunction like hypersensitivity or immunosuppression; Changes in susceptibility to infection diseases.	Bennett et al., 2001; De Swart et al., 1996; Kakuschke et al., 2005; Kakuschke et al., 2006; Lalancette et al., 2003; Pillet et al., 2000; Ross, 2002; Siebert, et al., 1999
Cetaceans (15 different species)	Live stranding	*Vascular compromise?*	Accumulation of acute-phase proteins in hepatocytes; Acute liver congestion.	Unclear.	Godinho et al., 2005
Beluga	(Mutagenic) Pollutants	Activation and/or suppression of lymphocyte reactions; Consistent with GC and/or toxic effects of contaminants; Effects of mutagenic pollutants; PCB toxicology.	See consequences.	Immunological dysfunction in vitro & in vivo; Increase opportunistic bacterial infection; Adrenal cortex degeneration/proliferation; Cancer; CYP induction.	Buckingham, 2006; De Kloet et al., 1998; Escriva et al., 1997; Hahn, 2002; Herold, McPherson & Reichardt, 2006; Matsumara, 1995; McMillan et al., 2007; Remillard & Bunce, 2002; Wang et al., 2003; Williamson, Gasiewicz & Opanashuk, 2005

Animal	Stimulus	Mechanisms	Observations	Consequences	Sources
Eastern Tropical Pacific (ETP) dolphins	Purse-seine fishery (Acoustic cues associated with imminent capture attempt)	Set evasion.	Increased swim speed (2-3 m/sec); Leaping out of the water to breathe; Evasive maneuvering; Likely separation of mothers and young calves.	Energetic cost; Physiological stress response; School (social) disruption; Foraging disruption, Calf separation, Calf mortality, Capture myopathy.	Edwards, 2002, 2006; Myrick & Perkins, 1995; Noren & Edwards, 2007; Noren, Biedenbach & Edwards, 2006; NRC, 1992; Reilly et al., 2005; Weihs, 2004
ETP dolphins	Fishery capture	Wait for release.	Relatively calm milling and schooling in section of net far from vessel and close to section of net section where backdown channel will form.	Reduced net entanglement – therefore reduced in-net mortality; Interrupted social and foraging activities.	Edwards, 2002, 2006; Myrick & Perkins, 1995; Noren & Edwards, 2007; Noren, Biedenbach & Edwards, 2006; NRC, 1992; Reilly et al., 2005; Weihs, 2004
ETP dolphins	Release from purse-seine	Escape.	Prolonged (90 minutes) high speed (3-4 m/sec) escape swimming.	Energetic cost; Physiological stress response; School (social) disruption; Foraging disruption, Calf separation; calf mortality; Capture myopathy.	Edwards, 2002, 2006; Myrick & Perkins, 1995; Noren & Edwards, 2007; Noren, Biedenbach & Edwards, 2006; NRC, 1992; Reilly et al., 2005; Weihs, 2004
Harbor porpoise	Bycatch	*Suffocation?*	Accumulation of acute-phase proteins in hepatocytes; Death.	Death by suffocation.	Godinho et al., 2006
Marine mammals	Tonal/impulsive noise	Temporary Threshold Shift (TTS) in hearing.	TTS.	Compromised food-finding, navigation, and communication; Increased risk of predation	Finneran et al., 2002; Kastak et al., 1999; Schlundt et al., 2000
Cetaceans	Seismic surveys	*???*	Lower sighting rates; Avoidance of seismic array; Less feeding.	Energetic consequences.	Stone & Tasker, 2006
Coastal odontocetes	Chronic intermittent boat interactions	Flight response.	Behavioral budget alteration.	Reduced reproductive success; Decreased population viability; Habitat displacement.	Bejder, 2005; Bejder et al., 2006; Lusseau, 2004; Lusseau, Slooten & Currey, 2006

Animal	Stimulus	Mechanisms	Observations	Consequences	Sources
Coastal odontocetes	Boat interactions	Masking.	Reduce foraging time.	*Decreased survival rates?*	Erbe, 2002; Lusseau et al., submitted; Williams, Lusseau & Hammond, 2006
Small odontocetes	Seismic surveys	*???*	Faster swimming.	*Energetic consequences?*	Stone & Tasker, 2006
Bottlenose dolphins	Boat approach	*Masking of signals of interest for social communication and foraging?*	Higher whistling rate.	*Time/energy costs?* *Information ambiguity?*	Buckstaff, 2004
Beaked whales	Shipping noise	Masking of signals of interest for social communication and foraging.	High noise levels.	*Energetic consequences?* *Information ambiguity?*	Aguilar Soto et al., 2006
Beaked whales	Military exercises	Gas and fat embolism (hypothesis).	Atypical mass stranding (land and/or sea); Gas and fat embolic pathology.	Individual deaths; Possibly local population displacement or death.	Fernández et al., 2005; Jepson et al., 2003
Beaked whales	Shipping noise	*???*	*Activation of evasion mechanisms??*	Possible change in diving behaviour leading to reduction in foraging efficiency; Reduction in communication range.	Aguilar Soto et al., 2006
Killer whale	High boat traffic	*Masking of signals of interest for social communication and foraging?*	Increased call length.	*Time/energy costs?* *Information ambiguity?*	Foote, Osborne & Hoelzel, 2004
Killer whale	Acoustic Harassment Devicess	*???*	Long-term avoidance of area.	*Time/energy costs? Loss of opportunity for foraging, social interaction, mating?*	Morton & Symonds, 2002
Beluga	Boat noise	*Masking?*	Shifted frequencies; Used different call types.	Energetic/time/predator/prey costs; *Information ambiguity?*	Lesage et al., 1999
Beluga	Seismic like noise	*???*	Increased stress hormone levels.	*Immunity/illness consequences?*	Romano et al., 2004

Animal	Stimulus	Mechanisms	Observations	Consequences	Sources
Beluga	Icebreaker noise	*???*	Avoidance and flight at long ranges.	*Time/energy costs? Loss of opportunity for foraging, social interaction, mating?*	Cosens & Dueck, 1993; Finley et al., 1990
Pilot whales	MF sonar	*Masking?*	Increases in whistles.	*Time/energy costs?*	Rendell & Gordon, 1999
Sperm whales	Pingers	*???*	Fell silent.	*Compromised foraging or communication?*	Watkins & Schevill, 1975
Sperm whales	MF Sonar	*???*	Fell silent.	*Compromised foraging or communication?*	Watkins, Moore & Tyack, 1985
Sperm whales	Seismic surveys	*???*	Fewer creaks; No foraging dives near seismic vessel; Reduced fluke strokes and effort.	*Compromised foraging?*	IWC, 2007
Pilot, sperm whales	Low frequency pulses (similar to Acoustic Thermometry of Ocean Climate – ATOC – signals)	*???*	Decrease in vocalizations.	*Compromised foraging or communication?*	Bowles et al., 1994
Pilot, sperm whales	Seismic surveys	*???*	Decrease in vocalizations.	*Compromised foraging or communication?*	Bowles et al., 1994
Mysticetes	Seismic surveys	*???*	Avoidance; More time at surface; Fewer animals feeding.	*Time/energy costs?* *Reduced foraging?*	Stone & Tasker, 2006
Blue whales	Long range shipping noise	Masking.	Shifting frequency of call; May be some amplitude increase.	*Reduced mating opportunity?*	Croll et al., 2001; Payne & Webb, 1971
Fin whales	Seismic surveys	*???*	Suspension of vocalizations for weeks/months.	*Reduced mating opportunity?*	IWC, 2007
Fin whales	Boat noise	*???*	Decrease in vocalizations.	*Reduced mating opportunity?*	Watkins, 1986
Gray whales	Industrial noise, dredging and shipping	*???*	Long-term displacement of breeding area.	*Reduced mating opportunity?*	Bryant, Lafferty & Lafferty, 1984; Jones et al. 1994

Animal	Stimulus	Mechanisms	Observations	Consequences	Sources
Gray whales	Low frequency active (LFA) sonar (inshore)	*???*	Shift in migration path.	*Increased predation?* *Greater mother-calf/group separation??* *Anxiety?*	Tyack & Clark, 1988
Gray whales	Seismic surveys	*???*	Displacement out of primary feeding area; Faster respiration; Faster, straighter movement over larger areas.	*Reduced foraging?* *Time/energy costs?*	IWC, 2005, 2007
Gray whales and bowheads	Industrial noise	*???*	Shift in migration path.	*Increased predation?* *Greater mother-calf/group separation??* *Anxiety?*	Malme et al., 1983, 1984; Richardson et al., 1985; Richardson, Würsig & Greene, 1990
Bowheads	Seismic surveys	*???*	Shorter dives and lower respiration rates at as much as 50-70 km away.	*Widespread reduction in foraging?*	Richardson, Würsig & Greene, 1986
Humpbacks	LFA sonar	*???*	Mating songs lengthened.	*Long-term mating/energetic/time consequences?*	Fristrup, Hatch & Clark, 2003; Miller et al., 2000
Humpbacks	Seismic surveys	*???*	Avoidance; Occasional attraction prior to swimming away.	*Compromised foraging or breeding?*	McCauley et al., 2000
Humpbacks	Explosions	*???*	Greater entrapment in fishing gear	Often death.	Todd et al., 1996
Northern elephant seals	ATOC	*???*	Increased descent and decreased ascent rate in dives; Escape response.	*Reduced foraging?* *Time/energy costs?*	Costa et al., 2003

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IN THE UNITED STATES DISTRICT COURT

FOR THE DISTRICT OF HAWAII

CONSERVATION COUNCIL FOR HAWAII, et al., Plaintiffs, vs. NATIONAL MARINE FISHERIES SERVICE, et al. Defendants.	)	CIVIL NO. 13-00684 SOM/RLP AMENDED ORDER GRANTING CONSERVATION COUNCIL'S MOTION FOR SUMMARY JUDGMENT, GRANTING NRDC'S MOTION FOR SUMMARY JUDGMENT, DENYING NRDC'S MOTION FOR LEAVE TO SUBMIT EXTRA-RECORD EVIDENCE, AND GRANTING IN PART AND DENYING IN PART DEFENDANTS' MOTION TO STRIKE
NATURAL RESOURCES DEFENSE COUNCIL, INC, et al., Plaintiffs, vs. NATIONAL MARINE FISHERIES SERVICE, et al., Defendants.	)	CIVIL NO. 14-00153 SOM/RLP

AMENDED ORDER GRANTING CONSERVATION COUNCIL'S MOTION FOR SUMMARY JUDGMENT, GRANTING NRDC'S MOTION FOR SUMMARY JUDGMENT, DENYING NRDC'S MOTION FOR LEAVE TO SUBMIT EXTRA-RECORD EVIDENCE, AND GRANTING IN PART AND DENYING IN PART DEFENDANTS' MOTION TO STRIKE

I. INTRODUCTION.

This case involves challenges by environmental groups to federal government actions affecting vast areas of the Pacific Ocean and the marine life in those areas. Before the court is a motion for summary judgment filed in Civil No. 13-00684 by Plaintiffs Conservation Council for Hawaii, Animal Welfare Institute, Center for Biological Diversity, and Ocean Mammal

Institute (collectively, "Conservation Council"), and a separate motion for summary judgment filed in Civil No. 14-00153 by Plaintiffs Natural Resources Defense Council, Inc., Cetacean Society International, Animal Legal Defense Fund, Pacific Environment and Resources Center, and Michael Stocker (collectively, "NRDC"). The cases were consolidated by stipulation, but the stipulation provided that separate summary judgment motions could be filed by the parties in each case. See ECF Nos. 22, 23, 24 (ECF Nos. cited in this order refer to the docket sheet in Civil No. 13-00684). The court grants both summary judgment motions.

The government actions that are challenged in this case permit the Navy to conduct training and testing exercises even if they end up harming a stunning number of marine mammals, some of which are endangered or threatened. Searching the administrative record's reams of pages for some explanation as to why the Navy's activities were authorized by the National Marine Fisheries Service ("NMFS"), this court feels like the sailor in Samuel Taylor Coleridge's "The Rime of the Ancient Mariner" who, trapped for days on a ship becalmed in the middle of the ocean, laments, "Water, water, every where, Nor any drop to drink."

II. FACTUAL BACKGROUND.

The issues in this case are best understood by examining specific details, but the court begins by providing a broad overview. This introductory section thus has the limited purpose of providing the context for the challenges raised by Conservation Council and NRDC to the actions taken by NMFS and the Navy. Illustrations will be provided in connection with the court's analysis of specific challenges.

The Navy proposed to conduct training and testing activities in an area of the Pacific Ocean known as the Hawaii-Southern California Training and Testing ("HSTT") Study Area. This area includes (1) the Southern California Range Complex, consisting of San Diego Bay and approximately 120,000 square nautical miles of ocean between Dana Point, California, and San Diego, California; (2) the Hawaii Range Complex, consisting of approximately 2.7 million square nautical miles of ocean around the Hawaiian Islands; (3) Silver Strand Training Complex, on and adjacent to the Silver Strand, an isthmus between San Diego Bay and the Pacific Ocean; (4) pierside locations in Hawaii and Southern California; and (5) a transit corridor between Southern California and Hawaii. See ECF No. 70, PageID # 13556; ECF No. 79, PageID # 14041. Thirty-nine marine mammal species have been identified as occupying the HSTT Study Area, eight of which are endangered and one of which is threatened under the Endangered Species Act ("ESA"). See ECF No. 66-19, PageID # 10214.

In 2010, the Navy began the process of reviewing the environmental impact of its proposed activities and invited NMFS to act as a cooperating agency in the preparation of the environmental impact statement ("EIS"). The Navy ultimately issued its corrected Final Environmental Impact Statement ("FEIS") on August 30, 2013, and NMFS adopted that FEIS on December 5, 2013. ECF No. 66-18, PageID # 10201; ECF 66-21, PageID # 10267. While working on the FEIS, the Navy was also consulting with NMFS on compliance with the Endangered Species Act and was applying for Letters of Authorization from NMFS under the Marine Mammal Protection Act ("MMPA") that would allow the Navy to take, incidental to the Navy's training and testing activities, a certain number of marine mammals in the HSTT Study Area.

Under the MMPA, "to take" means "to harass, hunt, capture, or kill, or attempt to harass, hunt, capture, or kill any marine mammal." 16 U.S.C. § 1362(13). The Navy's proposed activities included "[s]onar use, underwater detonations, airguns, pile driving and removal, and ship strike," which the NMFS viewed as "the stressors most likely to result in impacts on marine mammals that could rise to the level of harassment, thus necessitating MMPA authorization." ECF No. 66-19, PageID # 10209.

The Navy sought authorization for the incidental take of the HSTT Study Area's thirty-nine species of marine mammals by Level B harassment. Id. at PageID # 10208. As applied to military readiness activities, Level B harassment is "any act that disturbs or is likely to disturb a marine mammal or marine mammal stock in the wild by causing disruption of natural behavioral patterns, including, but not limited to, migration, surfacing, nursing, breeding, feeding, or sheltering, to a point where such behavioral patterns are abandoned or significantly altered." 16 U.S.C. § 1362(18)(B)(ii). In addition, the Navy sought authorization for the incidental take of twenty-four of the thirty-nine species of marine mammals by Level A harassment or mortality. ECF No. 66-19, PageID # 10208. Level A harassment is "any act that injures or has the significant potential to injure a marine mammal or marine mammal stock in the wild." 16 U.S.C. § 1362(18)(B)(i).

In December 2013, pursuant to the MMPA, NMFS issued its Final Rule applicable to the period from December 2013 through December 2018, and issued Letters of Authorization permitting the Navy to take marine mammals in the HSTT Study Area during that period. In summary, NMFS determined that the effect of the activities proposed by the Navy would have a "negligible impact" on all the marine mammal species and stocks that would be affected. See ECF No. 66-19, PageID # 10249. NMFS set authorized take levels for Level A and Level B harassment for each such species or stock. The authorized take levels were the levels requested in the Navy’s application and included authorized mortalities. See id. at PageID #s 10244-48.

Also in December 2013, the NMFS-ESA Cooperation Division issued a final Biological Opinion concerning the Navy’s activities. The Biological Opinion included NMFS’s finding of “no jeopardy” to endangered whale species, authorization for an “unspecified number” of takes of turtles by vessel strikes, and a finding of “no jeopardy” to turtles.

Amended versions of the December 2013 LOAs and Biological Opinion subsequently issued. See ECF No. 67-22, PageID #s 12766-69; ECF No. 67-23, PageID #s 12784-87; ECF No. 67-19.

Conservation Council has sued NMFS, which falls under the jurisdiction of the Department of Commerce, and other related parties, seeking judicial review under the Administrative Procedure Act (“APA”) of administrative decisions that Conservation Council asserts violate the National Environmental Policy Act (“NEPA”), the MMPA, and the ESA. See ECF No. 78. NRDC has sued NMFS and related federal officials as well as the Navy, similarly seeking judicial review under the APA for alleged violations of the MMPA and the ESA. See ECF No. 73. Plaintiffs in both cases seek summary judgment on all their claims.

For their part, Defendants contend that, having complied with the requirements of NEPA, the MMPA, and the ESA, they are entitled to summary judgment in their favor in both actions. <u>See</u> ECF No. 68; ECF No. 71.

III. STATUTORY FRAMEWORK.

This case requires analysis of four statutory schemes.

A. MMPA.

The MMPA was enacted to address concern that "certain species and population stocks of marine mammals are, or may be, in danger of extinction or depletion as a result of man's activities." 16 U.S.C. § 1361(1). Congress noted that "such species and population stocks should not be permitted to diminish beyond the point at which they cease to be a significant functioning element in the ecosystem of which they are a part, and, consistent with this major objective, they should not be permitted to diminish below their optimum sustainable population." 16 U.S.C. § 1361(2).

The MMPA imposes a general prohibition on the "taking" of marine mammals unless the taking falls under a statutory exception. <u>See</u> 16 U.S.C. § 1371(a).

One statutory exception to the prohibition on the taking of marine mammals permits "citizens of the United States who engage in a specified activity (other than commercial fishing) within a specified geographical region" to take "small numbers of marine mammals of a species or population stock" during "periods of not more than five consecutive years each" if the Secretary[1] finds that "the total of such taking during each five-year (or less) period concerned will have a negligible impact on such species or stock and will not have an unmitigable adverse impact on the availability of such species or stock for taking for subsistence uses." 16 U.S.C. § 1371(a)(5)(A)(i).

Congress amended the MMPA to exempt military readiness activities from the "specified geographical region" and "small numbers" requirements in 16 U.S.C. § 1371(a)(5)(A)(i). See 16 U.S.C. § 1371(a)(5)(F). Therefore, take of marine mammals incidental to military readiness activities, such as the Navy's activities at issue in this case, may be permitted if the taking will have a "negligible impact" on an affected species or stock and will not have "an unmitigable adverse impact on the availability of such species or stock for taking for subsistence uses." 16 U.S.C. § 1371(a)(5)(A)(i).

If those two findings are made, the Secretary must prescribe regulations setting forth "permissible methods of

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[1] "Secretary" is defined as "the Secretary of the department in which the National Oceanic and Atmospheric Administration is operating, as to all responsibility, authority, funding, and duties under this chapter with respect to members of the order Cetacea and members, other than walruses, of the order Pinnipedia" and "the Secretary of the Interior as to all responsibility, authority, funding, and duties under this chapter with respect to all other marine mammals covered by this chapter." 16 U.S.C. § 1362(12)(A). NOAA falls within the Department of Commerce, meaning that protection of marine mammals is split between the Department of Commerce and the Department of the Interior.

taking" and "other means of effecting the least practicable adverse impact on such species or stock and its habitat." 16 U.S.C. § 1371(a)(5)(A)(i)(II)(aa). In determining the "least practicable adverse impact" with respect to a military readiness activity, the Secretary is required to consider "personnel safety, practicality of implementation, and impact on the effectiveness of the military readiness activity." 16 U.S.C. § 1371(a)(5)(A)(ii).

B. ESA.

The ESA requires federal agencies, in consultation with the Secretary of Commerce, to "insure that any action authorized, funded, or carried out by such agency . . . is not likely to jeopardize the continued existence of any endangered species or threatened species or result in the destruction or adverse modification of habitat of such species." 16 U.S.C. § 1536(a)(2). "Jeopardize the continued existence of means to engage in an action that reasonably would be expected, directly or indirectly, to reduce appreciably the likelihood of both the survival and recovery of a listed species in the wild by reducing the reproduction, numbers, or distribution of that species." 50 C.F.R. § 402.02.

The Secretary of Commerce has delegated responsibility for administering the ESA with respect to threatened and endangered marine species to NMFS. See 50 C.F.R. § 17.2; see also Trout Unlimited v. Lohn, 645 F. Supp. 2d 929, 932 (D. Or. 2007).

After completing consultation regarding a proposed action, NMFS must prepare a Biological Opinion that discusses whether the proposed action is likely to cause jeopardy and the effects of the proposed action on listed species or on the species' critical habitat. 50 C.F.R. § 402.14(h). In preparing its Biological Opinion, NMFS must use "the best scientific and commercial data available." 50 C.F.R. § 402.14(g)(8).

If NMFS concludes that a proposed action will result in the incidental taking of an endangered or threatened species but will not cause jeopardy, it must include in its Biological Opinion an "incidental take statement" specifying, among other things, "the impact of such incidental taking on the species" affected. See 16 U.S.C. § 1536(b)(4); 50 C.F.R. § 402.14(i). If an endangered or threatened species of marine mammal is involved, the take must be authorized under the MMPA. See 16 U.S.C. § 1536(b)(4)(C). Under the ESA, a taking that complies with an incidental take statement "shall not be considered to be a prohibited taking of the species concerned." See 16 U.S.C. § 1536(o)(2).

C. NEPA.

NEPA is the "basic national charter for protection of the environment." 40 C.F.R. § 1500.1(a). Congress enacted NEPA to ensure that all federal agencies would factor environmental considerations into decisionmaking.

To achieve this goal, NEPA requires a federal agency to prepare an EIS for "major Federal actions significantly affecting the quality of the human environment." 42 U.S.C. § 4332(2)(C). The EIS "shall provide full and fair discussion of significant environmental impacts and shall inform decisionmakers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment." 40 C.F.R. § 1502.1.

An EIS shall "[r]igorously explore and objectively evaluate all reasonable alternatives, and for alternatives which were eliminated from detailed study, briefly discuss the reasons for their having been eliminated." 40 C.F.R. § 1502.14(a). "[S]ubstantial treatment" must be devoted "to each alternative considered in detail including the proposed action so that reviewers may evaluate their comparative merits." 40 C.F.R. § 1502.14(b). A "no action" alternative also must be considered. 40 C.F.R. § 1502.14(c).

In reviewing an EIS, courts must ensure that the agency has taken a "hard look" at the environmental consequences of the proposed action. See Earth Island Inst. v. U.S. Forest Serv., 351 F.3d 1291, 1300 (9th Cir. 2003); Smallwood v. U.S. Army Corps of Eng'rs, Civ. No. 08-00512 DAE-KSC, 2009 WL 196228, at *10 (D. Haw. Jan. 26, 2009).

D. Administrative Procedure Act.

The APA is the vehicle through which challenges to agency action as violative of the MMPA, ESA, and NEPA are brought to court. Oregon Natural Res. Council v. Allen, 476 F.3d 1031, 1036 (9th Cir. 2007) (review of ESA challenge under the APA); Ocean Advocates v. U.S. Army Corps of Eng'rs, 402 F.3d 846, 858 (9th Cir. 2005) (review of MMPA and NEPA challenges under the APA).

Under the APA, a court must set aside agency action that is "arbitrary" or "capricious." 5 U.S.C. § 706; see also Butte Envtl. Council v. U.S. Army Corps of Eng'rs, 620 F.3d 936, 945 (9th Cir. 2010). Review under the arbitrary and capricious standard is "highly deferential, presuming the agency action to be valid and affirming the agency action if a reasonable basis exists for its decision." Sacora v. Thomas, 628 F.3d 1059, 1068 (9th Cir. 2010) (internal quotation marks omitted). "A reasonable basis exists where the agency considered the relevant factors and articulated a rational connection between the facts found and the choices made." Arrington v. Daniels, 516 F.3d

1106, 1112 (9th Cir. 2008) (internal quotation marks omitted). An agency's decision will be set aside only if

> it has relied on factors which Congress had not intended it to consider, entirely failed to consider an important aspect of the problem, offered an explanation for its decision that runs counter to the evidence before the agency, or is so implausible that it could not be ascribed to a difference in view or the product of agency expertise.

Butte, 620 F.3d at 945 (internal quotation marks omitted). A court may not "infer an agency's reasoning from mere silence." Crickon v. Thomas, 579 F.3d 978, 982 (9th Cir. 2009) (internal quotation marks omitted). "[E]ven when an agency explains its decision with less than ideal clarity, a reviewing court will not upset the decision on that account if the agency's path may reasonably be discerned." Id.

IV. LEGAL STANDARD.

The parties ask this court to resolve their dispute through summary judgment motions. Summary judgment shall be granted when "the movant shows that there is no genuine dispute as to any material fact and the movant is entitled to judgment as a matter of law." Fed. R. Civ. P. 56(a) (2010); see Addisu v. Fred Meyer, Inc., 198 F.3d 1130, 1134 (9th Cir. 2000). However, in the context of reviewing an administrative decision under the APA, "there are no disputed facts that the district court must resolve." Occidental Eng'g Co. v. I.N.S., 753 F.2d 766, 769 (9th Cir. 1985). "[T]he function of the district court is to determine whether or not as a matter of law the evidence in the administrative record permitted the agency to make the decision it did." Id.; see also City & Cnty. of San Francisco v. United States, 130 F.3d 873, 877 (9th Cir. 1997). "[S]ummary judgment is an appropriate mechanism for deciding the legal question of whether the agency could reasonably have found the facts as it did." Occidental, 753 F.2d at 770.

V. EXTRA-RECORD MATERIAL.

A. NRDC's Motion for Leave to Submit Extra-Record Evidence is Denied.

Judicial review of agency action is generally limited to the administrative record. Lands Council v. Powell, 395 F.3d 1019, 1029 (9th Cir. 2005). There are narrow exceptions to this general rule. Extra-record evidence may be allowed when "(1) supplementation is necessary to determine if the agency has considered all factors and explained its decision; (2) the agency relied on documents not in the record; (3) supplementation is needed to explain technical terms or complex subjects; or (4) plaintiffs have shown bad faith on the part of the agency." San Luis & Delta-Mendota Water Auth. v. Jewell, 747 F.3d 581, 603 (9th Cir. 2014) (quoting Fence Creek Cattle Co. v. U.S. Forest Serv., 602 F.3d 1125, 1131 (9th Cir. 2010)). NRDC relies on the third exception, arguing that extra-record evidence is necessary to clarify complex scientific concepts for the court. See ECF No. 76, PageID # 13857.

The court does not agree with NRDC that it needs the extra-record evidence NRDC wishes to submit. The exceptions to the general rule against extra-record evidence "operate to identify and plug holes in the administrative record." Powell, 395 F.3d 1019, 1030 (9th Cir. 2005). NRDC fails to identify any holes in the administrative record that need to be plugged. Many of the terms and concepts NRDC identifies as warranting explanation are adequately explained in the record or need not be reviewed in such depth that additional evidence is needed.

B. Defendants' Motion to Strike is Granted in Part and Denied in Part.

Defendants move to strike the Declaration of Robin W. Baird, Ph.D., and Exhibits 1, 3, 4, and 5 to the declaration, arguing that no exception to the general rule barring extra-record evidence applies. See ECF No. 53, PageID # 1993.

Conservation Council argues that the Baird declaration is necessary to explain complex scientific matters and to show whether NMFS considered all factors and explained its decision. See ECF No. 83, PageID #s 14268-74. Exhibit 1 is Baird's curriculum vitae. Conservation Council also argues that Exhibits 3, 4, and 5 may be taken into account to show whether NMFS considered all factors and explained its decision. See id. at PageID #s 14257-67.

The court strikes the Baird declaration and Exhibit 1. Conservation Council fails to show that the Baird declaration is necessary to explain technical terms or complex subjects. Conservation Council does not point to any specific concepts or terms absent from, or inadequately addressed in, the administrative record. While Conservation Council contends that the Baird declaration "provides necessary technical expertise" regarding the scientific tools available to NMFS, ECF No. 83, PageID # 14270, Conservation Council does not show that such "technical expertise" is needed to decide the motions before this court. Conservation Council may be offering the Baird declaration to explain the material contained in Exhibits 3, 4, and 5, but it is not clear that those documents require further explanation.

Nor is the Baird declaration necessary to a determination as to whether NMFS considered all factors and explained its decision. Exhibits 3, 4, and 5 respond to that need on their own, and no scientific interpreter is necessary.

The court will supplement the administrative record with Exhibits 3, 4, and 5. Those documents are offered to show the existence of particular factors, approaches, or analyses that NMFS did not utilize. This is a purpose falling squarely within the first exception to the general rule barring extra-record evidence. See Jewell, 747 F.3d at 603 (extra-record evidence is permitted if: "(1) supplementation is necessary to determine if the agency has considered all factors and explained its decision" (quoting Fence Creek Cattle Co. v. U.S. Forest Serv., 602 F.3d 1125, 1131 (9th Cir. 2010))). As Conservation Council notes, it must be able to show the existence and availability of a particular approach to support its argument that the approach was relevant and was not considered by NMFS. See Asarco, Inc. v. U.S. Envtl. Prot. Agency, 616 F.2d 1153, 1160 (9th Cir. 1980) ("It will often be impossible . . . for the court to determine whether the agency took into consideration all relevant factors unless it looks outside the record to determine what matters the agency should have considered but did not. The court cannot adequately discharge its duty to engage in a 'substantial inquiry' if it is required to take the agency's word that it considered all relevant matters.").

Exhibits 3, 4, and 5 were all prepared by NMFS, are all publicly available and easily accessible, and present no facts new to the parties, unlike the declarations submitted by NRDC, which provide new explanations or interpretations of matters in the administrative record.

The Baird declaration (ECF No. 79-1) and any references to it are stricken. Exhibit 1, Dr. Baird's curriculum vitae (ECF No. 79-2), is stricken as irrelevant. The court has not considered any of the stricken material in arriving at its summary judgment rulings.

VI. CONSERVATION COUNCIL AND NRDC ARE ENTITLED TO SUMMARY JUDGMENT.

A. NMFS's "Negligible Impact" Finding Under the MMPA is Arbitrary and Capricious.

To permit the taking of marine mammals incident to military readiness activities, NMFS is required to find that the taking will have a "negligible impact" on affected species or stock. 16 U.S.C. § 1371(a)(5)(A)(i). Under the MMPA, a taking has a "negligible impact" if it "cannot be reasonably expected to, and is not reasonably likely to, adversely affect the species or stock through effects on annual rates of recruitment or survival." 50 C.F.R. § 216.103.

While NMFS has found that the Navy's proposed activities will have a "negligible impact" on affected species or stock in the HSTT Study Area, that finding is so insufficiently supported as to be arbitrary and capricious.

1. NMFS Must Examine the Impact of the Authorized Take, Not the Anticipated Take.

Before analyzing the bases NMFS provides for its "negligible impact" finding, this court resolves an unexpected dispute. The parties have spilled much ink over the subject of what kind of take needs to have only a negligible impact. Conservation Council and NRDC are adamant that the take that NMFS has *authorized* must have a negligible impact. See ECF No. 89, PageID # 14357; ECF No. 90, PageID # 14368. Defendants, however, say that what is relevant in this case is the take that is *anticipated*. In Defendants' view, NMFS is "required to find that the incidental take expected from the activity, not the take requested, would have a negligible impact on affected species." ECF No. 88, PageID # 14338.

In this case, the take requested was the take authorized, and the take authorized exceeds what NMFS and the Navy say is the take that is anticipated. In short, this threshold determination is not merely technical; there are substantial differences between the anticipated take numbers and the authorized take numbers. For example, the Navy is authorized to kill nineteen small odontocetes (e.g., dolphins) and pinnipeds (e.g., seals, sea lions) per year by testing activities using impulsive sound sources, even though the Navy says it expects no such mortalities to occur. See ECF No. 66-6, PageID # 9558. The Navy is also authorized to kill six large whales per year by vessel strike, even though the Navy says that the likelihood of such mortalities is virtually nil. See id. at PageID # 9636.

This dispute takes the court by surprise for two reasons. First, the MMPA makes it clear that it is *authorized* take that must be evaluated in determining whether there will be only a negligible impact. Specifically, the MMPA says that the Secretary "shall allow . . . the incidental . . . taking . . . . of . . . marine mammals of a species or population stock if the

Secretary . . . finds that the *total of such taking* . . . will have a negligible impact on such species or stock." 16 U.S.C. § 1371(a)(5)(A)(i) (emphasis added). Because "the total of such taking" is the incidental taking that the Secretary "shall allow," this court concludes that the statute looks to the authorized take.

Second, if an agency bases its finding on the anticipated take but can then authorize a far greater take than is anticipated, the authorized take could end up having no basis at all. Suppose, for example, that the Navy anticipated that a particular exercise would kill one sperm whale in a certain stock of that endangered species, and NMFS found that to be a negligible impact. Under Defendants' reasoning, NMFS could then authorize the killing of any number of sperm whales, just because only one killing was anticipated. It makes no sense for NMFS to be able to *authorize* ten, fifty, or a hundred killings once it finds that the *anticipated* killing of one whale will have a "negligible impact." The impact of taking the additional nine, forty-nine, or ninety-nine whales would not have been considered at all before being authorized.

In fact, allowing any agency to apply this kind of reasoning to authorize the taking of marine mammals could not only mean authorizing the wiping out of endangered and threatened species, it could also mean authorizing the extinction of even marine mammals that are not endangered or threatened. After all, under Defendants' reasoning, if the taking of a hundred mammals was anticipated and an agency found that for that particular plentiful mammal the loss of a hundred would have a negligible impact, Defendants' reasoning would allow the agency to authorize the taking of a million such mammals.

While the court doubts that Defendants would argue that the MMPA allows the exaggerated example the court posits, and the court is certainly not suggesting that Defendants have any interest in giving or receiving authorization for such a take, that example is precisely where Defendants' argument leads.

This court's focus throughout this case will be on the take *authorized* by NMFS. As a practical matter, it is the exceeding of the authorized take level that triggers a review of the Navy's activities by NMFS. See 54 Fed. Reg. at 40,347 (Sept. 29, 1989) ("[W]hen an incidental take authorization is exceeded, the activity must be reevaluated."). While a review may also occur if the *anticipated* take is exceeded, even defense counsel conceded at the hearing on these motions that a review is not necessarily required solely because the anticipated take level is exceeded. Indeed, as defense counsel noted at the hearing, the very reason that the Navy sought authorization of takes in excess of anticipated levels in the first place was that the Navy wanted to avoid having its exercises interrupted. If it had Letters of

Authorization providing authorized take levels, the Navy would not need to stop its activities even if the activities were clearly affecting marine mammals, so long as the Navy did not exceed the authorized take levels. The Navy thus considered the authorized take to be a check on its behavior, while nothing in the record suggests that the anticipated take operated with equivalent effect.

No one is disputing the importance of military readiness, but recognition of that importance does not permit the parties or this court to ignore the MMPA. Although MMPA provisions have been adjusted with respect to military activities, those adjustments do not permit the Navy to skirt the MMPA purely to avoid having its training and testing activities interrupted. Focusing on the authorized take, this court therefore turns to the bases of NMFS's "negligible impact" finding to determine whether that finding is supportable.

2. NMFS Failed To Analyze the Effects of Authorized Takes on Many Affected Species and Stocks.

The MMPA requires examination of the impact of the activities in issue not only on affected species, but also on affected stocks of marine mammals. A "stock" refers to a group of marine mammals within a species, such as the Island of Oahu's stock of bottlenose dolphins, or the California coastal stock of bottlenose dolphins. See 16 U.S.C. § 1362(11) ("The term ‘population stock’ or ‘stock’ means a group of marine mammals of the same species or smaller taxa in a common spatial arrangement, that interbreed when mature.”).

Conservation Council and NRDC contend that NMFS’s “negligible impact” finding is arbitrary and capricious because NMFS failed to address the effects of authorized take on all the marine mammal species and stocks affected. This court agrees.

The requirement that NMFS examine the effect on every species and stock affected is contained in the statutory provisions permitting the taking of marine mammals of a species or population stock upon a finding that the authorized taking “will have a negligible impact on *such species or stock* and will not have an unmitigable adverse impact on the availability of such species or stock for subsistence uses.” 16 U.S.C. § 1371(a)(5)(A)(i) (emphasis added). Notwithstanding this statutory requirement, the court is unable to locate in the voluminous administrative record a discussion of all the affected species and stocks.

NMFS did prepare a “Five-Year Regulation” or Final Rule, and that document does contain a section with the heading “Species-Specific Analysis.” ECF No. 66-19, PageID #s 10249-52. However, despite its promising heading, that section overlooks numerous species and stocks.

The "Species-Specific Analysis" includes a subsection on "mysticetes" that mentions "humpback, blue, Western North Pacific gray, fin, and sei whales" without including a separate discussion of the effects on the population of each. There is a discussion of humpback whale activity around Hawaii and the Navy's agreement to limit its activities in the designated Humpback Whale Cautionary Area. There is also a reference to the use of waters in the Southern California portion of the HSTT Study Area as a summer feeding ground by the California, Oregon, Washington stock of humpback whales. This cursory reference by no means corresponds to a review of the effect of the Navy's activities on that stock. The report also says that feeding areas for fin and blue whales overlap the SOCAL Range Complex but asserts that major training events are not typically planned there and that the whales are large enough to be easily avoided.

Without analyzing the content of each subsection within the "Species-Specific Analysis" section, the court notes that the subsections cover sperm whales, pygmy and dwarf sperm whales, Dall's porpoise, beaked whales, false killer whales, short-beaked common dolphins, California sea lions, northern fur seals, northern elephant seals, and Hawaiian monk seals. Conservation Council complains that NMFS never discusses stocks of Guadalupe fur and harbor seals; bottlenose, Fraser's, long-beaked common, northern right whale, Pacific white-sided, pantropical spotted, Risso's, rough-toothed, spinner, and striped dolphins; and killer, pygmy killer, short-finned pilot, and melonheaded whales. ECF No. 78, PageID # 14004.

Defendants point to two pages of NMFS's Final Rule preceding the "Species-Specific Analysis," see ECF No. 66-19, PageID #s 10248-49, but those pages do not explain NMFS's determination that authorized take would have a negligible impact on the species and stock not mentioned in the "Species-Specific Analysis." Defendants also cite to large portions of NMFS's Proposed Rule, but many of the pages cited are irrelevant to the present inquiry. The pages that bear some relevance discuss the potential effects of impulsive and nonimpulsive sound sources and vessel strike on marine mammals, but do not examine, with specific reference to the Navy's proposed activities, what impact those potential effects may have on annual rates of recruitment and survival of affected species and stock. See ECF No. 66-10, PageID #s 9902-16.

This court is not saying that an agency may never group stocks in considering the effects of a proposed activity. The court can certainly envision the possibility that, if a certain species typically reacts to a certain stimulus in a certain manner, an agency may have a basis for assuming that members in different stocks of that species will react similarly. That is, if, for example, a certain species of whale typically leaves an area when sonar signals are emitted at a certain distance, level, and volume, there may be no reason for an agency to have to discuss reactions stock-by-stock. That does not mean, however, that the analysis of population effects may be grouped, as it is unlikely that different stocks of the same species will share the same population numbers, or have identical sex, age, and reproduction statistics such that the effects of an activity on the different stock populations can be assumed to be identical.

The clearest evidence that NMFS failed to consider the impact of the Navy's activities on all the affected species and stocks is ironically contained in the chart it submitted in response to an order requiring that Defendants provide specific record references by species and stock to show that NMFS did indeed consider the effect of the Navy's activities on all affected species and stocks. See ECF No. 95. With respect to the stocks not addressed in NMFS's "Species-Specific Analysis," NMFS provides record references to only general discussions with little, if any, relevance to the population-level effects on specific species and stock, and to conclusory statements that no such effects are expected. This is nothing short of an admission that many stocks and species lack discussions in the record about the effects of the proposed Navy activities on them specifically. See, e.g., ECF No. 95-1, PageID #s 14543-53 (citing exactly the same 10 pages in the administrative record for 25 stocks, including stocks from different species, with frequent direction for the reader looking at the chart entry for one stock to see the chart entry for another stock).

The chart is particularly notable for highlighting how little attention NMFS gave to the effect on the populations of affected species and stocks of the mortalities the Navy was asking NMFS to authorize. In the chart, NMFS cites to brief discussions in the administrative record of mortalities of short-beaked common dolphins, Northern elephant seals, and California sea lions by explosion, stating for each that lethal takes "would be unlikely to have measurable long-term consequences" because the stock consists of hundreds of thousands of animals. See ECF No. 64-22, PageID #s 5684, 5686, 5694, 5695; see also id. at PageID #s 5698, 5704. For the remaining species and stocks affected by lethal takes, NMFS cited to no analysis at all of the population-level effects of lethal takes.

That NMFS cannot point to where it analyzed the impact of at least deaths on all species and stocks is particularly troubling to the court. The court can no more find the rationale for NMFS's conclusion that "any mortalities that do occur up to the maximum authorized levels would have a negligible impact on marine mammal species or stocks," ECF No. 68 at PageID # 13500, than it can find the rationale for NMFS's almost identical statement that "any resulting impacts to individuals are not expected to affect annual rates of recruitment or survival," ECF No. 66-19, PageID # 10250. The most Defendants do is cite pages of NMFS's Final Rule, ECF No. 66-19, PageID #s 10248-49, that are silent with respect to numerous species and stocks. Thus, the court cannot determine from the pages Defendants cite why NMFS concluded, for example, that the fifteen large whale mortalities authorized will have a negligible impact on the whale species affected. This failure is especially puzzling in light of NMFS's recognition that "[t]he death of a female of any of the large whale species would result in a reduced reproductive capacity of the population or species." ECF No. 67-19, PageID # 12661.

NMFS must "articulate[] a rational connection between the facts found and the choices made." Arrington, 516 F.3d at 1112 (internal quotation marks omitted). While not concluding that the discussions of the species and stocks mentioned in the "Species-Specific Analysis" are adequate, the court has no hesitation in saying that, when NMFS does not actually analyze the impact on certain species and stocks, NMFS does not satisfy its burden of showing how it reached its conclusions with respect to those species and stocks. The court is left unable to determine how NMFS could conclude what impact the Navy's activities would have on the recruitment or survival of those species and stocks.

For species and stocks that are at least mentioned, this court sees no reason to examine whether NMFS sufficiently considered the impact of the proposed Navy activities on them. That is because it is not clear that the Navy would even have applied for authorization to take only those species and stocks. The Navy knew that its proposed activities would likely affect more than those species and stocks, and authorization to take fewer than all affected species and stocks would not likely have sufficed for the Navy's purposes.

NMFS's failure to explain the bases of its conclusion with respect to all species and stocks affected renders its "negligible impact" findings arbitrary and capricious. See Ctr. For Biological Diversity v. Kempthorne, 588 F.3d 701, 710 (9th Cir. 2009) ("A negligible impact finding is arbitrary and capricious under the MMPA . . . if the agency . . . entirely failed to consider an important aspect of the problem." (internal quotation marks omitted)).

The court understands that NMFS may not have readily available data for each stock. Even if, as NMFS argues, it has no duty to create such data, it can hardly justify concluding that the Navy's activities will have only a "negligible impact" on every stock, much less justify setting stock-specific authorized take levels, if it has no information on which to base such a conclusion or authorized take level. That is clearly arbitrary and capricious. Having made "negligible impact" findings and set authorized take levels for all affected species and stocks without articulating its bases, NMFS acted arbitrarily and capriciously.

3. NMFS Failed to Use the "Best Scientific Evidence Available."

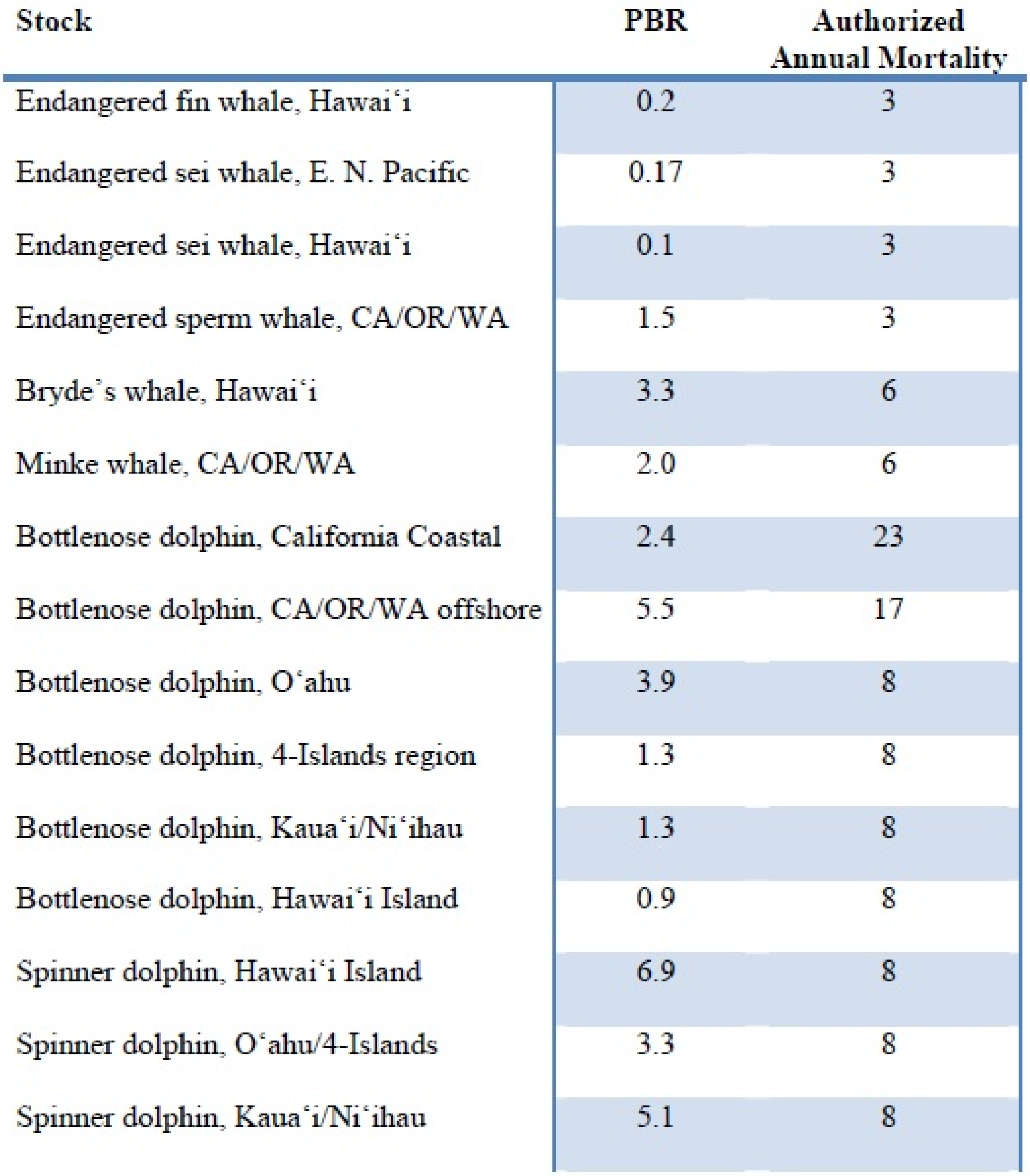
Under 50 C.F.R. § 216.102(a), NMFS was required to use the "best scientific evidence available" in making its finding of "negligible impact." NMFS acted arbitrarily and capriciously in failing to use the best scientific evidence available.

Conservation Council and NRDC point to more than one kind of scientific evidence that they complain NMFS should have relied on but ignored. In this order, this court zeroes in on one particular kind of evidence that NMFS disregarded: evidence of "Potential Biological Removal" ("PBR") levels. A PBR level is defined in the MMPA as "the maximum number of animals, not including natural mortalities, that may be removed from a marine mammal stock wile allowing that stock to reach or maintain its optimum sustainable population." 16 U.S.C. § 1362(20); see ECF No. 78, PageID #s 14007-08. NMFS authorized the Navy to kill marine mammals in 15 stocks at levels much higher than their PBR levels. Because any mortality level that exceeds PBR will not allow the stock to reach or maintain its optimum sustainable population ("OSP"), such a mortality level could not be said to have only a "negligible impact" on the stock.

Indeed, the MMPA provides that "species and population stocks . . . should not be permitted to diminish below their optimum sustainable population." 16 U.S.C. § 1361(2). See also 54 Fed. Reg. at 40,341, 40,342 ("In order to make a negligible impact finding, the proposed incidental take must not prevent a depleted population from increasing toward its OSP." . . . "If a particular stock were known to be within its OSP range, then the Service believes a finding of negligible impact can only be made if the permitted activities are not likely to reduce that stock below its OSP. However, not all takings that do not reduce the population below its OSP would be considered negligible.").

In 1999, NMFS itself developed criteria for comparing incidental mortality levels to PBR levels in the fisheries context. Those criteria provided, "If total fisheries related serious injuries and mortalities are greater than PBR, permits may not be issued." 64 Fed. Reg. 28,800-01 (May 27, 1999). Conservation Council argues that NMFS should have used those criteria in setting authorized mortality levels for the marine mammals that would be affected by the Navy's activities. Disregarding PBR, NMFS set authorized mortalities at levels higher than PBR for 15 stocks, some of them involving endangered whales.

This is one of the instances alluded to earlier in this order in which the issue is best understood by examination of specific details. The court therefore includes here a chart prepared by Conservation Council:



Stock	PBR	Authorized Annual Mortality
Endangered fin whale, Hawai‘i	0.2	3
Endangered sei whale, E. N. Pacific	0.17	3
Endangered sei whale, Hawai‘i	0.1	3
Endangered sperm whale, CA/OR/WA	1.5	3
Bryde’s whale, Hawai‘i	3.3	6
Minke whale, CA/OR/WA	2.0	6
Bottlenose dolphin, California Coastal	2.4	23
Bottlenose dolphin, CA/OR/WA offshore	5.5	17
Bottlenose dolphin, O‘ahu	3.9	8
Bottlenose dolphin, 4-Islands region	1.3	8
Bottlenose dolphin, Kaua‘i/Ni‘ihau	1.3	8
Bottlenose dolphin, Hawai‘i Island	0.9	8
Spinner dolphin, Hawai‘i Island	6.9	8
Spinner dolphin, O‘ahu/4-Islands	3.3	8
Spinner dolphin, Kaua‘i/Ni‘ihau	5.1	8

ECF No. 78, PageID # 14009.

As shown by the chart included here, NMFS authorized an annual mortality for the Hawaii stock of endangered sei whales of 3, which was 30 times the PBR level of 0.1. NMFS authorized an annual mortality of 8 for the Hawaii Island stock of bottlenose dolphins, which was nearly 9 times the PBR level of 0.9. Confusingly, the number 8 was the same number of deaths authorized for the Oahu stock of bottlenose dolphins, which had a PBR of 3.9.

Defendants respond to the PBR-related argument in two ways.

First, Defendants raise procedural arguments, contending that the matter is not properly before this court. They note, for example, that nothing about PBR levels is mentioned in any iteration of the Complaints filed by Conservation Council or NRDC. See ECF No. 68, PageID # 13501. The court is unpersuaded by this contention.

Conservation Council's pleading asserts that NMFS "failed to perform any scientifically valid analyses to determine whether the authorized take levels would have only a negligible impact on each of the affected species or stocks." ECF No. 41, PageID # 366. This allegation put Defendants on notice that Conservation Council was challenging NMFS's scientific analysis in evaluating authorized take. Conservation Council was not required to refer expressly to PBR levels to satisfy the requirement in Rule 8(a) of the Federal Rules of Civil Procedure that its complaint contain a short and plain statement of its claims.

Similarly, NRDC alleged in its pleading, "The Service's issuance of a Final Rule and Letters of Authorization permitting the take of marine mammals incidental to the Navy exercises challenged here violates the requirements of 16 U.S.C. § 1371 and its implementing regulations. The Service failed, among other things, to consider the best available scientific information, and to properly analyze the information it did consider, when it concluded that the requested takes of beaked whales, endangered blue whales, and other marine mammals will have a negligible impact on those species or stocks." ECF No. 40, PageID # 310. This allegation gave Defendants sufficient notice that NRDC was challenging NMFS's purported use of the best available scientific information. Rule 8(a) did not require further allegations by NRDC on this point.

In another try at raising a procedural bar, Defendants contend that even if Conservation Council and NRDC properly pled the PBR argument, they may not raise the PBR issue here because they did not mention PBR when they commented on NMFS's Proposed Rule. See ECF No. 68, PageID # 13501; ECF No. 71, PageID # 13625. Once again, this court is unpersuaded. Defendants' reliance on the doctrine of waiver is noticeably lacking any suggestion that allowing Conservation Council and NRDC to advance the PBR argument at this time would take Defendants by surprise or somehow unfairly prejudice Defendants. NMFS had independent knowledge of PBR levels, which were actually discussed during the administrative process, although ultimately disregarded. See ECF No. 66-27, PageID # 10309; ECF No. 66-20, PageID #s 10262-64; see also ECF No. 68, PageID # 13501 (Defendants concede that "agency staff discussed PBR during the rulemaking"). NMFS's awareness of this issue precludes any reliance on waiver. See 'Ilio'ulaokalani Coal. v. Rumsfeld, 464 F.3d 1083, 1093 (9th Cir. 2006) (plaintiffs did not waive challenge when agency "had independent knowledge of the very issue that concern[ed] Plaintiffs"); see also Today's IV, Inc. v. Fed. Transit Admin., No. LA CV13-00378 JAK, 2014 WL 3827489, at *14-15 (C.D. Cal. May 29, 2014); Ctr. for Food Safety v. Vilsack, No. C 08-00484 JSW, 2009 WL 3047227, at *6 (N.D. Cal. Sept. 21, 2009). NMFS even used stock assessment reports from 2012 in considering the Navy's take request. See ECF No. 66-19, PageID # 10214. Those reports contain PBR levels for stocks affected by the Navy's activities. See ECF No. 64-4.

Besides making procedural arguments, Defendants make the substantive argument that NMFS is not restricted by PBR levels. Defendants view Conservation Council and NRDC as premising their PBR arguments on the understanding that "Congress intended for PBR to limit NMFS's authority to permit take under section 101(a)(5)(A)." ECF No. 68, PageID #s 13501-02. The court does not view either Conservation Council or NRDC as arguing congressional intent at all. Instead, the court views them as pointing out that NMFS, having itself treated PBR as the best scientific evidence available, is acting arbitrarily and capriciously in disregarding PBR with respect to the Navy's request.

Although Defendants protest that PBR "was added to the MMPA as a fisheries management tool, not as a limit on NMFS's authority under Section 101(a)(5)(A)," see ECF No. 68, PageID # 13502, NMFS itself has not restricted its reliance on PBR criteria to the fisheries context. Thus, NMFS said in examining an application in a different case, "because NMFS has determined that the loss of even a single northern right whale is significant (i.e., greater than PBR), a negligible impact finding under section 101(a)(5)(A) cannot be made for ship strikes of northern right whales by the USCG." 61 Fed. Reg. 54,157-58 (Oct. 17, 1996).

NMFS's past reliance on PBR criteria in the context of making a "negligible impact" finding under 16 U.S.C. § 1371(a)(5)(A) makes sense given the very definition of PBR and the specific mention of optimum sustainable population in relevant statutes. If a whale is killed, the impact on the population of the species or stock is the same whether the death occurs during fishing activities or during a Navy exercise. Clearly PBR levels were available for at least some of the stocks in issue, as shown by Conservation Council's chart, included in this order. Given the connection between OSP, PBR, and the negligible impact analysis, NMFS cannot reasonably authorize mortalities without any mention of PBR. NMFS's failure to evaluate lethal takes against PBR violated the requirement that NMFS utilize the best scientific evidence available.

While Defendants argue that NMFS would have made the same "negligible impact" finding even if it had compared lethal takes to PBR levels, this "it makes no difference" argument is irrelevant to this court's review. As noted earlier in this order, NMFS was required to "articulate a rational connection between the facts found and the choices made." Arrington, 516 F.3d at 1112 (internal quotation marks omitted). A failure in that regard is not rendered inconsequential by an after-the-fact explanation. If after-the-fact explanations sufficed, agencies would never have to explain their decisions to start with. In this instance, NMFS's failure to discuss PBR in issuing the Final Rule invalidates NMFS's conclusion.

Given the importance of the PBR issue, this court sees no need to address other alleged deficiencies in the scientific evidence that Conservation Council and NRDC complain about in the context of their MMPA challenges. Some of those other challenges appear to require this court to substitute its own judgment for NMFS's judgment as to what study to rely on, without giving deference to NMFS, or to find contradictions that are less than obvious to this court. The deficiencies growing out of a total failure to consider clearly important information are glaring enough that the court finds it unnecessary to make judgment calls.

The court is not unmindful of the efficiencies that might be achieved by having this court opine on every failing Conservation Council and NRDC charge NMFS with. If NMFS issues a new Final Rule and new LOAs, knowledge of a court's view of all failings alleged might avoid a repetition of problems. But in this case, the problems this court identifies are so fundamental that the court cannot conceive of a new Final Rule or new LOAs that simply tweak the earlier documents and regurgitate old language. If NMFS addresses the matters identified here, any new Final Rule or new LOAs will need to be so completely different from existing documents that present issues should be irrelevant.

4. NMFS's Analysis of Mitigation Measures is Arbitrary and Capricious.

NRDC argues that NMFS also acted arbitrarily and capriciously in its cursory analysis of ways to mitigate the negative effects of the Navy's activities on affected species and stocks. This court agrees.

Before authorizing the Navy's incidental taking of marine mammals under the MMPA, NMFS was required to prepare regulations setting forth "permissible methods of taking pursuant to such activity, and *other means of effecting the least practicable adverse impact on such species or stock and its habitat*, paying particular attention to rookeries, mating grounds, and areas of similar significance, and on the availability of such species or stock for subsistence uses." See 16 U.S.C. § 1371(a)(5)(A)(i)(II)(aa) (emphasis added).

NRDC contends that NMFS failed to prescribe means of effecting the "least practicable adverse impact" on affected species and stocks. Notably, NRDC says, NMFS outlines no mitigation measures that adequately address significant behavioral disruptions and imposes no time/area restrictions on the Navy's activities other than in the Humpback National Marine Sanctuary. See ECF No. 75, PageID #s 13845-49.

Defendants respond that NMFS met its statutory obligation by "prescrib[ing] a suite of mitigation designed to avoid the most serious impacts on marine mammals that could lead to population-level harm." ECF No. 71, PageID # 13629. NMFS's "suite of mitigation" consists primarily of using lookouts and "mitigation zones," and of requiring the powering down or shutting down of acoustic sources when a marine mammal is detected within certain proximities. See ECF No. 66-19, PageID

#s 10256-57. NMFS claims to have reasonably found that behavioral disturbances outside of mitigation zones are not likely to result in population-level harm. ECF No. 71, PageID # 13630. Defendants also argue that the MMPA contains no "mandate" requiring time/area restrictions, and that NRDC has failed to establish that time/area restrictions "are the only means by which NMFS can achieve the least practicable adverse impact." Id. at PageID # 13631.

This court agrees with Defendants that NRDC neither shows that there is a "mandate" in the MMPA for time/area restrictions nor establishes that time/area restrictions are the only means of achieving the "least practicable adverse impact." However, this court notes that, for their part, Defendants cite no authority for their suggestion that avoiding the most serious impacts satisfies the statutory requirement that Defendants set forth measures for effecting the "least practicable adverse impact."

Moreover, Defendants appear to think that they satisfy the statutory "least practicable adverse impact" requirement with a "negligible impact" finding. See ECF No. 71, PageID # 13630 ("NRDC first argues that NMFS failed to prescribe sufficient mitigation to 'mitigate the harm to populations' from Level B behavioral disturbances occurring outside the mitigation zones. . . . This argument fails because NMFS reasonably found that behavioral disturbances are not likely to cause population-level harm. *Supra* 4-22.”). But if one could conflate the two, the “least practicable adverse impact” requirement would become no reqirement at all. And, of course, this court has determined that, among other things, NMFS’s failure to address the effect of the Navy’s activities on all affected species and stocks renders its “negligible impact” finding arbitrary and capricious.

This court is not here ruling that time/area restrictions are necessarily required to meet the “least practicable adverse impact” provision of the MMPA. But, whether with or without time/area restrictions, something more than a refusal to consider mitigation measures and an unexplained assertion that further mitigation is not practical is needed. That “something more” is lacking here.

For example, when it received public comments recommending that the ocean on the leeward side of the Island of Hawaii out to a depth of 3,281 yards be excluded from the Navy’s activities, NMFS acknowledged that there was evidence “suggesting that several resident populations of marine mammals may be present off the leeward side of Hawaii.” ECF No. 66-19, PageID # 10224. NMFS’s response was that, given the very low historical level of Navy activities in the area, time/area restrictions “would not further reduce the likelihood or magnitude of adverse impacts” and “are not necessary at this point.” Id. NMFS said it would revisit the matter if future reports suggested that increased Navy operations were overlapping with the resident marine mammal populations. Id. This is not a response consistent with the requirement that NMFS set forth regulations for the "least practicable adverse impact." In the first place, a history of low Navy activity does not demonstrate that time/area restrictions or, for that matter, other restrictions, in that area are impractical. Second, because there is no guarantee concerning the future level of Navy activities, NMFS's "wait and see" approach puts the marine mammals at risk of sustaining adverse impacts before the authorization provided by NMFS may be revisited. NMFS does not explain why, if the Navy's activity level in the area was low, NMFS did not impose restrictions that would have been unlikely to affect the Navy, instead of freeing the Navy to increase its activities.

Similarly, in response to public comment suggesting restrictions in areas off California important to large whales, NMFS acknowledged that the SOCAL Range Complex contains important areas for fin and blue whales, but said that "these areas are . . . adjacent to the Navy's only west coast underwater instrumented training range" and that the Navy "indicated that establishment of a time-area closure within this region is not practical." Id. at PageID # 10229. Although NMFS must consider "personnel safety, practicality of implementation, and impact on the effectiveness of the military readiness activity" in evaluating the least practicable adverse impact, NMFS must explain its conclusion as to why a "time-area closure within this region is not practical." NMFS only summarizes the Navy's indication of impracticality without analyzing it at all. NMFS cannot just parrot what the Navy says. If NMFS is accepting the Navy's position, NMFS must articulate a rational basis for that decision. NMFS does not meet the "least practicable adverse impact" requirement when it just repeats the Navy's position.

NMFS does impose restrictions in the Humpback National Marine Sanctuary, but provides no explanation as to why no other time/area restrictions are practicable. At most, Defendants note that humpback whales are endangered and "[i]t is reasonable to treat an area of importance to an endangered species differently than an area that may hold resident populations of larger, non-listed stocks." ECF No. 71, PageID # 13633. This rationale is not included in the Final Rule. More importantly, NMFS's obligation to impose measures ensuring the "least practicable adverse impact" applies with equal force to endangered and unendangered species and stocks. The HSTT Study Area covers millions of square nautical miles, and the court has a hard time assuming that absolutely no other time/area restriction is practicable in that vast area.

The court repeats its statement that it is not saying that the only way an agency can avoid being arbitrary and capricious with respect to the "least practicable adverse impact" requirement is to impose time/area restrictions. But if time/area restrictions are indeed practicable and NMFS chooses not to impose them when the Navy proposes to engage in, for example, sonar exercises, then NMFS must consider measures of equivalent effect, given the "weight of scientific evidence point[ing] to avoidance of marine mammal habitat as the most effective means of minimizing sonar-related injury to marine mammals." See Ocean Mammal Inst. v. Gates, 546 F. Supp. 2d 960, 992 (D. Haw. 2008). NMFS may not satisfy its obligation by the use of lesser options such as lookouts and mitigation zones without considering the practicability of other measures, especially knowing that many potential disruptions to marine mammal behavior will be difficult to detect or avoid through lookouts.

No one is saying that every adverse impact must be avoided. But the "least practicable adverse impact" requirement is part of "a stringent standard" that Congress deliberately imposed on agencies like NMFS. Evans, 279 F. Supp. 2d at 1159. "Although the agency has some discretion to choose among possible mitigation measures, it cannot exercise that discretion to vitiate this stringent standard." Id. NMFS treats the standard as if it requires almost no effort at all. This reads the words "least practicable adverse impact" out of the MMPA and is therefore arbitrary and capricious.

Given NMFS's failure to consider authorized takes, to analyze the impact of the Navy's activities on all affected species and stocks of marine mammals, to use the best scientific evidence available, and to prescribe means of effecting the "least practicable adverse impact" on affected species and stocks, this court concludes that MMPA requirements have not been met and that NMFS's finding that Navy activities will have only a "negligible impact" on affected species and stocks is arbitrary and capricious.

B. NMFS's Biological Opinion Does Not Satisfy the ESA.

Conservation Council and NRDC also challenge NMFS's Biological Opinion as failing to satisfy the ESA. This court concludes that the Biological Opinion is deficient with respect to including an arbitrary and capricious "no jeopardy" finding for whales and including an invalid incidental take statement and "no jeopardy" finding for turtles.

1. The Court Declines Defendants' Request To Stay the Challenges to the Biological Opinion.

Before turning to the contents of the Biological Opinion, this court addresses Defendants' request that this court dismiss or stay the ESA claims in light of the reinitiation of consultation by NMFS and the Navy to "reconsider their analyses, while giving 'careful consideration to issues . . . recently raised in litigation.'" ECF No. 68, PageID # 13505. According to Defendants, the agencies "have agreed to conclude the consultation by April 3, 2015." Id.

The court declines to dismiss or stay the ESA claims. Although Defendants characterize the ESA claims as "anticipatorily moot," this court is not required to dismiss or stay a live controversy simply because it may become moot in the future. See Hunt v. Imperial Merch. Servs., Inc., 560 F.3d 1137, 1142 (9th Cir. 2009). A court may, of course, "allow agencies to cure their own mistakes rather than wasting the courts' and the parties' resources reviewing a record that both sides acknowledge to be incorrect or incomplete." S. Yuba River Citizens League v. Nat'l Marine Fisheries Serv., No. 2:13-CV-00042-MCE, 2013 WL 4094777, at *9 (E.D. Cal. Aug. 13, 2013). However, Defendants have not acknowledged that the Biological Opinion is deficient in any specific manner and instead say only that they plan to give "careful consideration to issues . . . recently raised in litigation" and "address these issues, *if appropriate*, in the new [Biological Opinion]." ECF No. 68, PageID # 13505 (emphasis added)(internal quotation marks and brackets omitted).

During their reinitiated consultation, NMFS and the Navy are continuing to rely on the Biological Opinion challenged in this action. It makes no sense to this court to grant a dismissal or stay if Defendants can continue to actively rely on the existing Biological Opinion. Such an action by this court would be advantageous to Defendants while treating Conservation Council and NRDC as if they had never brought an ESA challenge at all. The court recognizes that Defendants' promised April 3 completion date is almost here, but the court must rule in any event on the MMPA and NEPA claims. This court might take a different view of the stay request if Defendants were offering to suspend their reliance on the existing Biological Opinion during the reinitiated consultation period, but that is not an offer Defendants have made.

2. NMFS's "No Jeopardy" Finding for Whales is Arbitrary and Capricious.

NMFS's Biological Opinion concludes that authorized mortalities of large whales will not appreciably reduce the likelihood of both the survival and recovery of affected large whale species in the wild. Because NMFS does not support this conclusion with adequate evidence or analysis, this "no jeopardy" finding is arbitrary and capricious.

The "no jeopardy" finding flows from NMFS's repeated conclusory statements. This does not satisfy the ESA.

For example, NMFS recognized that blue whales, fin whales, humpback whales, sei whales, Western North Pacific grey whales, and sperm whales could be killed or injured (including in a manner affecting their ability to reproduce) if struck by Navy vessels. However, NMFS ignored the effects of individual whale deaths or injuries on the survival or recovery of the species or stocks. See ECF No. 67-19, PageID #s 12637-47. The failure to examine these effects is at odds with NMFS's own recognition in the Biological Opinion that "[w]hen individual animals would be expected to experience reductions in their current or expected future reproductive success, we would also expect those reductions to also reduce the abundance, reproduction rates, or growth rates . . . of the populations those individuals represent." Id. at PageID # 12371.

Similarly, for most of the large whale species at issue, NMFS simply states, "Removal of one or more individuals of a particular species from a population will have different consequen[c]es on the population depending on sex and maturity of the animal." Id. at PageID # 12638; see also id. at PageID #s 12640, 12643, 12644, 12647. Yet NMFS does not follow up with an examination of the potential consequences based on sex and maturity. Instead, NMFS announces without detail that the Navy's activities are not likely to reduce the fitness of individual whales, and so the activities are not likely to reduce the viability of affected whale populations. See id. at PageID #s 12638-39, 12640, 12643, 12644, 12647. A dead whale may not be an "unfit" individual, but would clearly have been removed from the population. Because NMFS recognizes that the impact of the removal of one or more individuals depends on the sex and maturity of the animal, it is unclear how NMFS can so easily conclude that a removal is not likely to reduce the viability of an affected whale population.

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

The "no jeopardy" finding is rendered further perplexing by the recognition within the Biological Opinion itself that "[t]he death of a female of any of the large whale species would result in a reduced reproductive capacity of the population or species." Id. at PageID # 12661. The "no jeopardy" finding and that statement are not reconciled anywhere in the Biological Opinion, despite NMFS's obligation to "articulate[] a rational connection between the facts found and the choices made." Arrington, 516 F.3d at 1112 (internal quotation marks omitted).

Attempts by Defendants to shore up the "no jeopardy" finding are unavailing. First, Defendants contend that NMFS's "no jeopardy" finding must be valid given NMFS's "negligible impact" finding, reached under a less demanding standard. See ECF No. 68, PageID # 13509. Having invalidated NMFS's "negligible impact" finding in analyzing the MMPA claims, this court finds that argument unpersuasive.

Second, Defendants support the "no jeopardy" finding for whales by pointing to statements in their opposition to the summary judgment motions. See ECF No. 68, PageID # 13509. Those statements assert the low risk of mortalities resulting from the Navy's activities. See id. at PageID #s 13497-13504. As this court noted in its discussion of MMPA issues, NMFS was required to focus on what it was authorizing the Navy to take, not on what the Navy said it anticipated it would actually take.

Conservation Council also argues that the Incidental Take Statement for whales allows more mortalities than allowed by the MMPA. However, that Incidental Take Statement is expressly dependent on satisfaction of requirements for authorization under the MMPA. The Biological Opinion could certainly have been crafted more clearly with respect to the need for MMPA authorization, but the court does not rely in the present order on the contention that the Incidental Take Statement for whales allows excess mortalities. However, it happens, of course, that, because this court invalidates NMFS's "negligible impact" finding under the MMPA in the present order, the MMPA prerequisite in the Incidental Take Statement for whales is not satisfied. Because the ESA requires an Incidental Take Statement when an agency issues a "no jeopardy" finding, the absence of an Incidental Take Statement that satisfies all prerequisites represents a different problem under the ESA than the excess mortality issue.

In light of the court's overarching discussion concerning the Biological Opinion's "no jeopardy" finding as to whales, the court sees no need to reach the additional arguments raised by Conservation Council and NRDC relating to alleged deficiencies in the Biological Opinion concerning specific whale species or stocks. As this court noted in its MMPA discussion, when the court has identified flaws so fundamental to a document that the document needs to be totally rewritten, it makes little sense for this court to engage in fine-tuning. The "no jeopardy" finding for whales is arbitrary and capricious, and the Biological Opinion is therefore unsustainable with respect to whales.

3. The "No Jeopardy" Finding for Turtles is Arbitrary and Capricious, and the Incidental Take Statement for Vessel Strikes of Turtles is Invalid.

Just as troubling to the court as the Biological

Opinion's cursory discussion of whale mortalities is the manner in which turtles are addressed by NMFS for ESA purposes. The problem occurs with respect to the absence of analysis supporting the "no jeopardy" finding concerning turtles in the Biological Opinion, and to the uncapped number of turtle takes by vessel strike authorized in the Incidental Take Statement.

The Biological Opinion authorizes an "unspecified number" of turtle takes and includes a "no jeopardy" finding for turtles. Authorization of an "unspecified number" of takes necessarily means that NMFS is authorizing even mortalities that eliminate the entire ESA-listed turtle population. This cannot avoid being arbitrary and capricious.

Defendants point to what they say is the limited anticipated take, as opposed to the unlimited authorized take. This position remains unavailing. Authorizing the Navy to take an unlimited number of turtles makes it impossible for NMFS to justify a finding that the "action authorized. . . is not likely to jeopardize the continued existence of any endangered species or threatened species." 16 U.S.C. § 1536(a)(2). The patent absurdity of the "no jeopardy" finding for turtles makes it unnecessary for this court to consider other arguments raised in support of the challenges to the Biological Opinion's "no jeopardy" finding for turtles.

Having found "no jeopardy," NMFS was required by the ESA to issue an Incidental Take Statement for turtles. Claiming that "it is very difficult to estimate the number and species composition of turtles that could be 'taken' in the HSTT Study Area in transit zones and range complexes," ECF No. 67-19, PageID #s 12658, 12660, NMFS placed no numerical cap at all on how many turtles may be taken as a result of vessel strikes during Navy activities. Instead, the Incidental Take Statement provides that "[t]ake will be exceeded if activity levels as proposed are exceeded." Id.

The Ninth Circuit has recognized Congress's clear "preference for expressing take in numerical form." Oregon Natural Res. Council v. Allen, 476 F.3d 1031, 1037 (9th Cir. 2007). If an Incidental Take Statement "utilizes a surrogate instead of a numerical cap on take," it "must explain why it was impracticable to express a numerical measure of take." Id.; see also Natural Res. Def. Council, Inc. v. Evans, 279 F. Supp. 2d 1129, 1184 (N.D. Cal. 2003) ("In the absence of a specific numerical value . . . the defendant must establish that no such numerical value could be practically obtained.").

In issuing an Incidental Take Statement without a numerical cap on the taking of turtles by vessel strike, NMFS did not show that it could not practically obtain a numerical value. NMFS did no more than say that it was "very difficult" to estimate the take of turtles in the HSTT Study Area and make statements in the Biological Opinion such as, "The information available has not allowed us to estimate the probability of the different sea turtle[] species being exposed to . . . vessel traffic . . . associated with the activities the U.S. Navy plans to conduct in the HSTT Study Area." ECF No. 67-19, PageID # 12631. Such statements in effect repeat the mantra that it is "very difficult" to make an estimate. See also ECF No. 67-19, PageID # 12535 ("[W]e do not have sufficient information to estimate how many sea turtles might be exposed to [vessel strike]."); id. at PageID # 12592 ("While the potential for serious injury and mortality of sea turtles from vessel strike exists, it is very difficult to estimate the number and species composition of turtles that could be taken in the HSTT Study Area in transit zones and range complexes."). These are not explanations. This "unexplained failure" by NMFS to comply with its obligation "renders the Incidental Take Statement invalid." See Allen, 476 F.3d at 1038.

Even if NMFS could be said to have established that it could not provide a number, NMFS should have done more than it did to ensure that there were sufficient controls on the taking of turtles. Specifically, when an Incidental Take Statement lacks a numerical trigger, the Incidental Take Statement must "set forth a 'trigger' that, when reached, results in an unacceptable level of incidental take, invalidating the safe harbor provision, and requiring the parties to re-initiate consultation." Ariz. Cattle Growers' Ass'n v. U.S. Fish & Wildlife, Bureau of Land Mgmt., 273 F.3d 1229, 1249 (9th Cir. 2001). That is, when a numerical limitation on take is not used, there must be a surrogate that can "perform the functions of a numerical limitation." Allen, 476 F.3d at 1038.

NMFS's authorization of an "unspecified number" of vessel strikes on turtles and its statement that "[t]ake will be exceeded if activity levels as proposed are exceeded," ECF No. 67-19, PageID #s 12658, 12660, do not perform the functions of a numerical limitation. The Incidental Take Statement does not "set forth a 'trigger' that, when reached, results in an unacceptable level of incidental take." Ariz. Cattle Growers' Ass'n, 273 F.3d at 1249. Instead, no matter how many turtles are taken by vessel strike within the scope of the project, the Navy and NMFS will not be required to reinitate consultation. This failure to provide for the reinitiation of consultation invalidates the Incidental Take Statement for vessel strikes of turtles.

Defendants appear to be suggesting that the Incidental Take Statement does indeed have numerical limitations for takes in the form of numbers for Permanent Threshold Shift (i.e., permanent hearing loss). Defendants say that NMFS assumed that turtles close enough to vessels to be at risk of permanent hearing loss were also vulnerable to ship strike, and that, because numbers for Permanent Threshold Shift were stated, those numbers functioned as limits on takes by vessel strike and thus as triggers for reinitiation of consultation. See ECF No. 68, PageID # 13512 (referring to ECF No. 67-19, PageID # 12535).

This argument is not supported by the record. If NMFS had meant to have the numerical cap for Permanent Threshold Shift serve as the cap for vessel strike takes, NMFS would not have authorized an "unspecified number" of turtle takes by vessel strike. In addition, Defendants have elsewhere stated that "PTS is not a good surrogate" for vessel strikes and that "the modeled PTS estimates cannot serve as a means of quantifying sea turtle vessel strikes in this case." ECF No. 88, PageID #s 14348, 14349.

This court concludes that the Incidental Take Statement for vessel strikes of turtles is invalid.

C. The FEIS Fails To Comply with NEPA.

Conservation Council challenges the FEIS prepared by the Navy and adopted by NMFS under NEPA on the grounds that the FEIS arbitrarily and capriciously fails to analyze a true "no action" alternative and fails to analyze alternatives with less environmental harm. See ECF No. 78, PageID #s 14027-37. This court agrees in both respects.

1. The FEIS Fails To Consider a "No Action" Alternative.

In examining the "environmental impacts of the proposal and the alternatives in comparative form," an EIS must "[i]nclude the alternative of no action." 40 C.F.R. § 1502.14. Conservation Council contends that the "no action" alternative considered in the FEIS is not truly a "no action" alternative because it presumes approval of the requested MMPA authorizations and continuation of "currently conducted training and testing activities (baseline activities) and force structure (personnel, weapons and assets) requirements." ECF No. 65-5, PageID # 6980. Conservation Council complains that the FEIS should have examined a "no action" alternative based on denial of the requested MMPA authorizations. See ECF No. 78, PageID # 14028.

The FEIS analyzed the following alternatives: (1) the continuation of baseline activities (what the FEIS termed the "No Action Alternative"); (2) the "[o]verall expansion of the Study Area plus adjustments to types and levels of activities, from the baseline as necessary to support current and planned Navy training and testing requirements" ("Alternative 1"); and (3) "Alternative 1 plus the establishment of new range capabilities, modifications of existing capabilities, and adjustments to type and levels of training and testing" ("Alternative 2"). ECF No. 65-5, PageID # 6980.

All three alternatives describe the Navy's training and testing activities, rather than being driven by the effect of authorizing the taking of marine mammals that the Navy was requesting. While the level of the Navy's activities relates to the level of take NMFS might authorize, it was certainly not NMFS's task to determine what training or testing activities the Navy should engage in. See, e.g., ECF No. 88, PageID # 14350-51 (Defendants' statement that, if NMFS had not acted on the Navy's requests, it would have been left to the Navy, not NMFS, "to pursue alternative MMPA compliance arrangements"); see also ECF No. 78, PageID # 14029 (Defendants not suggesting that NMFS had a duty to fashion alternative activities for the Navy in the absence of NMFS authorizations and instead saying that the Navy would have presumably modified its activities); ECF No. 80, PageID # 14236 (no basis for "suggestion that denial of take authorizations would preclude all Navy activities").

NMFS's job was to determine whether to authorize the takes requested by the Navy. It is therefore disturbing that the alternatives studied in the FEIS are all descriptions of different levels of Navy activity. This may be the result of the Navy's preparation of the FEIS, but NMFS was not required to adopt the Navy's document as NMFS's "NEPA documentation for the rule-making process under the MMPA." ECF No. 65-6, PageID # 6831.

The FEIS's alternatives avoid the task actually facing NMFS. In assuming that, no matter what, Navy activities would surely occur, NMFS was neglecting to consider what would be a true "no action" alternative from NMFS's perspective. The Navy and NMFS appear to have recognized that a "no action" alternative from NMFS's perspective might well have been the scenario in which, under the MMPA, NMFS denied the Navy's request for an incidental take authorization. NMFS was aware that "for NMFS, this constitutes the NEPA-required No-Action Alternative." See ECF No. 66-24, PageID # 10290. An agency decision memorandum states that the FEIS, despite failing to consider this alternative, nevertheless "supports [its] analys[i]s." Id. The reasons for that support are unstated.

With what it called a "no action" alternative, NMFS was assuming the very take activities the Navy was proposing to engage in. This is a glaring deficiency in the FEIS.

2. The FEIS Fails To Sufficiently Consider Alternative Restrictions on Navy Activities.

An EIS must "[r]igorously explore and objectively evaluate all reasonable alternatives." 40 C.F.R. § 1502.14(a). "Judicial review of the range of alternatives considered by an agency is governed by a 'rule of reason' that requires an agency to set forth only those alternatives necessary to permit a 'reasoned choice.'" California v. Block, 690 F.2d 753, 767 (9th Cir. 1982). An EIS's range of reasonable alternatives is necessarily tethered to the stated goal of the project. City of Carmel-By-The-Sea v. U.S. Dep't of Transp., 123 F.3d 1142, 1155 (9th Cir. 1997).

An agency is required to assess and consider public comments to an EIS. In response to those comments, an agency may "[d]evelop and evaluate alternatives not previously given serious consideration by the agency" or "[e]xplain why the comments do not warrant further agency response, citing the sources, authorities, or reasons which support the agency's position." 40 C.F.R. § 1503.4. The record contains no evidence that, in response to public comments, the Navy itself developed alternatives not previously given serious consideration. The Navy instead restricted itself to discussing what others were suggesting. The court therefore turns to addressing whether that discussion met NEPA's requirement that the Navy take a "hard look" at the environmental consequences of its proposed actions. See Earth Island, 351 F.3d at 1300. The Navy took no such "hard look," and, in adopting the FEIS, NMFS similarly failed to satisfy NEPA.

Conservation Council identifies what it says were "[n]umerous commenters" who "urged the Navy to consider alternatives that would reduce harm to marine mammals by prohibiting or restricting HSTT activities in specific areas identified as biologically important." See ECF No. 79 at PageID

#s 14049-50. Public comments suggested time/area restrictions on the Navy's activities in blue and fin whale foraging areas, in the Catalina Basin, in the Blainville's beaked whale habitat west of the Big Island, and in the Hawaii insular false killer whale habitat between east Oahu and north Maui and off Hawaii Island, among other places. See ECF No. 63-17, PageID # 4143; ECF No. 63-20, PageID #s 4177-78. The Navy's main response was that it was impractical to require that the Navy avoid all marine species habitats. ECF No. 65-8, PageID # 88465. This was not a fair response to those public comments, as the comments were not seeking total avoidance.

The Navy also said in the FEIS that "[l]imiting training and testing activities to specific locations . . . would be impractical" and provided a number of reasons for that impracticality, including: (1) the necessity of using "the diverse and multidimensional capabilities of each range complex and testing range" to "develop and maintain high levels of readiness"; (2) the safety concerns presented by "requiring activities to take place in more remote areas where safety support may be limited"; (3) the impact access restrictions would have on the Navy's "ability to adapt training" and to "evolve as the threat evolves"; (4) the negative effect of restrictions on the "realism of training"; and (5) the "increase [in] transit time" resulting in "an increased risk to personnel safety, particularly for platforms with fuel restrictions (e.g., aircraft)" if access to marine mammal protected areas was restricted. ECF No. 65-8, PageID #s 8461-62, 8465. This response by the Navy to the specific proposals in public comments was general and cursory, and assumed with little analysis that no restriction at all could be accommodated.

This court recognizes that its review of the FEIS is to be "highly deferential, presuming the agency action to be valid and affirming the agency action" if "the agency considered the relevant factors and articulated a rational connection between the facts found and the choices made." Thomas, 628 F.3d at 1068; Arrington, 516 F.3d at 1112. Judicial review examines whether the agency's response to public comments is "so implausible that it could not be ascribed to a difference in view or the product of agency expertise." Butte, 620 F.3d at 945. Even with that recognition, this court concludes that the FEIS is deficient by reason of its repeated reliance on sweeping, absolute statements that allow for no possibility of any restriction at all.

Thus, for example, the FEIS says that limiting training and testing to specific locations would be impractical, ECF No. 65-8, PageID # 8461, as if, out of an ocean area bigger than the land mass occupied by the entire United States, it is simply not feasible to say that there is even a single square mile outside of the Humpback National Marine Sanctuary that the Navy could possibly avoid using for any period without reducing military readiness. This cannot be anything but pure hyperbole. The Navy does not have the vessels or manpower to occupy every single square mile of the HSTT Study Area continuously, and it cannot possibly need to do so any more than the Army needs to continuously occupy every square mile of land within the United States.

Similarly, the FEIS says that "[t]raining and testing activities require continuous access to large areas consisting potentially of thousands of square miles of ocean and air space." Id. at PageID # 8462. This assertion assumes that because training may require access to large areas covering thousands of miles, the Navy must have access to millions of miles, and that even if training and testing will not occur on, say, Thanksgiving Day, access must be "continuous." No restriction of any kind is even hypothesized. Again, the breathtaking assertions allow for no limitation at all, but this makes no sense given the size of the ocean area involved.

The Navy never explains why, if it can accommodate restrictions for humpback whales, it cannot accommodate restrictions for any other species. Even if it understandably cannot avoid all contact with marine mammals, it provides no reason that the only contact it can avoid is contact with humpback whales.

Cognizant that it "is not empowered to substitute its judgment for that of the agency," see Arrington, 516 F.3d at 1112, the court is not presuming to set a certain number of square miles or weeks that the Navy must confine its activities to. Nor is the court selecting areas or species that the Navy must avoid entirely. But the court is saying that the Navy's categorical and sweeping statements, which allow for no compromise at all as to space, time, species, or condition, do not constitute the "hard look" required by NEPA.

VII. CONCLUSION.

NRDC's motion for leave to submit extra-record evidence is denied. Defendants' motion to strike is granted in part and denied in part, as noted earlier in this order.

The court grants Conservation Council's motion for summary judgment in Civil No. 13-00684 and also grants NRDC's motion for summary judgment in Civil No. 14-00153.

This order disposes of all claims and all parties in both cases. Accordingly, the Clerk of Court is directed to enter judgment in favor of Plaintiffs in both cases and to close these consolidated actions.

IT IS SO ORDERED.

DATED: Honolulu, Hawaii, March 31, 2015.

UNITED STATES DISTRICT COURT
DISTRICT OF HAWAII

/s/ Susan Oki Mollway
Susan Oki Mollway
Chief United States District

Conservation Council for Hawaii, et al. v. National Marine Fisheries Service, et al., Civ. No. 13-00684 SOM/RLP; Natural Resources Defense Council, Inc., et al. v. National Marine Fisheries Service, et al., Civ. No. 14-00153 SOM/RLP; AMENDED ORDER GRANTING CONSERVATION COUNCIL’S MOTION FOR SUMMARY JUDGMENT, GRANTING NRDC’S MOTION FOR SUMMARY JUDGMENT, DENYING NRDC’S MOTION FOR LEAVE TO SUBMIT EXTRA-RECORD EVIDENCE, AND GRANTING IN PART AND DENYING IN PART DEFENDANTS’ MOTION TO STRIKE

UNITED STATES DISTRICT COURT
WESTERN DISTRICT OF WASHINGTON
AT SEATTLE

UNITED STATES OF AMERICA, et al, Plaintiffs, v. STATE OF WASHINGTON, et al., Defendants.	No. C70-9213 Subproceeding No. 09-01 FINDINGS OF FACT AND CONCLUSIONS OF LAW AND MEMORANDUM ORDER

I. INTRODUCTION

This subproceeding is before the Court pursuant to the request of the Makah Indian Tribe (the "Makah") to determine the usual and accustomed fishing grounds ("U&A") of the Quileute Indian Tribe (the "Quileute") and the Quinault Indian Nation (the "Quinault"), to the extent not specifically determined by Judge Hugo Boldt in Final Decision # 1 of this case. The Court is specifically asked to determine the western boundaries of the U&As of the Quileute and Quinault in the Pacific Ocean, as well as the northern boundary of the Quileute's U&A. A 23-day bench trial was held to adjudicate these boundaries, after which the Court received extensive supplemental briefing by the Makah, Quileute, Quinault, and numerous Interested Parties and took the matter under advisement. The Court has considered the vast evidence presented at trial, the exhibits admitted into evidence, trial, post-trial, and supplemental briefs, proposed Findings of Fact and Conclusions of Law, and the arguments of counsel at trial and attendant hearings. The Court, being fully advised, now makes the following Findings of Fact and Conclusions of Law. To the extent certain findings of fact may be deemed conclusions of law, or certain conclusions of law be deemed findings of fact, they shall each be considered conclusions or findings, respectively.

I. BACKGROUND

On February 12, 1974, Judge Hugo Boldt entered Final Decision # 1 in this case. The decision set forth usual and accustomed fishing grounds and stations ("U&As") for fourteen tribes of western Washington, wherein the tribes had a treaty-secured right to take up to 50% of the harvestable number of fish that could be taken by all fishermen. *See United States v. Washington*, 384 F.Supp. 312 (W.D. Wash. 1974) ("*Final Decision 1*"). The Court enforced its ruling through entry of a Permanent Injunction, whereby it provided for any party to the case to invoke the continuing jurisdiction of the Court on seven different grounds, the sixth of which permits adjudication of "the location of any of a tribe's usual and accustomed fishing grounds not specifically determined by Final Decision # I." *Id.* at 419 (Permanent Injunction, ¶ 25(a)(6)), as modified by the Court's Order Modifying Paragraph 25, Dkt. # 13599.[1] After innumerable subproceedings and appeals and multiple decisions from this country's highest Court, this forty year-old injunction remains in place, safeguarding the rights reserved by these tribes in treating with the United States government to continue to fish as they had always done, beyond the boundaries of reservations to which they agreed to confine their homes.

It is under the jurisdiction set forth by the Permanent Injunction that the parties are again before this Court. The Makah Indian Tribe initiated this subproceeding on December 4, 2009 by filing a request for this Court to determine the usual and accustomed fishing grounds and stations of the Quileute Indian Tribe and the Quinault Indian Nation, to the extent not specifically determined by Judge Boldt in Final Decision # 1. In particular, the Makah ask the Court to define the western and northern boundaries of the Quileute U&A and the western boundary of the Quinault's U&A in the Pacific Ocean – waters beyond the original case area considered by Judge Boldt.[2] After a series of pre-trial rulings, this subproceeding proceeded to trial under Paragraph 25(a)(6) of the Permanent Injunction. *See* No. 09-01, Order on Motions, Dkt. # 304.

This is only the second subproceeding in the long history of this case in which this Court has been asked to rule on the boundaries of a tribe's usual and accustomed fishing grounds in the Pacific Ocean. In the first such subproceeding, this Court in 1982 adjudicated the boundaries of the Makah Tribe's Pacific Ocean U&A, determining its western boundary to be located forty miles offshore and its southern boundary to be located at a line drawn westerly from Norwegian Memorial. *United States v. Washington*, 626 F.Supp. 1405, 1467 (W.D. Wash. 1982) ("*Makah*"), *aff'd* 730 F.2d 1314 (9th Cir. 1984). Since that time, the Quileute and Quinault have been fishing at locations up to forty miles offshore under regulations adopted by the federal government pending formal adjudication by this Court. *See* No 09-01, Dkt. # 304 at pp. 3-4.

The subproceeding was tried to the Court over the course of 23 days commencing March 2, 2015 and concluding April 22, 2015. The Court heard testimony from eleven witnesses and admitted 472 exhibits comprised of thousands of pages. The Court also heard argument and reviewed briefs by

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[1] Citations to docket entries herein are to those under *United States v. Washington*, Case No. 70-9213, unless stated otherwise.

[2] The Makah, Quileute, and Quinault stipulated that these boundaries were not specifically determined in Final Decision # 1. *See* No. 09-01, Joint Status Report, Stipulation and Proposed Discovery Plan, Dkt. # 181 at p. 2.

the Makah, Quileute, Quinault, and a number of Interested Parties, including the State of Washington and the Hoh, Port Gamble S'Klallam, Jamestown S'Klallam, Tulalip, Swinomish, Upper Skagit, Nisqually, Squaxin Island, Muckleshoot, Puyallup, and Suquamish Tribes. The Court commends counsel for each of these parties – and for the Makah, Quinault, and Quileute in particular – for their exhaustive, thorough, and diligent efforts throughout the course of trial and the proceedings leading up to it. Indeed, trial on these three boundaries exceeded the length of the original trial before Judge Boldt leading to Final Decision # 1, a reflection of the great care and extensive research time and resources invested by all parties to this case. It is with the utmost respect for the impassioned efforts and the sincere professionalism demonstrated by all parties during this unusually extensive trial, as well as for the profound investment of diverse communities in the decision rendered herein, that the Court sets forth the following findings of fact and conclusions of law.

II. FINDINGS OF FACT

The following findings of fact are based upon a preponderance of the evidence presented at trial. Where relevant, the Court also draws on findings of fact set forth by Judge Boldt in Final Decision # 1.

A. Treaty Background

As an initial matter, the Makah and Interested Party the State of Washington are at odds with the Quileute, Quinault, and a number of Interested Party tribes with respect to the scope of the treaty-secured "right of taking fish." Specifically, the parties dispute whether evidence of a tribe's harvest of marine mammals, including fur seals and whales, may be the basis for establishing a tribe's U&A. The Makah and the State, joined by three Interested Parties, take the position that a tribe's U&A must be established on the basis of locations where it went at treaty time for the purpose of taking finfish. By contrast, the Quileute and Quinault, with support from a number of Interested Parties, argue for a construction of their treaty that would allow for a U&A to be established based on a broader interpretation of "fish" inclusive of evidence of a tribe's treaty-time marine mammal harvest activities. The following findings of fact concerning the background of tribal treaty rights are made in answer to the question of treaty interpretation raised by the parties.

1. General Context of Treaty Negotiations

1.1. On August 30, 1854, Isaac Stevens, the first Governor and Superintendent of Indian Affairs of the Washington Territory, was notified of his appointment to negotiate treaties with tribes west of the Cascade Range (hereinafter, the "Stevens Treaties"). The principal purposes of the Stevens Treaties were to extinguish Indian claims to the land in Washington Territory and to provide for peaceful and compatible coexistence of Indians and non-Indians in the area. Governor Stevens and the treaty commissioners who worked with him were not authorized to grant to the Indians or treat away on behalf of the United States any governmental authority of the United States. *Final Decision 1*, Findings of Fact ("FF") 17, 19.

1.2. At the treaty negotiations, a primary concern of the Indians whose way of life was so heavily dependent upon harvesting fish, was that they have freedom to move about to gather food at their usual and accustomed fishing places. In 1856, it was felt that the development of the non-Indian fisheries in the case area would not interfere with the subsistence of the Indians, and Governor Stevens and the treaty commissioners assured the Indians that they would be allowed to continue their fishing activities. FF 20.

1.3. It was the intention of the United States in negotiating the treaties to make at least non-coastal tribes agriculturists, to diversify Indian economy, and to otherwise facilitate the tribes' assimilation into non-Indian culture. There was no intent, however to prevent the Indians from using the fisheries for economic gain. FF 21.

1.4. There is nothing in the written records of the treaty councils or other accounts of discussions with the Indians to indicate that the Indians were told that their existing fishing activities or tribal control over them would in any way be restricted or impaired by their treaty. The most that could be implied from the treaty context is that the Indians may have been told or understood that non-Indians would be allowed to take fish at the Indian fishing locations along with the Indians. FF 26.

1.5. Since the vast majority of the Indians at the treaty councils did not speak or understand English, the treaty provisions and the remarks of the treaty commissioners were interpreted by Colonel Benjamin F. Shaw, the treaty commission’s official interpreter, to the Indians in Chinook jargon and then translated into native languages by Indian interpreters. Chinook jargon, a trade medium of limited grammar and a vocabulary of only 300 or so terms, was inadequate to express precisely the legal effects of the treaties, although the general meaning of treaty language could be explained. Even so, many of those present did not understand Chinook jargon. There is also no record of the Chinook jargon phrase that was actually used in the treaty negotiations to interpret the provision for the “right of taking fish.” FF 22; *see also* Ex. 64.

2. Treaties with the Makah, Quileute, and Quinault

2.1. The Makah were a party to the Treaty of Neah Bay, signed on January 31, 1855. The Treaty of Neah Bay was negotiated with the Makah by Governor Stevens and members of his treaty commission, including George Gibbs (a lawyer and adviser to Stevens), Colonel Michael Simmons, and Colonel Shaw. Gibbs maintained a journal that includes a still extent record of the treaty negotiations with the Makah. It appears from Gibbs’ journal that tribes to the south of the Makah, likely including the Quileute, were invited to attend the treaty council, but Governor Stevens decided to proceed without them to avoid delaying the negotiations. The Treaty of Neah Bay was ratified by the United States Senate on March 8, 1859, and proclaimed by the President on April 18, 1859. A reserved fishing rights provision is found in Article 4 of the Treaty of Neah Bay, which provides as follows:

> The right of taking fish and of whaling or sealing at usual and accustomed grounds and stations is further secured to said Indians in common with all citizens of the United States and of erecting temporary houses for the purposes of curing, together with the privilege of housing and gathering roots and berries on open and unclaimed lands: Provided, however, That they shall not take shell-fish from any beds staked or cultivated by citizens.

Ex. 29 at pp. 1, 4; Ex. 65 at p. 19 (journal of George Gibbs, recording decision to send for the "other tribes" to meet at Grays Harbor); Ex. 298.

2.2. Governor Stevens, along with Gibbs, Simmons, and Shaw, first attempted to negotiate a treaty with the Quinault and other tribes in southwest Washington in February 1855 at the Chehalis River Council. As with the Treaty of Neah Bay, Gibbs' journal provides a record, albeit a likely incomplete one, of the failed Chehalis River negotiations. The Quileute were not represented at the Council, although they sent two boys along with the Quinault to observe. The Chehalis River Council was intended to treat with the remaining tribes of Washington Territory west of the Cascade Range. However, it was accidentally discovered at the council, perhaps upon negotiators' overhearing the different language spoken by the two Quileute boys, that the Quinault did not occupy the entire area between the Chehalis River and Makah territory and that a distinct tribe – the Quileute – was situated between the two. Gibbs attributed the exclusion of the Quileute to their speaking a different language from the Quinault such that messengers sent up the coast to provide notice of the council had not communicated with the tribe. For these reasons, the Quileute were omitted from the negotiations. The

Chehalis River negotiations ultimately broke down when participating tribes refused to agree to Governor Stevens' proposal that a single reservation be established for all of the tribes. *See* Ex. 65 at pdf pp. 23-24; Ex. 68 at pp. 172-73.

2.3. The Quileute and Quinault, together with the Hoh Tribe, were ultimately parties to the Treaty of Olympia, negotiated a few months later on July 1, 1855 at a village at the mouth of the Quinault River, now known as Taholah. Tr. 3/3 at 19:3-7 (Hoard). When the Treaty of Olympia was negotiated, only half of the four-member U.S. treaty commission was present: both Governor Stevens and George Gibbs were absent, and Stevens sent Colonel Simmons to negotiate in his stead, with Shaw serving as interpreter. Simmons utilized the draft treaty developed at the Chehalis River negotiations. As a result, the only substantive difference between the two is that the Treaty of Olympia provides that more than one reservation might be established for the Quileute and Quinault. There is no surviving journal of the negotiations conducted by Simmons. The Treaty of Olympia was signed by Governor Stevens in Olympia on January 25, 1856, ratified by the United States Senate on March 8, 1859 and proclaimed by the President on April 11, 1859. Article 3 of the Treaty of Olympia contains the following reservation of rights provision:

> The right of taking fish at all usual and accustomed grounds and stations is secured to said Indians in common with all citizens of the Territory, and of erecting temporary houses for the purpose of curing the same; together with the privilege of hunting, gathering roots and berries, and pasturing their horses on all open and unclaimed lands. Provided, however, That they shall not take shell-fish from any beds staked or cultivated by citizens; and provided, also, that they shall alter all stallions not intended for breeding, and keep up and confine the stallions themselves.

Ex. 297.

2.4. Not all of the differences between treaties can be attributed to differing degrees of importance that tribes attached to various resources. For instance, a provision for pasturing horses is absent from the Treaty of Neah Bay but present in both the Treaty of Olympia and the draft Chehalis River Treaty. It is probable that Governor Stevens included this provision deliberately in the draft Chehalis River Treaty in response to specific concerns of the Chehalis and Cowlitz tribes for maintaining their horse traditions. By contrast, the fact that the draft Chehalis River Treaty was used as a template for the Treaty of Olympia most likely explains the inclusion of this provision in the treaty with the Quinault and Quileute. In particular, the limited use of horses by the Quileute Tribe makes the inclusion of this provision in the Treaty of Olympia anomalous. Stevens, unlike Simmons, was invested with authority to tailor treaty provisions in response to needs and concerns expressed by the tribes. As Governor Stevens was absent from the Treaty of Olympia negotiations, the ability of the Quileute and the Quinault to negotiate tailored treaty provisions was most likely limited. *See* Tr. 3/16 at 182:13 – 184:18; 192:3-10 (Boxburger).[3]

3. Scope of the Right of Taking Fish

3.1. Although the treaty commission was primarily concerned with obtaining land, *see* Tr. 3/16 at p. 187:18-22 (Boxburger), the minutes that are available indicate a persistent concern among the Indians with preserving their entire subsistence cycle. For instance, when Che-lan-the-tat of the Skokomish Tribe expressed a concern at the negotiation of the Treaty of Point-No-Point with the ability of the tribes to feed themselves upon ceding so much land, Benjamin Shaw assured the tribes that they were "not called upon to give up their old modes of living and places of seeking food, but only to confine their houses to one spot." Ex. 65 at p. 11. Governor Stevens informed the tribes at that same council that the treaty "secures [their] fish." *Id.* at p. 14. Stevens similarly informed the tribes at the Chehalis

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[3] Transcript citations herein are to the unofficial draft transcripts of trial proceedings produced by the Court Reporter.

River Council that the members of the treaty commission "want you to take fish where you have always done so and in common with the whites." *Id.* at p. 22.

3.2. The minutes from the Chehalis River negotiations indicate that the participating tribes were specifically concerned with reserving the right to take sea mammals. During the Chehalis River negotiations, the assembled Indians raised the issue of whales at least twice. Tuleh-uk, the head chief of the Lower Chehalis, stated, "I want to take and dry salmon and not be driven off…I want the beach. Everything that comes ashore is mine (Whales and wrecks.) I want the privilege of the berries (Cranberry Marsh)." Governor Stevens responded, "He (Tuleh-uk) sees that we write down all that he says… That paper (the Treaty) was the heart of the Great Father which he thought good. It said he should have the right to fish in common with the whites, and get roots and berries." Ex. 65 at p. 24. Stevens' response to Tuleh-uk suggests that the term "fish" was used in a capacious sense, encompassing finfish as well as whales. *See* Tr. 3/3 at pp. 34:1-35:21 (Hoard). While Stevens elsewhere distinguished between "fish" and "whales" in responding to a demand from representatives of the Chinook Tribe for "one half of all that came ashore on the weather beach," he made no distinction between the tribes' right to take beached whales and to hunt for swimming whales. *See* Ex. 65 at p. 26 ("They of course were to fish etc. as usual. As to whales, they were theirs…."); TR 3/3 at pp. 36:5-39:1 (Hoard).

3.3. Although the draft treaty was read to the assembled tribal representatives, no objection was made despite the lack of an express reference to the right to take sea mammals. *See* Ex. 65 at p. 32. It is reasonable to infer from the absence of any objection that the tribes understood the right to take whales to be provided for in the treaty. *See* 3/3 Tr. at pp. 45:13-25; 78:1-79:7 (Hoard).

3.4. Nothing in the record of the negotiations of any of the treaties indicates that the U.S. treaty commission intended to exclude the harvest of sea mammals from the tribes' reserved fishing rights. By contrast, the intent to include the harvest of sea mammals is corroborated by James Swan's record of the treaty negotiations. Swan recounts that "[t]he Indians, however, were not to be restricted to the reservation, but were to be allowed to procure their food as they had always done, and were at liberty at any time to leave the reservation to trade with or work for the whites." Ex. 291 at p. 344. It is reasonable to infer from Swan's statement that Governor Stevens intended the treaties to reserve to tribes that had customarily harvested sea mammals the right to continue to do so "as they had always done."

3.5. Dictionary definitions at the time also evidence a broad popular understanding of the word "fish." For instance, the 1828 Webster's American Dictionary of the English Language defined "fish" expansively as "[a]n animal that lives in the water." Ex. 334. While the dictionary recognized the Linnaean taxonomic classification of "fish," which limited the term to aquatic animals that "breathe by means of gills, swim by the aid of fins, and are oviparous," it nonetheless acknowledged its broader popular meaning: "Cetaceous animals, as the whale and dolphin, are, in popular language, called fishes, and have been so classified by some naturalists…. The term *fish* has also been extended to other aquatic animals, such as shell-fish, lobsters, etc." *Id.* (emphasis in original). Other dictionaries from the time corroborate the term's broad meaning in popular usage. *See, e.g.*, Ex. B222.6 (quoting Worcester's 1860 dictionary and Walker's 1831 dictionary, which both define fish as "an animal that inhabits the water"); 3/3 Tr. pp. 52:15, 56:4-57:25, 202:22-203:12 (Hoard). The common usage in legal opinions from the mid to late 1800s of the terms "fish" and "fisheries" in reference to both whales and seals suggests that the U.S. treaty negotiators may themselves have intended to use the term “fish” in its broadest sense. *See, e.g.*, *In re Fossat*, 69 U.S. 649, 696 (1864) (“For all the purposes of common life the whale is called a fish, though natural history tells us that he belongs to another order of animals.”); *Ex parte Cooper*, 143 U.S. 472, 499 (1892) (discussing “seal fisheries”); *The Coquitlam*, 77 F. 744, 747 (9th Cir. 1896) (“They all had the usual ships’ supplies and stores and outfit for seal fishing.”).

3.6. There is no record of the Chinook phrase that was actually used to communicate the “right of taking fish.” FF. 22. The severe limitations of Chinook jargon as a medium for communication, as well as the limited familiarity of negotiators on both sides with the language, inhibited the capacity to communicate treaty terms with precision. The negotiators most likely used the Chinook word “pish,” translated by George Gibbs in his 1863 “Dictionary of the Chinook Jargon” as “English. Fish.” Ex. 64 at p. 26. The negotiators may also have used the Chinook phrases “mamook pish” or “iskum pish,” meaning “to take fish” or “to get fish.” *See* Tr. 3/3 at pp. 66:6-67:24 (Hoard). While Chinook jargon did contain terms for some individual aquatic species, including whales, seals, and salmon, it lacked cover (i.e. high-level) terms that could differentiate between taxa or larger groupings of aquatic animals, such as finfish, shellfish, cetaceans, and sea mammals. *See* Ex. 64. It is reasonable to infer that the negotiators employed broad cover terms from Chinook jargon when negotiating the fishing rights provision and that these cover terms would not have been used in a restrictive sense. *See* Tr. 3/3 at p. 68:7 (Hoard).

3.7. The sweep of the words for “fish” in the Quileute and Quinault languages is even broader than in Chinook jargon. The Quinault cover term for “fish,” “Kémken,” is defined alternatively as “salmon,” “fish,” and “food.” *See* Ex. 76. Similarly, the Quileute cover term, “?aàlita?” is translated by multiple lexicographers as “fish, food, salmon.” Exs. 225, 233. As with the Chinook jargon, neither tribe's language possessed terms that could differentiate between groupings of aquatic species, such as sea mammals, shellfish, and finfish. It is reasonable to infer from the records of the Quileute and Quinault languages that members of these tribes would have understood that the treaty reserved to them the right to take aquatic animals, including shellfish and sea mammals, as they had customarily done.

3.8. Post-treaty activities also suggest that all parties to the Treaty of Olympia understood its subsistence provision to secure to the Quinault and Quileute the right to take whales and seals at their usual and accustomed harvest grounds. During the post-treaty period, these tribes continued to harvest whales and seals from the Pacific Ocean without any protest from government agents. To the contrary, Indian agents actively encouraged these tribes to continue their sea mammal harvest. For instance, Indian Agent Charles Willoughby urged the Quileute to "continue your fisheries of salmon and seals and whales as usual" and assured them that if they wanted any blacksmith work done, such as "spear heads for seals or harpoons for whales, the blacksmith at the agency at Neah Bay will do the work." Ex. 281 at pp. 165, 167. These two tribes were also among those along the coast of the United States and Canada that were exempted from restrictions on fur sealing imposed through the 1893 Bering Sea Arbitration Award and 1894 Bering Sea Arbitration Act. *See* Ex. B85 at p. 53. Post-treaty activities are thus consistent with the reservation of the right to harvest sea mammals in the Treaty of Olympia and inconsistent with a restrictive reading of the treaty's fishing rights provision.

A. Quinault Indian Nation's Western Boundary

1. Background on Traditional Quinault Economy

4.1. There is comparatively little documented information about aboriginal Quinault culture and subsistence fishing activity relative to information about other western Washington tribes. Evidence regarding treaty-time activities of the Quinault is limited even in comparison to the similarly isolated Quileute and substantially more limited than for the Makah, whose location amidst the deep harbors at Neah Bay made this latter tribe unusually accessible to non-Indian traders, settlers, and visitors. Tr. 3/16 at 4:22-25 (Boxburger).

4.2. Treaty-time governmental contacts with the Quinault were few. In 1854, just prior to the Treaty of Olympia negotiations, George Gibbs wrote, “Following up on the coast, there is another tribe upon the Kwinaitl [Quinault] River, which runs into the Pacific some twenty-five miles above the Chihalis, its headwaters interlocking with the streams running into Hood’s canal and the inlets of Puget sound. Little is known of them except that they speak a different language from the last.” Ex. B90 at p. 426. Federal Indian agent reports about the Quinault were all written post-treaty and focus on activities with the potential for commercial development to aid in the government’s assimilation policy. These reports, narrow in their purview, are consequently of limited utility in discerning Quinault treaty-time practices. *See* Tr. 3/30 at p. 99 (Thompson); Tr. 4/2 at pp. 65-68 (Renker).

4.3. There have been no archaeological excavations that have generated data associated with aboriginal Quinault occupancy. *See* Tr. 4/7 at pp. 101-103 (Wessen). The only recorded pre-treaty historical accounts that mention the Quinault consist of records of a 1775 encounter with the Spanish vessel Sonora (an encounter that some scholars attribute to the Quileute rather than the Quinault, *see* Ex. 255 at p. 97 & n. 34), a 1788 encounter with English explorers on the Columbia expedition, and accounts by James Swan of his three-day trip to Quinault in 1854 as well as an encounter with several Quinault Indians while Swan was living 60 miles south of Quinault in Shoalwater Bay. One of nine accounts of the Wilkes Expedition also records an encounter with canoes carrying some men “from southward about Grays Harbor" at the western end of the Strait of Juan de Fuca on August 3, 1841. Ex. B200 at pdf p. 5. These men may have been Quinault. TR 3/18 at pp. 175-178 (Boxburger).

4.4. Most of what is known about Quinault culture and subsistence activities before and at treaty times comes from Dr. Ronald Olson's ethnology of the Quinault. Dr. Olson conducted anthropological fieldwork at Quinault for one month each in the spring of 1925 and the winters of 1925-26 and 1926-27 and published an ethnography on the Quinault in 1936. Ex. 213. Dr. Olson's ethnography intended to describe Quinault culture and society prior to contact with non-natives and drew from the memories and oral histories of informants, whom Dr. Olson described as "thoroughly reliable, reasonably intelligent" and "familiar with the old life." Ex. 213 at p. 3. Some of these informants, all of whom were over 60 years of age, had memories reaching back to the 1850's. Ex. 212 at p. 696. Dr. Olson's field notes are available in addition to his 1936 ethnography, though it is uncertain whether the remaining field notes are complete. Ex. 211. Dr. Olson also testified before the Indian Court of Claims ("ICC") on behalf of the Quinault in 1956. Ex. 212.

4.5. The Quinault occupied the coast of Washington State for thousands of years. Tr. 3/16 at p. 2 (Boxburger). The current members of the Quinault Tribe are descendants of the treaty-time occupants of the villages situated in the territory extending roughly between the Queets River system to the north and the north shore of Gray's Harbor to the south. Ex. 141 at p. 1 (1973 Lane Report). Chief Tahola, Head Chief for the Quinault, expressed the important relationship of the tribe to these traditional lands in his remarks to Governor Stevens at the Chehalis River Council: "He wanted his country. His children live there and wanted food. He wanted them to get it there, did not want to leave it. The river he did not want to sell near the salt water, nor the sand beach mouth, but that part above the mountains and off the river he would sell." Ex. 65 at p. 23.

4.6. Fishing constituted the principal economic activity of the Quinault at treaty time. Salmon and steelhead served as the principal food and as an important item of trade for the tribe. FF 122. Gibbs remarked that the Quinault Tribe is "celebrated for its salmon, which are considered to excel in quality even those of the Columbia." Ex. 68 at p. 172. The large, glacier-fed rivers in the Quinault region provided a rich source of salmon for the tribe. Reflecting the Quinault's adaptation to extracting resources from this environment, Judge Boldt included a number of rivers and streams in his determination of the Quinault U&A within the original case area: Clear water, Queets, Salmon, Quinault (including Lake Quinault and the Upper Quinault tributaries), Raft, Moclips, Copalis, and Joe Creek. FF 120.

4.7. At the same time, the position of the Quinault on the Olympic Peninsula coast played an undeniable role in shaping and orienting the tribe's culture, trade, and economic activities. *See* Ex. 213 at p. 12 ("The location of the Quinault on the open coast had its influence on their life."). Comparing their Quinault to their northern neighbors, the anthropologist Jay Powell explained that, despite many Quileute families maintain settlements along inland river courses, "the Quileute, like their neighbors (the Quinaults, Ozettes, and Makahs), were primarily seafarers, deriving most of their livelihood from the oceans." Ex. 224, p. 105. Intermarriages between the Quinault and members of tribes to the north and south were common in traditional Quinault society, as was inter-tribal trade along the coast. Ex. 213 at p. 13; Ex. 277 at p. 81-84. Before and at treaty time, the Quinault, whom Dr. Olson described as "expert canoemen," possessed large ocean going canoes that they manufactured themselves or obtained in trade from the Makah and the Quileute. *Id.* at pp. 68, 73. The Quinault also manufactured sails out of cedar mats and used bailers and inflated sealskins to aid them in traveling on ocean voyages. *Id.* at p. 72. Before and at treaty time, the Quinault regularly traveled the Washington coast between Cape Flattery and the Columbia River. *Id.* at p. 87; Ex. B200 at pdf p. 5 (1841 report documenting encounter with Indians from Grays Harbor near Cape Flattery). The important linkage between the Quinault's coastal location and the tribe's subsistence practices is reflected in Judge Boldt's determination that, in addition to inland fisheries, the Quinault utilized "[o]cean fisheries … in the waters adjacent to their territory." FF 120.

4.8. In addition to salmon, the Quinault made use of a wide variety of aquatic coastal and oceanic resources for food as well as for materials such as clothing, bedding, ropes, containers, and tools. For instance, Captain Willoughby, who served as Indian agent at Neah Bay prior to serving as Indian agent on the Quinault Reservation, recorded a wide range of plants and animals harvested by the tribe for food, including "[m]any varieties of salmon," "tender shoots of rushes, young salmon-berry sprouts and other succulent growth of the spring-time," bulbous roots, a wide range of berries, whale, seal, otter, deer, bear, elk, sea-gulls, ducks, geese, seaweed, and a variety of shellfish. Ex. 351 at pp. 269-70. In addition to many of these species, Dr. Olson noted Quinault harvest of halibut, cod, rock cod, sea bass, and sole. Ex. 213 at p. 36. The Quinault traditionally hunted for sea mammals, including whales, fur and hair (harbor) seals, sea otters, and sea lions. The Quinault both ate the flesh of seals and whales and used them to extract oil. They also traditionally made use of seal skins, as well as the skins of elk, bear, and rabbit, for clothing. Ex. 351 at p. 3. Skins of hair seals were used as buoys on whaling expeditions. Ex. 213 at p. 44. Sarah Willoughby, Captain Willoughby's wife, included many of these products in her 1887 description of the possessions of a man named Riley, a Haida Indian and former slave who shared a lodge at Quinault with three other families. Among Riley's possessions, Sarah Willoughby noted: "[g]reat skins of seal and whale oil," "long festoons of whale blubber and dried clams," "baskets of dried halibut and salmon," "the skins of a beautiful sea otter," three large bear skins, and other products obtained either locally or by trade. Ex. 355 at pdf pp. 2-4. The anthropologist Ram Raj Prasad Singh listed a similarly broad range of food resources traditionally used by the Quinault on a regular, seasonal basis. Among marine resources, Singh included: sea trout, night smelt, sea lion, blueback, candlefish, fur seal, salmon, whale, sea otter, smelt, and silver and king salmon. He also noted "some deep sea fishing" occurring from April through June. Ex. 277 at p. 67. Much of the salmon, halibut, rock cod, and bass caught by the Quinault were preserved for later consumption. Ex. 142 at p. 11.

4.9. Traditional Quinault culture did not recognize the "idea of ownership of land beyond a 'use ownership' of the house site." Ex. 213 at p. 115. Individuals owned canoes and implements and could also own guardian spirits. *Id.* The concept of ownership did not extend to coastal and oceanic fishing grounds.

4.10. The Quinault possessed the navigational skills, knowledge, and technologies to travel extensively on the open ocean out of sight of land. Reflective of their oceanic navigational skills, the Quinault recognized six directions, one of which was expressed alternatively as "ocean side" and "far out to the ocean." Ex. 213 at p. 178. The Quinault navigated chiefly by means of the sun but also watched the ocean swells when at sea, as they were said to always come from the west. *Id.* A few Quinault shamans were said to be able to control the weather. *Id.* at p. 150. The Quinault also had knowledge of the constellations, including of the Pole-star, which was known to be used by the Makah to navigate at night while whaling. *Id.* at pp. 177-78; Ex. 332 at p. 47. In consideration of this and other evidence, the noted anthropologist Dr. Barbara Lane wrote in a 1977 report on Quinault fisheries that "the record is clear that the Quinault possessed seaworthy canoes, navigational skills, and gear and techniques designed to harvest a variety of offshore fisheries and that they customarily did so." Ex. 142 at p. 12.

2. Quinault Offshore Fishing

5.1. At and before treaty time, the Quinault engaged in offshore fisheries on a regular, seasonal basis for salmon, halibut, cod, rock cod, sea bass, sole, smelt, candlefish, and herring. Ex. 213 at pp. 36-38. The Quinault harvested smelt and candlefish by means of a dip net, and caught halibut, cod, rock cod, and sea bass with hook and line. *Id.* Herring were harvested with a herring rake used from a canoe. *Id.* at p. 38. The Quinault also regularly harvested razor clams, mud clams, oysters, mussels, sea anemones, and crabs along the shore. *Id.* at pp. 38-39. During the summer months, some Quinault migrated from their upland villages to sites along the coast to engage in these ocean fisheries. *Id.* at p. 38; Ex. 277 at p. 71.

5.2. Dr. Olson recorded some of the usual locations and distances at which these offshore fish species were customarily harvested by the Quinault at and before treaty time. Smelt and candlefish were taken by the people of the lower villages at the river mouth and at the surf of the beach, and herring was taken within a mile of the beach. Ex. 213 at pp. 36-38. Halibut, cod, rock cod, sea bass, and sole "could be taken anywhere along the coast within six miles of shore." *Id*. One of Dr. Olson's informants reported that halibut, rock cod, and bass were fished in an identical manner between July and August at locations five to six miles offshore, in waters close to rocks and approximately twenty-five feet deep. Ex. 211 at pdf p. 28.

5.3. Although the Quinault most likely harvested these fish within six miles, they may have fished at distances further offshore on at least an occasional basis. Dr. Lane, for instance, concluded in her 1977 report on Quinault ocean fisheries that, while "[i]t is not feasible to document the outer limits of

Quinault fishing, [] it appears that Quinault fishermen were familiar with offshore resources for at least thirty miles west of the Olympic peninsula." Ex. 142 at p. 1. Evidencing this familiarity, unidentified Indians informed the United States Fish Commission of a fishing bank at the continental shelf, approximately 30 miles offshore from Shoalwater Bay. Ex. 318 at p. 65. In 1895, Beriah Brown wrote an article on Quinault marine mammal hunting, in which he noted that the fur seal stop at this bank on their migration northward, where many of them fall victim to the Quinault. Brown described this bank as a "famous [] fishing ground." Ex. 18 at pdf p. 2. More likely than not, the Quinault Indians were the ones who informed the U.S. Commission of the location of the bank, given that they frequented Shoalwater Bay at treaty-time and ranged 30 miles offshore in their marine mammals hunts. The Quinault also manufactured fishing lines two to three hundred fathoms in length, which would be consistent with deep-sea fishing practices. Ex. 211 at pdf p. 675.

3. Quinault Whaling

6.1. Whaling has been consistently recognized as an important cultural and economical tradition is pre-treaty Quinault society. While Quinault, like other coastal tribes, made use of drift whales that beached on their territorial coast, the historical and ethnographic evidence demonstrates that the active pursuit of whales was a deeply engrained practice in Quinault society. Dr. Olson, for instance, described the Quinault as the "most southern people who engaged in the pursuit of whales." Ex. 213 at p. 12. While Dr. Olson was of the opinion that the abundance of salmon in Quinault Territory mitigated the tribe's need and desire to engage in whaling to the extent of the Makah and Quileute to the north, he nonetheless recognized the importance of the practice in Quinault society, as manifested by traditional Quinault secret societies dedicated to whaling and of rituals associated with the hunt. *Id.* *See id.* at p. 44 (describing whaling as a "dangerous and spectacular pursuits [] hedged about with ritual.”). Dr. Olson recorded only two Quinault whalers – Nicagwa’ts and his brother – active around 1850, though he reported that there were as many as six Quinault whalers at any time in the pre-treaty era, when the population was larger. As each whaler would have needed to “call together seven other men to aid him,” *id.*, the number of individuals engaged in whaling in 1850 would have been a substantial proportion of the population, which consisted of only 158 Quinault according to a treaty-time census. Tr. 3/16 at 60:2-18 (Boxburger). Edward Curtis, a Seattle photographer who visited Quinault in 1910, gave a similar account of the existence of two Quinault whalers at treaty-time, each captaining a canoe of eight men in total. Ex. 347 at pp. 9-10.

6.2. Quinault whalers traditionally made use of large ocean canoes, sufficient to fit six paddlers, the steersman, and the harpoon thrower, who also served as the head whaler. The Quinault whalers made use of a harpoon similar to that used by the Makah as well as buoys made of whole skins of hair seal.

6.3. A generations old myth describes how the Quinault learned to hunt whales. The “Story of the Dog Children,” recorded by Livingston Farrand, tells of five children who could change from human to dog form. Cast away from society, the children learned to hunt whales from their mother using sealskin floats and harpoons. When their whaling prowess was discovered by the villagers, the children were welcomed back into society, becoming chiefs of the village and always keeping the people well supplied with whales. Ex. 52 at pp. 127-28. The myth expresses the substantial time depth of the Quinault whaling tradition as well as its important place in Quinault identity and culture.

6.4. Quinault whaling was a specialized occupation. A Quinault whaler spent much of the year making and repairing the necessary equipment, which included a large ocean canoe and considerable other valuable gear. The head whaler had to possess the requisite guardian spirit, called sláo’ltcu, which was acquired shortly after puberty. In addition, a whaler went through a month of training previous to the season of whaling. During this period, the whaler bathed in a ritualized fashion each night in the ocean or river, went out alone in his canoe to practice throwing his harpoon and to converse with his spirit, and refrained from sexual intercourse for ten days prior to the hunt. *Id.* at pp. 44-46.

6.5. Whale products played an important role in the Quinault diet, economy, and ceremonial traditions. Whale meat was cured for later consumption and the blubber rendered into oil that was used as a condiment and in ceremonies and rituals. Dried foods were traditionally dipped into whale oil before they were eaten, and rendered whale fat was stored in the stomachs of seal or sea lion and in bags made from sections of whale intestines. Ex. 142 at p. 10.

6.6. Treaty-time historical accounts are consistent with customary Quinault whaling practices. During the first recorded contact with the Sonora in 1775, Indians (likely Quinault though possibly Quileute) offered whale meat to the Spanish sailors. The second recorded contact between Quinault and non-natives occurred in 1788, when the English ship Columbia encountered two whaling canoes with whaling implements from the village of Quinault. Around treaty-time, James Swan also came to know a famous Quinault whaler named Neshwarts, who was most likely the same whaler, Nicagwa'ts, reported by Dr. Olson. Ex. 283 at pp. 85-86; Tr. 3/16 at 104:5-105:18. Swan's descriptions of Neshwarts indicate that Swan was familiar with the Quinault whaling tradition.

6.7. The substantial number of words in the Quinault language associated with whaling practices is also indicative of the time depth of the Quinault whaling tradition. Quinault have separate words for whale, little whale, whale blubber, whale bone, whale oil, and whaling canoe. Ex 176 at p. 315. The

Quinault language also contains words indicative of ocean-going practices, including words meaning to "navigate on the ocean" and ocean canoe. *Id.* at p. 281.

6.8. The historical and ethnographic evidence shows that before and at treaty time, whaling was a regular and customary subsistence practice exercised by the Quinault, taking place each year on a seasonal basis during the summer months when Quinault Indians would migrate from upland coastal villages to participate in the hunt. According to Dr. Olson, the Quinault whaled each year from May to August, when a Quinault whaler would spend much of his time on the open water, "cruising for the animals." Ex. 213 at p. 24. Singh too included whaling in his description of the Quinault's seasonal rounds, taking place during these summer months. Ex. 277 at p. 67. One of Dr. Olson's Quinault informants related that his grandfather, who would have lived before treaty time, harpooned 77 whales in his lifetime, a feat that would have required hunting whales regularly during the summer season. Ex. 213 at p. 155; Tr. 3/16 at pp. 53-54 (Boxburger). The summer season of active whale hunts stands in contrast to the winter season, when the waters were typically too turbulent for the tribe to venture far offshore but a drift whale or two would often make its way to the Quinault coast. *See* Ex. 211 at pdf p. 308.

6.9. The few ethnographic and historical accounts that exist of Quinault whaling show that the whaling voyages regularly required Quinault whalers to go up to 30 miles offshore on their hunts. Dr. Olson, for instance, records that "[w]hales were most often encountered 12 to 30 miles off shore." Ex. 213 at p. 44. Dr. Olson testified at the 1956 ICC hearing that Quinault hunted whale in the open ocean, "going as far out as 25 miles or even more to harpoon and capture whale." Ex. 212 at p. 514. When pressed about the western boundary of the Quinault territory, Dr. Olson testified that the Quinault "used to go out as much as 25 miles hunting whale." *Id.* at p. 503. Dr. Lane agreed with these distances. *See* Ex. 142 at p. 4 ("In contrast to the herring which could be taken quite close to shore, whales and seals were harvested as far as twenty-five and thirty miles offshore.").

6.10. Indian whaling canoes could also expect to be towed many miles out to sea as part of their hunt. *See* Ex. 260, pp. 18-19 (account by Dr. Lane of Makah whale hunt); Tr. 3/30 at p. 73:16-20 (Thompson). In his description of the traditional Quinault whale hunt, Dr. Olson noted that after a whale was struck by a harpoon, the whale "might run as much as ten to fifteen miles before being killed." *Id.* at p. 45. A whaler with particularly strong power, such as Nicagwa'ts, was able to spur the whale to run toward shore instead of out to sea. According to Dr. Olson, Nicagwa'ts was never forced to tow a whale more than five miles, which would be consistent with harpooning a whale up to twenty miles offshore. *Id.*

6.11. The length of time needed for a single whale hunt is consistent with whaling practices taking place far offshore. Singh, for instance, noted that hunting a whale could require two or three days. Ex. 277 at p. 41. Among the various rituals and cultural taboos associated with whaling, Dr. Olson recorded the belief that should a whaler's wife be unfaithful while her husband was away on a hunt, "the whale would be wary and 'wild,' and the men would be unable to kill any." Ex. 213 at p. 46.

6.12. Hunts taking place at distances 20 to 30 miles offshore would have placed Quinault whalers at the edge of the continental shelf, a location where whales would have been found in abundance during the summer months. *See* Tr. at 3/9, pp. 103:22-105:24 (Trites). The continental margin starts at 20 miles offshore at the Quinault canyon and runs, on average, 30 miles offshore adjacent to Quinault territory. *Id.* at 105:15-24. Biologist Dr. Andrew Trites described this margin as an ocean "Serengeti," through which large herds of marine animals, including whales and fur seals, would migrate on a seasonal basis. *Id.* at 104:8-23. The Court finds the testimony of Dr. Trites credible and consistent with traditional Quinault whaling voyages taking place at the distances described by Dr. Olson and other anthropologists.

3. Quinault Fur Sealing

7.1. The evidence also shows that fur sealing was traditionally practiced by the Quinault at and before treaty time. As with whaling, the Quinault language contains words specifically associated with fur sealing, including words for fur seal ("ma·a'i"), little seal, seal oil, and sealing canoe. Ex. 213 at p. 49, Ex. 176 at p. 295. Dr. Olson and Singh both described the hunting of fur seal as a seasonal Quinault activity, taking place regularly each year in the months of April and May when the animals could be encountered offshore on their annual migration to breeding grounds off the coast of Alaska. Ex. 213 at p. 49; Ex. 277 at p. 67. Dr. Lane was in accord. *See* Ex. 143.

7.2. Quinault traditionally fur sealed in an ocean canoe holding three men. According to Dr. Olson, the sealers cruised around the open ocean until a seal was sighted asleep in the sun. The sealers paddled quietly to move within harpoon range of the seal, whereupon the animal was struck with a harpoon, hauled toward the canoe, killed with a club, and hoisted aboard. Quinault preserved the meat and fat of the fur seal for consumption and used the skins for blankets and ropes. Ex. 213 at p. 49. These uses are consistent with treaty time subsistence purposes, taking place prior to trade with non-Indians. Tr. 3/16 at 122:16-123:5 (Boxburger). The Quinault sealing tradition mirrors that practiced by the Quileute and the Makah.

7.3. Beriah Brown's 1895 article on Quinault marine mammal hunts shows that Quinault fur sealing continued in its traditional form through the late 1800s. Brown described implements of fur sealing similar to those described by Dr. Olson, including the "bone harpoon" and a specialized ocean-going sealing canoe fifteen or sixteen feet in length, and noted that the Quinault hunt fur seals in the open ocean, along with finback whales. Ex. 18 at pdf pp. 1-2. According to Brown, the Quinault "alone among the coast tribes…still follow the customs of their ancestors" in their pursuit of the seal, carrying out sealing voyages in canoes manned by three sealers and paddling as quietly as possible upon reaching the sealing grounds so as not to disturb the sleeping herds. *Id.* at p. 2. According to Brown, the sealers would regularly spend two days at sea during a hunt before returning to their village for several days' rest. *Id.* Though written post-treaty, Brown's account is indicative of both the important place of fur sealing in Quinault culture and the time depth of this customary practice.

7.4. The Quinault more likely than not ventured up to thirty miles offshore in pursuit of fur seals on a regular, seasonal basis at and before treaty times. Dr. Olson recorded that it was necessary for the Quinault to go ten to twenty-five miles offshore to hunt fur seals. Ex. 213 at p. 49; Ex. 211 at pdf p. 31. Dr. Olson contrasted fur seal hunting, which took place at distances far offshore, with the hunting of hair seals, which could be found on rocks close to shore. *Id.* While it is likely that the Quinault ventured even further post-treaty prompted by the demands of the commercial fur seal industry, the context of Dr. Olson's descriptions makes clear that he was describing the Quinault's pre-contact, traditional fur sealing activities. *See* Tr. 4/2 at pp. 80:1-81:12 (Renker). Beriah Brown's article also places fur sealing thirty miles offshore, in the vicinity of the famous fishing bank off the coast from Shoalwater Bay. Ex. 18. Although Brown's report was likely influenced by observations of post-treaty commercial fur sealing practices, he believed these practices to be consistent with pre-contact Quinault traditions.

7.5. These accounts of the distances at which the Quinault traditionally fur sealed place the sealers in the vicinity of optimal harvest. Fur seals are pelagic animals, spending their entire lives at sea other than their visit each year to their perennial breeding grounds. *See* Tr. 3/9 at 17:7-13. Current day tracking records and scientific studies demonstrate that, consistent with Dr. Olson's ethnography, fur seals can be found in great abundance in April and May at the continental margin off the coast of Washington as they carry out their annual migration to breeding grounds, such as the Pribolof Islands in Alaska. *See id.* at 17-13, 44:10-22 (Trites). Consistent with Dr. Olson's description of the Quinault fur sealing tradition, Dr. Trites explained that fur seal sleep during the day off the continental margin, making them vulnerable to hunters traveling quietly by canoe. *Id.* at p. 37:20-25; 60:1-61:13. Dr. Trites' descriptions of current day fur seal behaviors were unrebutted, and the Court finds credible Dr. Trites' testimony about the continuity of fur seal biology and behavior. As described in greater detail below, the behavior of fur seals at and before treaty-time is more likely than not consistent with their observed behavioral patterns today. These patterns support an inference that the Quinault were harvesting fur seals up to thirty miles off the coast of their territory at and before treaty-time.

B. Quileute Indian Tribe's Western Boundary

1. Background on Traditional Quileute Economy

8.1. As with the Quinault, the Quileute Tribe was isolated before and in the decades immediately following the signing of the Treaty of Olympia. Prior to 1855, there were only four recorded interactions between the Quileute and non-Indians, or five if the 1775 Spanish encounter with either Quileute or Quinault whalers is included. The four encounters definitely attributed to the Quileute and their Hoh relatives include: (1) a report of a British expedition led by Charles Barkely, which visited the Washington coast in 1787 and was attacked by the Hoh at Hoh River, (2) an account of the 1782 Columbia expedition, which traded skins with the Quileute on its way north to Nootka Sound, (3) an account of the 1808 wreck of the Russian ship, the Sv. Nikolai, which wrecked off the coast of Quileute territory, and (4) the testimony of Mr. James, who was at La Push in 1854 for nine weeks assisting survivors of the wreck of the steamer Southerner and served as a witness in the Quileute's land dispute with the settler Dan Pullen. Little was written by any of these visitors about Quileute culture or economy.

8.2. The United States government was almost entirely unaware of the presence of a tribe located between the Makah and the Quinault prior to the negotiation of the Treaty of Olympia. In 1854, George Gibbs wrote that "[s]till further north, and between the Kwinaitl [Quinault] and the Makahs, or Cape Flattery Indians, are other tribes whose names are still unknown, but who, by the vague rumors of those on the Sound, are both numerous and warlike." Ex. B090.39. As set forth above, the Quileute were included in neither the Neah Bay nor Chehalis River negotiations. It was only in the course of these latter negotiations that the treaty commission became aware of the presence of the Quileute, whose population they estimated to number around 300 people. Ex. 65 at pdf pp. 23-24.

8.3. The Quileute remained isolated in the decades following the execution of the Treaty of Olympia, continuing to live in their traditional manner. *See* Tr. 3/12 at 50:17-51:4 (Boxburger). Annual reports of Indian agents evidence the difficulty in traveling to Quileute territory and the lack of non-Indian presence in the area. Superintendent C.H. Hale, for instance, reported to Washington on August 8, 1864 that the Quileute "know but little of the whites… Their advantage consists in the fact of their village being surrounded for many miles with an almost impenetrable forest of gigantic growth. It is believed that no white man has ever been permitted to visit their village and its locality is only approximately known." Ex 218 at p. 23. In 1877, an Indian agent similarly reported that the "Queets, Hohs and Quillehutes live at such a distance from the agency as to be entirely out of reach." Ex. 218 at p. 33. In 1878, after oversight of the Quileute was transferred to the Neah Bay agency, Indian agent Charles Willoughby wrote that the "Quillehutes were unanimous in stating that they have only been once visited by an agent since the treaty was signed, and that visit they state was in the year 1862." Ex. 350 at pp. 2-3. By 1882, Willoughby too admitted to not being able to visit the Quileute: "The Quillehute Indians are 30 miles from the Agency by land and 40 miles by water and so difficult of access that I cannot make frequent visits to them." Ex. 218 at p. 33. The minimal familiarity of Indian agents with Quileute practices, coupled with the agency's economic development orientation, render Indian agent reports of little utility in reconstructing customary Quileute fishing practices at treaty time.

8.4. During this post-treaty period, the U.S. government intended to move the Quileute together with the Quinault onto a new reservation established at the Quinault river. Several different Indian agents reported that the Quileute did not understand that by signing their treaty they would be forced to give up their homes. *See, e.g.*, Ex. 7 at p. 335, Ex. B049 at pp. 14-15; Ex. B226 at pp. 5-6. In an 1879 council with the Quileute, Chief Howeattle, Head Chief of the Quileute, recalled that Colonel Simmons "told us when he gave us our papers that we were always to live on our land, that we were not to be removed to another place." Ex. 281 at p. 161. The Quileute oral tradition likewise firmly roots the Quileute in their ancestral lands. Unlike neighboring tribes, the Quileute have no tradition of arriving on the Olympic Peninsula from other lands, instead asserting that they have always lived in this place. *See* Ex. 247 at p. 19. The Quileute remained on their land despite efforts to relocate them, and on February 19, 1889, the Quillayute Reservation was established by Executive Order at the Quileute coastal village, La Push. The first white settler to take up residency in Quileute territory was a schoolteacher, sent to oversee the Quileute when the first school was established at La Push in 1883 and who set about attempting to assimilate the Indians by assigning them colonial names. Ex. 218 at p. 25.

8.5. Into the 1890s, the Quileute nonetheless remained unfamiliar with white culture and notions of property. Evidencing the tribe's indigenous worldview, the settler Karl Olof Erickson remarked on his meeting with the Quileute that "the leader of the group[] made an address and pointed to the woods, the ocean, and the sky." Ex. 145 at p. 85. Erickson presented the assembled Indians with his receipt for money paid at the U.S. Land Office in Seattle for his land claim, but this symbol of property ownership "did not mean anything" to the Quileute. *Id.* Tensions related to these differing notions of ownership arose when the settler Dan Pullen claimed land at La Push around 1883 and attempted to have the Quileute removed form the area. Several months after the Quillayute Reservation was established, Pullen burned the La Push village to the ground when its residents were away working in the Puget Sound hop fields. *See* Ex. B063.15. As a result, the Quileute suffered a devastating loss of most of their aboriginal artifacts, including their whaling and fur sealing implements and canoes. *See* Tr. 3/12 at pp. 26:15-28:8 (Boxburger); Ex. B63 at pdf. p. 15.

8.6. Owing to their relative isolation and minimal contact with Indian agents and white settlers, the Quileute maintained their traditional practices through the early 1900s. The noted anthropologist Dr. Leo Frachtenberg, who studied the Quileute from 1915-16, reported that his "investigation was facilitated by the fact that the Quileute Indians, numbering approximately 300 individuals, live together in a single village and still cling tenaciously to their native language, and to their former customs and traditions…. [Their] condition seems to be due to their complete isolation from the other tribes and from the white people, and to their persistence in adhering to the former customs and beliefs." Ex. B096 at pp. 111, 113.

8.7. Judge Boldt recognized that "[f]ishing is basic to the economic survival of the Quileute," FF 110, and it continues to be depended upon as a major source of income for the tribe. *See* Tr. 3/2 at

158:3-159:21. As it did for the Quinault, fishing constituted the principle economic and subsistence activity of the Quileute at and before treaty time. *See* FF 104, 105. Like the Quinault, the Quileute were favorably situated to harvest trout and steelhead, which were “taken in their long and extensive river systems.” FF 104. The Quileute were also able to travel into the upland foothills to hunt by following their river system in canoes. *Id.* Individual Quileute families asserted ownership of river fishing grounds. FF 106; Ex. 58a at pdf p. 120. Pre-treaty Quileute villages were located where the conditions of the rivers were optimal for catching fish, with each village obtaining its principal supply of fish from a sophisticated fishtrap located nearby. FF at 109. Recognizing the tribe’s customary use of rivers and lakes for their subsistence supply, Judge Boldt included a number of inland water bodies in his determination of the Quileute’s case area U&A, including: “the Hoh River from the mouth to its uppermost reaches, its tributary creeks, the Quileute River and its tributary creeks, Dickey River, Soleduck River, Bogachiel River, Calawah River, Lake Dickey, Pleasant Lake, [and] Lake Ozette.” FF 107.

8.8. At the same time, ocean fishing undoubtedly played a significant role in the traditional Quileute economy, culture, and identity. Judge Boldt recognized the importance of oceanic resources to the Quileute in including “adjacent tidewater and saltwater areas” in their U&A. FF 108. In furtherance of this determination, Judge Boldt found that before and at treaty time, the Quileute harvested diverse resources in the Pacific Ocean, including “smelt, bass, puggy, codfish, halibut, flatfish, bullheads, devilfish, shark, herring, sardines, sturgeons, seal, sea lion, porpoise, and whale.” *Id.* As they did with respect to their inland lakes, the Quileute viewed the waters of the ocean as common property. FF 106; Ex. 65(a) at pdf p. 120.

8.9. Early settlers and visitors to Quileute territory make mention of Quileute use of ocean resources, as does every ethnographer to have done work among the Quileute. The anthropologist Ram Raj Prasad Singh, who did field work with the Quileute in the 1950s, noted the unusual diversity of the tribe's economic resource base. Singh noted that, unique among the three Olympic coast tribes, the Quileute exploited all three of the economic resource areas available on the Peninsula: the deep sea economy, the river and coastal economy, and the inland economy. Ex. 277 at p. 4 (noting that "the Makah had primarily a deep sea economy; the Quinault, river, coastal, and inland; the Quileute, all three"). Singh explained that the Quileute were situated in a unique geographic zone where none of the economic resource areas was sufficient on its own to provide for adequate subsistence. *Id.* at p. 127.

8.10. The desire for dietary variety and the wide range of uses that the tribe found for the varied resources they exploited served as additional motivations for the Quileute to utilize a broad resource base. As one of Singh's Quileute informants related, "[t]he Indians did not want all fish or all whale but liked to get some of everything which they wanted to eat." Ex. 277 at p. 73. According to Singh, "[c]hoice in production gave the Indians a freedom unknown to most hunting tribes the world over." *Id.* Specialization in occupations and in the tools and technologies for extracting resources in their different environmental zones abetted the Quileute's exploitation of a diverse range of resources. *See* Tr. 3/12 at pp. 76:26-77:11 (Boxburger); Ex. 277 at p. 81. The Quileute, for instance, had specialized technology for seafaring and harvesting different ocean resources, including four different canoes and four specialized hooks for ocean hook and line fisheries. *See* Ex. B350.13; Ex. B310; Tr. 3/30 at pp. 47:21-48:5 (Thompson). Intra-tribal trade networks further spurred economic specialization. Members of both the Quileute and the Quinault tribes who lived on coastal settlements harvested aquatic resources for intra-tribal trade with upriver tribal members in exchange for meats and furs. *See* Ex. 277 at p. 81.

8.11. Anthropologists who studied the traditional Quileute economy noted a startling variety of ocean resources harvested by the tribe. These resources included a wide range of finfish (flounder, sole, rock fish, bullheads, suckers, skate, surgeon, smelt, sardines, herring, dog fish, sea bass, cod, salmon, halibut, and others), sea mammals (hair seal, sea lion, sea otter, porpoise, dolphin, fur seal, gray whale, humpback whale, killer whale, fin back whale, blue whale, and sperm whale), and shellfish (crab, clams, octopus, mussels, barnacles, squid, rock oysters, chiton, sea urchin, sea anemone, and goose neck barnacle). *See, e.g.*, Ex. 58(c) at pdf pp. 40-48, 61; Ex. 247 at pp. 14-16. According to Singh, marine resources were customarily harvested by the tribe during the months of April through August, when the tribe would harvest hair seal, fur seal, whale, sea lion, and smelt, and engage in "deep sea fishing." Ex. 277 at p. 65. Dr. Lane too reported that the Quileute "pursued whales, seals, sea-lion, porpoise and fished for halibut, cod, bass, salmon and other species in the marine waters off the west coast of the Olympic Peninsula." Ex. B349.2.

8.12. Quileute Indians who addressed government officials in the post-treaty era consistently attested to the tribe's customary subsistence harvest of ocean resources. Stanley Gray, a Quileute born in 1864, emphasized the importance of ocean resources in traditional Quileute culture and economy in his testimony in *United States v. Moore*, a case concerning the intended scope of the Quillayute Reservation. Gray testified that the Quileute hunted whale and seal in the Pacific Ocean "in the early days." He further testified that the Quileute "fished for halibut, ling cod, and whale" in the Pacific Ocean "continuously" during his lifetime. Ex. 178 at pp. 346-49. Similarly, when Edward Swindell, an attorney for the Department of the Interior, visited various tribes to identify their subsistence activities, several Quileute described the importance of ocean resources and intra-tribal trade between coastal and inland villages. Sextas Ward, a Quileute born in 1856, explained that "the Indians who lived in the villages along the various streams were able to catch much more salmon that those who lived along the ocean, whereas those along the ocean could obtain seal, whale and smelt; that as a result of this they were accustomed to trade amongst themselves so that they could have all kinds of fish and sea food for their daily subsistence." Ex. 293 at p. 221. Similarly, Benjamin Sailto, a Quileute born in 1853, told Mr. Swindell that the Indians living at the ocean would "catch whales and seals in the ocean" and that the people who lived upriver "would visit the Indians at other places or else come down to the main village at La Push for festivities and to obtain a supply of the different kinds of fish food which they could not obtain at their own fishing places." *Id.* at p. 225.

8.13. Like the Quinault, the Quileute possessed navigational skills, knowledge, and technologies to travel extensively on the open ocean, reaching distances out of sight of land. Dr. Lane opined that the "Quileute and Hoh Indians at treaty times were known for their seamanship." Ex. B349.2. Like the Quinault, the Quileute propelled their ocean canoes by means of both paddles and sails. Ex. 58(a) at pdf p. 160. Frachtenberg specifically contrasted the traditional Quileute ocean-going equipment, including large paddles and a single sail set upon poles in the bow of the canoe, with the oars and canvass sails used in the early 1900s. *Id.* According to Frachtenberg, the Quileute traditionally used their canoes to travel 20-30 miles westward, as far south as Tahola (50 miles south of La Push), and as far north as Neah Bay (45 miles from La Push). *Id.*

8.14. Various historical and anthropological accounts relate Quileute knowledge of weather forecasting and the sophisticated navigational techniques the Quileute employed when voyaging offshore. Chris Morgenroth, who settled on the Bogachiel River in the 1880s, described in his autobiography his near deadly attempt to reach Neah Bay in a whaling canoe launched from La Push and crewed solely by him and other white settlers. Upon leaving La Push, Morgenroth was warned by Chief Howeattle to "Look out for the East wind!," a warning that Morgenroth and his crew regretfully ignored. Ex. 180 at pp. 62-65. Both the anthropologist Professor Jay Powell, who lived with the Quileute for four decades, and the anthropologist Richard Daugherty commented on the traditional weather forecasting techniques used by the Quileute. *See* Ex. 220 at pp. 9, 111 (discussing the ability to tell which way the wind is coming from by the roar of the ocean and to predict weather by the appearance of fog and clouds); Ex. B345.14 (noting "weather forecasting" by Quileute sealers). Various oral traditions reflect Quileute knowledge of the stars used for navigation, as well as Quileute use of the sun's position as a navigational tool while at sea. *See, e.g*, Ex. B333 at pp. 51-56 (myths about the origin of the stars and constellations), 71-74 (oral tradition that whaling season begins when the sun goes straight across the ocean to the west).

8.15. The Quileute language reflects the tribe's oceanic orientation. Professor Powell's dictionary of the Quileute language records over ten distinct words for canoe, including separate words for "sealing canoe," "fur sealing canoe," "whaling canoe," and canoes of various sizes. Ex. 225 at pp. 44-45. Quileute words exist for a wide range of aquatic animals associated with the tribe's pre-treaty subsistence practices. The Quileute also possess distinct words associated with wide-ranging ocean traveling, including words meaning "to go out on the ocean," "at sea," "sea, blue water," and "sea, out in the ocean, west." *Id.* at p. 194; *see also* Ex. 233 at p. 159. Further words exist for a variety of sails used for traditional ocean travel and whaling purposes, as well as for stars associated with navigation. *See* Ex. 233 at pp. 154, 177.

2. Quileute Offshore Fishing

9.1. The archaeological and ethnographic evidence show that the Quileute engaged in offshore fisheries on a regular, seasonal basis for a range of oceanic finfish at and before treaty time.

9.2. Fish bone data assemblages from middens associated with aboriginal Quileute occupancy evidence a community continuously engaged in harvesting finfish from the Pacific Ocean. Quantified faunal data is available for four sites associated with the Quileute: Cedar Creek (representing late prehistoric occupation), Cape Johnson (representing occupancy from 700 to 1100 years before present), La Push (dating 600 to roughly 900 years ago), and Strawberry Point (representing occupancy between 1650 and 1950). The species compositions of the bone assemblages at these sites are very similar to those found at the ten sites associated with Makah occupancy, for whom a forty mile offshore U&A has been determined by this Court. The three most prevalent fish at each of the Quileute sites are: (1) greenling, red Irish lord, and lingcod (Cedar Creek), (2) greenling, red Irish lord, and cabezon (Cape Johnson), (3) rockfish, salmon, and flatfish (La Push), and (4) perch, greenling, and lingcod (Strawberry Point). The top species compositions at Makah sites are analogous, with flatfish, rockfish, greenling, salmon, and lingcod typically found among the most prevalent three or four species. *See* Tr. 4/6, 163:11-165:11 (Wessen). Based on these comparisons, the archaeologist Dr. Wessen, whose testimony the Court finds credible, testified that "there are broad similarities among all of these sites in fish bones." *Id.* at 164:8-9.

9.3. The types of species found at the Quileute sites suggest a strong oceanic orientation. Species like greenling, perch, lingcod, and sculpins (including red Irish lord and cabezon) would have been available to the tribe five to ten miles offshore, though they can also be found both nearer to shore and in deeper waters. *See* Tr. 3/11 at pp. 181-84 (Gunderson). Others, like rockfish, are most abundant in habitats deeper than 50 fathoms. *Id.* at 161:21-162:1. Hake, representing 1.4% of fish bone specimens at the Cape Johnson sites, and halibut, representing 2.5% of fish bone specimens at the La Push site, are strongly indicative of offshore harvest. Hake are a fish associated with deeper waters, *see* Tr. 3/11 at 15-16 (Schalk), though they too range from nearshore to distances beyond the 100-fathom line. *See* Tr. 4/3 at 109-109 (Joner). Dr. Gunderson, whose testimony the Court finds credible, testified that halibut are most common at depths from 30 to 230 fathoms, although they can be found in smaller quantities in nearshore waters as well. *See* Tr. 3/11 at 169:19-20 (Gunderson); *see also* Tr. 3/11 at 5:12-25 (Schalk).

9.4. The low percentage of halibut at Quileute sites may not accurately reflect its importance in the Quileute economy. In particular, evidence suggests that halibut may be underrepresented at archaeological sites because it was often filleted on the beach rather than at village sites. *See* Tr. 4/6 at 174:2-23 (Wessen). Limited archaeological excavations at three additional Quileute sites – the Toleak Point site and two sites on Destruction Island (located 4 miles offshore) – provide further evidence of Quileute engagement in halibut fishing. Tentative identifications of fish bones at the Destruction Island sites indicate the probable presence of halibut, Ex. 267 at p. 3, and hooks and grooved stone sinkers associated with halibut fishing have been found at the Toleak Point site. *See* 3/10 at pp. 142:1-145:2 (Schalk). Halibut is also present at high frequencies (26% of fish bones) at an additional site at Sand Point located on the Washington Coast west of the northern portion of Lake Ozette and abandoned approximately 1,600 years ago. The Sand Point site may be reflective of either Makah, Ozette, or Quileute activity. *See* Tr 4/6 at pp. 42-43 (Wessen).

9.5. The presence of offshore birds in the middens, accounting for 31% of bird bones at La Push, provides additional circumstantial evidence of offshore fishing activities. *See* Tr. 3/10 at 162:4-163:5

(Schalk). These birds were likely taken incidental to offshore fishing and marine mammal hunting. Ex. 338 at pp. 32-34.

9.6. Ethnographic and historical evidence is broadly consistent with the archaeological evidence of regular and customary ocean finfish harvest by the Quileute at and before treaty time. James Swan, who traveled to La Push in 1861 on a trading vessel and remained for four days, later informed the U.S. Fish Commission that the Indians south of Cape Flattery subsisted principally on "rock cod, surf smelt, tomcod, salmon, etc." Ex. 318 at p. 66 (1888 U.S. Fish Commission Bulletin). The importance of salmon and smelt to the Quileute is corroborated by Swan's descriptions of first salmon and first smelt ceremonies. *See* Ex. 287 at p. 45. While Swan did not believe that the Quileute were harvesting halibut, the archaeological and ethnographic record proves him mistaken on this point. For instance, multiple sources document traditional Quileute fishing for halibut at halibut banks, where specialized U-shaped hooks similar to those used by the Makah were employed to catch the fish. *See* Ex. 248 at p. 447, Ex. B346.40. Frachtenberg too discussed specialized gear and fishing techniques used by the tribe for offshore harvest of halibut, cod, bass, and other species. Ex. 56(c) at pdf pp. 68-76. According to Frachtenberg, the Quileute caught fish in the ocean using five different types of hooks as well as lines made of dried kelp. *See* Ex. 58(a) at pdf p. 128. Women and men would go out together on fishing trips in the ocean, during which specialized ocean canoes somewhat smaller than sealing canoes were used. Ex. 56(c) at pdf p. 69. The Quileute also took salmon by trolling in the open ocean and took herring from their canoes by means of a herring rake. *See* Ex. 293 at p. 184; Ex. 37a at p. 143; Ex. 58(a) at pdf p. 131.

9.7. While it is not possible to document the precise outer bounds of traditional Quileute finfish harvest in the Pacific Ocean, evidence suggests that the Quileute were more likely than not harvesting finfish up to twenty miles offshore on a regular and customary basis. According to Frachtenberg, halibut was harvested within two miles of shore, cod taken along rock and reefs, and other fish caught under rocks in rough weather with a kelp line. Ex. 56(a) at pdf at pp. 129-133. Other reliable accounts, however, place Quileute fishing further offshore. Singh, for instance, reported that the coastal Indians, including the Quileute and Hoh, harvested bass six miles offshore and fished at halibut beds eight to twelve miles offshore. Ex. 277 at pp. 19, 32. Quileute tribal member Bill Hudson, born 1881, informed Richard Daugherty that the Quileute fished for halibut in depths of 50 to 60 fathoms using kelp lines in the traditional, pre-contact style. Ex. B346.40 at pdf p. 340; Tr. 3/2 at 116:18-119:9 (Boxburger). Fishing at a depth of 50-60 fathoms would place the Quileute approximately twenty miles offshore of La Push and at areas of peak abundance of halibut during the summer season. *Id.*; Tr. 3/11 at 171:5-9, 174:12-25 (Gunderson). This is a distance to which Frachtenberg reported that the Quileute were accustomed to travel westward in their ocean canoes. Ex. 56(a) at pdf pp. 162-63.

9.8. One post-treaty historic reference places traditional Quileute fishing at distances even greater than twenty miles offshore. Quileute member Luke Hobucket, born 1873, drew a picture of "implements used in fishing" by the Quileute, which depicts specialized halibut hooks and sinkers and notes that halibut fishing occurred "700 feet deep." Ex. B310A.1. Halibut fishing at 700 feet, or approximately 117 fathoms, would place the Quileute near the continental shelf break, about 40 miles offshore. Quileute finfish harvest 40 miles offshore at treaty time is not, however, corroborated by other sources and was unlikely to have been a regular practice at and before treaty time.

3. Quileute Whaling

10.1. Like the Quinault and the Makah, the Quileute harvested whales on a regular and customary basis at and before treaty time. Judge Boldt recognized whaling as a customary Quileute practice in setting forth the Quileute's case area U&A. FF 108. Evidence of Quileute whaling is present in the archaeological assemblages from Quileute middens and pervasive in the historical and ethnographic record.

10.2. Whale bones have been recovered from three archaeological sites associated with prehistoric and historic Quileute occupancy: the La Push, Strawberry Point, and Toleak Point sites. *See, e.g.*, Ex. 338 at p. 28, Ex. 201 at p. 92. While it is possible that some of the whale bones present in the middens resulted from drift animals, Dr. Wessen concluded in a seminal report on the La Push excavation that the presence of marine mammal bones in the midden indicates that marine mammal hunting was a very important activity and that the archaeological data provide "clear evidence that Quileute People ventured into deeper offshore waters." Ex. 338 at p. 68. Dr. Schalk, whose testimony the Court also finds credible, was in accord. *See* Tr. 3/10 at 182:9-185:12 (Schalk). The proportions of mammal bones found at La Push closely resemble the makeup of the midden at the Ozette village at Cape Alava, another site believed by experts to represent continuous whaling activity for hundreds of years up to and including treaty time. *See* Ex. 338 at p. 29; Tr. 4/7 at pp. 2-7 (Wessen). Excavations at Toleak Point also suggest that whale bones are present in substantial amounts at the site, though not yet identified to species or quantified. *See* Tr. 4/7 at 16:4-15 (Wessen).

10.3. Albert Reagan also identified a diverse array of whale bones in the La Push middens, including "sperm whale, black fish, fin-back, sulphur bottom, California gray, and killer whale." Ex. 247 at p. 15. There are reasons to doubt the species identifications made by Reagan, who provided no indication of his methodology and attempted species identifications among salmonids thought impossible by Dr. Schalk and others. *See* Ex. B126 at p. 8. It is likely that Reagan's list reflected his observations of

Quileute whaling in the early 1900s, as well as his knowledge of available whale species and historic Quileute whaling practices. *See, e.g.*, Tr. 4/6 at p. 61 (Wessen).

10.4. The significant presence of whale bones at Quileute sites is particularly telling because it is likely that whale bones would be underrepresented in the middens. Ethnographic information shows that whales were butchered on the beach, and it is likely that the only bones that ended up in the middens were those transported to the village for use in the manufacture of bone tools or in architectural elements. Tr. 4/6 at 107:9-108:3 (Wessen). The presence of whale bone artifacts in the middens both evidences this theory and demonstrates the important role that whales played in the traditional Quileute economy. Ex. 338 at p. 42.

10.5. The Quileute whaling tradition is deeply engrained in the tribe's identity, reaching as far back as the collective memory of the Quileute people. The Quileute Arthur Howeattle, for instance, informed Frachtenberg that "[w]haling was practiced since immemorial times and was an important industry, since the bone furnished them with material for their tools, the oil and meat their food." Ex. 58(c) at pdf p. 84. Albert Reagan's article on whaling practices of the Olympic Peninsula Indians similarly begins, "In this village from time immemorial have lived the Quileute Indians, a coastal people that engage in whaling." Ex. 252 at p. 25. Another oral history recorded by Reagan, "Why the People of Quillayute are Few in Numbers," teaches the importance of praying to mother earth to ensure that the meat of hunted whales will be good and details aboriginal whaling practices, including the use of hair sealskin buoys used in towing the whale. Ex B333.28. These and other oral traditions illustrate the centuries-long time depth associated with Quileute whaling.

10.6. As with the Quinault, Quileute whaling is surrounded by rituals suggestive of its importance in the tribe's culture. The anthropologist George Pettit, stationed at La Push during World War II, observed that aboriginal Quileute culture possessed a number of occupations associated with a specific guardian spirit and practiced only by a defined group of people sponsored by the proper spirit power. One such occupation was whaling. Fur sealing was another. Ex. 218 at p. 10. Edward Curtis, who described the Quileute as second only in whaling to the Makah, recorded an account of some of the rituals associated with whaling given by Yahatub, a Quileute born around 1835 who learned the trade from his uncle. Ex. 37(a) at pp. 145-47. Yahatub learned from his uncle to begin in the winter taking daily ritualized baths in the sea in an isolated location. While bathing, Yahatub would pray to the Universe, asking for help in taking a whale. Whalers were to keep away from women during the season for bathing and for whaling, which ended each year in October. Yahatub explained that "when summer approached, the Sun, some night as I slept, would show me that I would get whale the next day, and when the vision came I would start out." *Id.* at p. 146. Dr. Olson interviewed Quileute member Jerry Jones, born 1867, who informed him that his grandfather (born approximately 1815) was a whaler. Jones also described ceremonial whaling practices exercised by his relatives, which were wholly distinct from those practiced by the Makah, suggesting the substantial time depth of the Quileute whaling tradition. *See* Ex. 211 at pdf p. 286; Tr. 3/12 at 149:18-150:2 (Boxburger); Tr. 4/2 at 125:3-23 (noting differences between Quileute and Makah whaling rituals) (Renker).

10.7. While rituals may have differed between tribal groups, Quileute whaling practices mirrored those employed by both the Makah and the Quinault. Traditional whaling implements were similar to those used by the Makah, consisting of harpoons, sinew and cedar lines, and floats. Ex. 323 at p. 44; Tr 3/25 at 20:19-22:2 (Boxburger). Frachtenberg provided a lengthy description of aboriginal Quileute whaling practices. Like the Quinault, the Quileute practiced whaling in specialized ocean-going canoes in parties of eight, each with specified duties. The whalers brought their own lunch and used sails to voyage into the sea. Typically four of five canoes would go out together on a hunt, and after a whale was speared, the canoes would gather to assist in the fight. Frachtenberg characterized the Quileute as highly skilled whalers, better even than the celebrated Makah, and invested with "great skill, courage, and quickness on the part of spearman and steerman." Ex. 58(c) at pp. 84-97.

10.8. Whale products played an important and diverse role in pre-treaty Quileute economy and culture. Dr. Frachtenberg reported on various uses of whales, among them: whale bones for tools and arrowheads; whale sinew for necklaces, threads, fish line and hooks; whale ribs to pry open mussels and barnacles; whale oil for dipping of food; and preserved whale meat serving as a valuable winter food supply. *See* Ex. 58(c); Tr. 3/12 at pp. 147:10-149:17 (Boxburger). The Quileute whaler Yahatub informed Edward Curtis that "[a]fter being rendered, the [whale] blubber was dried and smoked, and laid away for the winter. The flesh was cut into sheets like halibut steaks and dried in the sun or the smoke." Ex. 37(a) at p. 147. Harry Hobucket, born 1884, corroborated these uses of whale in his article, "Quillayute Indian Tradition," recounting aboriginal Quileute whaling practices. Ex. 94 at p. 41. The Quileute Robert Lee, in his testimony in *United States v. Moore*, likewise confirmed Quileute use of whale for subsistence purposes prior to the arrival of non-Indians. Ex. 178 at pp. 348-59.

10.9. The limited historical accounts of pre-treaty contact with the Quileute corroborate the traditional nature of Quileute whaling practices. There were six recorded treaty-time Quileute villages associated with whaling. Ex. 119 at pp. 6-10. Members of the Quileute/Hoh Tribes offered whale oil to the Russians stranded in their territory following the 1808 wreck of the Sv. Nikolai. Ex. 214 at p. 53. Ultimately, one of the Russian survivors was traded to a whaler who departed for Destruction Island in Quileute/Hoh territory. *Id.* at p. 64. James Swan also recounted the Quileute offering him whale oil in trade when he visited La Push in 1861, several years after the signing of the Treaty of Olympia. Ex.

419 at pp. 5-6. Indians born around treaty-time recounted aboriginal whaling traditions to Edward Swindell, who visited the Quileute in 1942 to obtain information on their usual and accustomed activities. For instance, Benjamin Sailto, a Quileute born 1853, told Swindell that "in addition to smelt the Indians who lived at La Push would also catch whales and seals in the ocean." Ex. 293 at p. 225.

10.10. The many Quileute words associated with extraction of ocean resources and with whaling in particular are indicative of the importance of whaling in Quileute culture. Among others associated with whaling, Quileute possess different words for whale, killer whale, expert whaler, summer whale, whale society song, drift whale, whalers who inflate floats and assist with line, whalers who paddle and help to steer, steersman whaler, whale sinew, and different sorts of whaling equipment. Ex. 225. The Quileute words associated with offshore ocean travel, including words for "blue water" and "way out at sea," indicate Quileute familiarity with distances far offshore. *Id.*

10.11. The evidence shows that whaling was practiced by the Quileute at and before treaty time on a regular and customary basis, taking place habitually every summer. Singh noted that Quileute whaling traditionally took place each June and July, Ex. 277 at p. 65, while Powell recorded aboriginal Quileute whaling taking place each February, May, and June, Ex. 223 at pdf p. 14. According to Curtis, the tribe pursued the "winter whale" each June and July and the "summer whale" in August. Ex. 37(a) at p. 145. According to Frachtenberg, the Quileute hunted whale each spring and summer. Ex. 58(c) at pdf p. 90.

10.12. Quileute whaling practices continued in the same manner after treaty-time. Upon hearing from a number of Quileute witnesses in the 1893 *United States v. Pullen* hearing, the court concluded that "the male portion of these Indians spent their time sealing during the months of March, April and May. They hunted up the river early in June and went whaling in the same month, and continued at that during July." Ex. B242.21. The 1888 U.S. Commission of Fish and Fisheries Report similarly observed that the Quileute "engage in whaling during the summer; nine finback whales were captured in 1888; these were cut up and smoked for food. The catch is wholly for home consumption and has no commercial importance." Ex. 299 at p. 243.

10.13. Accounts of the distances at which the Quileute customarily whaled at and before treaty time are contradictory. Dr. Frachtenberg reported that Quileute whalers "were not forced to go very far into the sea as some whales came as far to the beach as the edge of the breakers." Ex. 58(c) at pdf p. 90. Consistent with this observation, Albert Reagan recorded that the Quileute principally pursued the California gray whale, Ex. 252 at p. 25, a species that frequently traveled within six miles of shore on its northbound summer migration. Tr. 3/9 at 152 (Trites). The humpback whale too migrates in close proximity to the coastline and, like the gray whale, could often be spotted from shore. *See* Ex. 428 at p. 37. Reagan and Frachtenberg both described Quileute villagers watching the hunt from shore.

10.14. Other ethnographic reports, however, describe customary whaling practices taking place at much greater offshore distances. Yahatub recounted that whalers "might spend several days in a fruitless search" and "usually found [their whale] out of sight of land." Ex. 37(a) at p. 146. Testimony and evidence submitted at trial show that the description "out of sight of land" is most likely associated with distances upward of 40 miles offshore. *See* Tr. 3/12 at pp. 132:10-133:24 (Boxburger); Ex. 348.2 (Quileute elder stating that land is no longer visible 50 to 60 miles offshore). Yahatub also detailed customs that the whalers would follow when forced to stay out over night in their search for whale. *Id.* ("When more than one day was spent at sea, the leader watched at night while his men slept."). Such customs are indicative of lengthy hunts. Dr. Pettit's description of aboriginal Quileute whaling practices placed them 25 to 50 miles offshore. Ex. 218 at pp. 8-9. Other reports suggest that whales could sometimes be seen spouting several miles offshore but that once harpooned would regularly drag a canoe out of sight of land, for as long as two to three days at sea. *See, e.g.*, Ex. 277 at p. 41 (Singh). Olof Erickson, for instance, recounted a whale pursuit with the Quileute tribe, where the whale was "discovered spouting five miles off shore" but once harpooned towed the canoe "[m]ile after mile…until not a sign of the Indian village could be seen." Ex. 145 at pp. 150-56.

10.15. Like the Makah, the Quileute likely employed more than one whaling strategy, engaging on a regular basis in both nearshore and offshore hunts. *See* Ex. 260 at p. 18; Tr. 3/12 at 151:10-21, 163:2-7 (Boxburger). Dr. Frachtenberg described both strategies, reporting both nearshore hunts taking place to the edge of the breakers and offshore hunts which required whalers to go "20 to 30 miles into the ocean attacking whales with their primitive weapons." Ex. 56(a) at pdf p. 3. Offshore hunts at these distances would allow Quileute whalers to access the most productive sites for whaling near the continental shelf break, which is generally located upward of 30 miles offshore adjacent to Quileute territory. Tr. 3/9 at 105:12-24 (Trites). While the gray whale and humpback whale migrate fairly close to shore, other whales associated with Quileute harvest are typically encountered 20 to 50 miles offshore. *See* Tr. 3/9 at pp. 113-121 (Trites). Synthesizing the various accounts, Dr. Lane opined that "whales were usually found out of sight of land, twenty-five to fifty miles offshore, and that whaling crews sometimes had to be at sea overnight. These accounts attest to the ability of the Quileute to navigate the offshore waters and to return home safely." Ex. B349.9-10. While it is not possible to place a precise outer bound on Quileute whaling, the evidence together indicates the Quileute whalers were more likely than not harvesting whales upwards of 30 miles offshore at treaty time on a customary basis.

4. Quileute Fur Sealing

11.1. The evidence profoundly demonstrates that since prehistoric times, the Quileute have been a fur sealing people, harvesting fur seals in great quantities from the Pacific Ocean for their subsistence uses. Evidence of the great time depth of the Quileute fur sealing tradition and of its substantial entanglement in Quileute economy and culture is ubiquitous across the archaeological, historical, and ethnographic record in this case.

11.2. First, archaeological data from middens associated with the Quileute people evidences over 1,000 years of consistent and continuous fur sealing by the Quileute people. Fur seal bones account for over 90% of the mammal bones recovered from the La Push midden, where mammal bones represent the most abundant class of recovered faunal remains. Ex. 338 at pp. 27-29 (accounting that the mammal bone assemblage represents 11% to 69% of the total specimens in the four strata represented in the La Push midden and concluding that the densities of mammal bones in the total archaeological assemblage are unusually high for regional standards); Tr. 4/6 at 111:22-23 (Wessen). Fur seal bones are dominant across the strata of the La Push midden, indicating a continuity in Quileute harvest of the animals stretching back 900 years before present. At the Cape Johnson site, whose archaeological remains reflect the time period from 1100 to 700 years before present, fur seals bones are similarly prevalent throughout the midden, accounting for roughly 70% of recovered mammal bone specimens. *Id.* at 111:23-24; Ex. 347, passim. The archaeological material recovered from the Strawberry Point site, located approximately 6 miles south of La Push and dating back 100 to 200 years, also shows the presence of fur seal bones in the midden, though in lower proportions than recovered at La Push and Cape Johnson. At the same time, there are reasons to believe that fur seal remains may be more prevalent in the Strawberry Push midden than accounted for in the available data. In particular, the relatively small overall sample size of the Strawberry Point excavation (four square meters in area, representing only 10% of the remaining deposit) casts doubt as to whether the recovered samples are representative of the whole. *See id.* at pp. 49-50; Tr. 3/10 at 151:23-152:3, 3/11 at 72:9-73:11 (Schalk).

11.3. The presence of large proportions of fur seal bones throughout prehistoric to historic strata refutes the hypothesis that fur sealing is a post-contact phenomenon. *See* Ex. A16 at p. 6; Ex. 338 at p. 68. Dr. Schalk credibly concluded from the midden evidence that Quileute use of offshore marine resources – and of fur seals particular – was persistent, taking place unabated over a period of many centuries up through treaty times. Tr. 3/10 at 182:13-22 (Schalk). Dr. Wessen, in his book chapter on "Prehistory of the Ocean Coast of Washington," similarly concluded that fur seal hunting has been ongoing on the Olympic Peninsula coast for the last 2,000 years. Ex. 344 at p. 421. The similarities between the La Push site and Makah sites like that at Ozette are indicative of the longstanding reliance on fur seal harvest by peoples spread across the Olympic Peninsula coast. *See* Ex. 338 at p. 29. Were archaeological data to be generated for sites associated with aboriginal Quinault occupancy, the data would more likely than not show a similar adaptation by the Quinault people to this feature of their coastal environment. *See* Tr. 190:8-191:5 (Schalk).

11.4. While it is not possible to ascertain from the midden evidence alone the locations from which fur seal were obtained by the Quileute, it is reasonable to infer from the abundance of fur seal remains at La Push and Cape Johnson that the Quileute did not merely rely on the happenstance drift of a fur seal carcass onto their coast. Rather, the midden evidence demonstrates a sophisticated adaptation of the Quileute and other tribes of the Olympic Peninsula coast to harvesting available ocean resources through, among other offshore activities, the deliberate and customary hunt of fur seals. *See* Ex. 344 at p. 421. Moreover, current scientific knowledge of fur seal biology supports a strong inference that these hunts were regularly taking place at distances substantially offshore at and before treaty time.

11.5. Fur seal biology evidences a centuries-old migration path followed by the animals 30-60 miles offshore of the Washington coast. As Dr. Trites credibly testified, these pelagic animals are driven by their biology to follow the continental shelf in order to access their prey on their annual return migration to rookeries in northern Alaskan waters. Each year, adult female seals from the Pribolof Islands in Alaska migrate south to access the productive waters of the California current system, returning northward to their breeding grounds in the spring and coming onto land once a year to breed at their established offshore rookeries. Both while breeding and during their annual migration, the seals feed over the continental shelf break, where they spend their nights diving to meet their prey as it rises up from the deep. During the day, when their prey is too deep for the seals to access, the seals spend their time sleeping and resting on the surface where they could easily be taken by furtive hunters.

11.6. Historical records and contemporary tracking data paint a robust picture of fur seal migratory behavior. Consistent with fur seal feeding patterns and expectations from the animals' physiology, these data document female fur seals following a settled migratory path along the continental shelf break roughly 30 to 60 miles off the coast of Washington as they return each spring to the Pribolof Islands to birth their young. Tr. 3/9 at 42-48 (Trites). In one recent study that tracked 81 migrating Alaskan seals, no fur seal came nearer than 15 or 20 miles from shore, and the majority of the seals remained 30 miles or more from the coast. *Id.* at 47:15-48:4. Historical data collected by sealing schooners between 1883 and 1897 corroborate these behaviors. *Id.* at 43:21-44:22. While errant fur seals occasionally wander closer to shore, it is highly unlikely that they leave the standard migratory path with sufficient frequency to account for the overwhelming abundance of fur seal remains in Olympic coast middens. *Id.* at 55:15-21.

11.7. While a hypothesis exists in the literature that a prehistoric nearshore rookery off the coast of Washington may have accounted for the prevalence of fur seals in the middens, this hypothesis is not supported by evidence of fur seal biology and behavioral patterns. First, all known fur seal rookeries are located on remote islands, over 25 miles offshore and characterized by cool and foggy weather. These inhospitable and inaccessible environmental conditions are necessary to protect the seals, particularly the vulnerable pups, from predators during their annual mating cycle. *Id.* at 17-23. As of 1850, only four documented breeding sites for northern fur seals existed, with the Pribolof Islands off the coast of Alaska representing the sole North American site. *Id.* at 24. A breeding site has since been reestablished in the Farallon Islands off the coast of California, where historical records show that a productive rookery was extirpated by Russian sealers in 1841, and another rookery has been established on California’s San Miguel Island at the likely location of a rookery extirpated by an indigenous population around 500 years ago. *Id.* at 25-29; Tr. 3/10 at 5:3-7 (Trites). Even with protective regulations enabling the return of fur seal populations to prehistoric rookeries, no rookery has been established off the Washington coast, and no known site in the region exists that would offer the protection necessary for fur seals during the breeding season. Tr. 3/9 at 73:17- 94:19 (Trites). Dr. Trites’ testimony that the hypothesized nearshore fur seal rookery would be a “biological impossibility” was not refuted by any qualified expert at trial. *Id.* at 91:21-23.

11.8. Second, the migratory behaviors of Pribolof Island, San Miguel Island, and Farallon Island fur seal populations fully account for the presence of bones of both male and female seals of varying ages in the middens. Variability in the size of fur seals of the same age accounts for some of the diversity in the size of bones present in the middens. *Id.* at 86:1-10. The adult female fur seals were most likely harvested during their return migration to Alaska or during their northward migrations from breeding grounds in California. Female fur seals returning to the breeding grounds carried fetuses in their last month of gestation, whose harvest likely accounts for the presence of pre-weaned pups in the middens. Historical accounts of fetal pups being extracted from pregnant mothers bound for the Pribolofs by crews aboard schooners and brought back to shore accords with the biological evidence. *See* Tr. 3/9 at 84:10-85:7. Dr. Trites further credibly testified that, more likely than not, the migration of prehistoric adult male fur seals and young pups northward from Californian rookeries to feed off the coast of Washington explains the presence of bull and weaned pup remains in the middens. *Id.* at 86:15-87:6; 102:20-103:15. These California-based breeding populations migrate along the same continental shelf pathway off the coast of Washington that is followed by the Alaskan fur seals leaving the California current system for breeding grounds in the Pribolofs. It is reasonable to infer from tracking data for adult females and weaned pups from California populations that these seals would have been available for harvest off the coast of Washington prior to the extirpation of the California rookeries, consistent with expectations from fur seal biology and physiology. *Id.* at 87:10-88:16.

11.9. Third, genetic analyses of modern fur seals and fur seals remains from coastal middens indicate that modern fur seals are genetically identically to prehistoric ones. The continuity of fur seal DNA across the centuries undercuts the hypothesized existence of a now extinct non-migratory fur seal species capable of breeding in the nearshore environment. Tr. 3/9 at 82:24-83:17. As Dr. Trites explained, fur seals today are the same species as that taken by coastal Indians in prehistoric times. *Id.* at 90:10-11. Changes in ocean currents may have exercised some influence on fur seal migratory patterns, but fur seals are “ultimately driven by their physiology and basic principles of oceanography, physics and biology.” *Id.* at 90:12-15. The known offshore migratory patterns of fur seals have remained constant across time and regardless of fluctuations in the fur seal population.

11.10. In sum, the stable physiological and biological characteristics of fur seals strongly support an inference that coastal Indians were harvesting the species off the continental shelf adjacent to their territories at and before treaty times. By contrast, the alternative nearshore rookery theory is based on speculation rather than evidence and, in the opinion of Dr. Trites and this Court, lacks a sufficient scientific basis to reliably account for the abundance of fur seal remains in the Quileute middens.

11.11. Ethnographic evidence corroborates the biological and archaeological evidence of the Quileute fur sealing tradition. Quileute accounts of pre-treaty sealing practices indicate that fur seals were harvested for the tribe's own subsistence use as well as for trade with neighboring tribes prior to the arrival of non-Indians in the area. Robert Lee, a Quileute Indian born 1879, attested to the time depth of the tradition, stating that the Quileute traded fur seal skins "regularly with the west coast (British Columbia) Indians…up until the time that a white man's trading post was established at Neah Bay. They then traded at this trading post until a store was established at La Push." Ex. B100.4. Based on information obtained from Mr. Lee, the authors of the Bureau of Indian Affairs article titled "Indians at Work" reported that the Quileute Indians had been engaged in pelagic sealing "[f]rom time immemorial. Before the advent of the white man these Indians used the skins so obtained for mats and bed coverings and for trading with the West coast and other Indians." Ex. 205, p. 12; Tr. 3/12 at pp. 181-83 (Boxburger). Lee likewise testified in *United States v. Moore* that the Quileute "used [fur seals] for themselves, before the white man come," "drying" the seal meat and "keeping it for winter use." Ex. 178 at p. 349. Recounting pre-contact Quileute history, Ruth Kirk wrote in a 1967 publication that the Quileute "lived by hunting whales and seals from dugout canoes when Great-Grandfather was a boy, and by gathering berries and digging roots in the forest. They knew nothing of white men's ways because white men had not yet settled along the west coast of Washington[.]" Ex. 135 at pdf p. 5.

11.12. A Quileute oral history recounted by the anthropologist Manuel Andrade attests to the time depth of the Quileute fur sealing tradition, consistent with the midden data. The oral tradition tells that "long ago three men in a canoe drifted from the other side (from Vancouver Island) and landed at Ozette," where they taught the people to hunt fur seals in their canoes. "[N]ot long afterward people from the Quileute arrived at exactly the same time as those who had been hunting seals were returning home," where they too were taught the fur sealing practice. "Ever since that time the Quileute" continue to hunt fur seal. Ex. 4 at pp. 205-07. The framing of this story as having taken place "long ago" places the origin of Ozette and Quileute fur sealing traditions in aboriginal times, far before contact with non-Indians. *See* Tr. 3/3 155:12-19 (Hoard). This story is corroborated by the borrowing of the Quileute words for "fur seal" and "fur sealing" from the Makah language. The linguistic evidence, credibly attested to by Dr. Hoard, suggests that these words were adopted sufficiently long ago for any competing terms, or doublets, to fade out of collective memory. *See* 3/3 at pp. 142-43, 150-56 (Hoard).

11.13. By contrast, the evidence does not support an inference that the Quileute began fur sealing only when trade with non-Indians made the practice commercially viable. The hypothesized introduction of fur sealing to the Quileute economy in the mid-1800s is based principally on a single account by the Quileute Arthur Howeattle given to Dr. Frachtenberg. Howeattle's account, as recorded by Frachtenberg, placed the origin of the Quileute fur sealing tradition only a decade prior to the Treaty of Olympia: "According to Arthur, fur sealing was introduced by the Ozettes at the time when Arthur's uncle (his father's immediate predecessor) was chief. This was about 70 years ago…. Since then the Quileutes developed fur-sealing as their most profitable industry." Ex. 58a at pdf p. 137. Contrary to Howeattle's report, evidence of a Quileute sealing tradition stretching back hundreds of years is written across the archaeological and ethnographic record. Howeattle’s report is also unreliable in other respects, including in his attestation that the Makah and the Ozette had given up fur sealing; these tribes in fact continued to practice sealing for years after 1916. *See* Tr. 3/13 at p. 22 (Boxburger).

11.14. Traditional Quileute use of fur seals continued after the arrival of non-Indians on the Olympic Peninsula, resilient to the expansion of the commercial fur seal industry. A physician for the Neah Bay Agency, who visited La Push in the spring of 1891, observed that “It was [the Quileute’s] sealing season, and seal flesh to them was a toothsome dish.” Ex. 157 at p. 450. Albert Reagan similarly reported in 1922 that “fur seal is, of course, killed for its valuable fur, through the Indians are fond of its flesh and use its paunch to store whale oil and salmon-egg cheese.” Ex. 248 at p. 447. Reagan’s account mirrors Quileute practices recorded by survivors of the 1808 wreck of the Sv. Nikolai, who reported that the Quileute/Hoh offered “two sealskin bags of roe” and a “bladder full of whale oil” in up-river trade transactions. Ex. 214 at p. 53. In an 1887 publication, James Swan described Quileute sealing continuing in its traditional form despite the introduction of schooners to the area. He recorded that in 1880 the Quileute had caught 602 seals using 20 canoes crewed by 60 Indians. Ex. 288 at p. 399. The strength and resilience of the Quileute fur sealing tradition can reasonably be inferred from its continuity post-treaty, through the growth of the commercial fur seal industry.

11.15. Historical and ethnographic accounts of Quileute fur sealing are consistent with the biological evidence of regular Quileute fur seal harvest at distances upward of 30 miles offshore during the seals' annual spring migration off the Washington coast. During a sealing trip with Quileute sealers in 1893, Chris Morgenroth observed that the seals’ migratory route was 30-50 miles: “Seal hunting by coastal Indians take place during these two months [April and May] in the 100 miles stretch of open sea between the mouth of the Queets River and Cape Flattery. Here the seals approach nearest to land, their line of northerly migration being about thirty to fifty miles offshore." Morgenroth further recounted leaving La Push "about 3:00 a.m. with fresh 'mokah' (east wind)" and reaching the "outskirts of the sealing grounds, some thirty miles from shore" after "six hours of strong paddling." Ex. 180 at pp. 58-60. Morgenroth's description is entirely consistent with Dr. Trites' testimony about the spring migration of fur seals and their density off the continental shelf 30 or more miles from shore. *See* Tr. 3/9 at 59:5-61:13 (Trites). In 1895, Captain C.L. Hooper related that Quileute fur sealer canoes crewed by three men were forced to go greater distances offshore than the Makah and were "often kept out over night." Ex B097.14. Hooper's account is also consistent with Dr. Trites' testimony that the fur seals would be available closer to shore off Makah territory given the nearer shore continental shelf break at the site of the Juan de Fuca Canyon off of Neah Bay. *See* Tr. 3/9 at 54:6-55:21 (Trites). So too is Dr. Singh's account that, during their spring migration northward, "Quinault and Quileute had to ge [sic] from twelve to thirty miles into the open sea, whereas near Cape Flattery the fur seal came near shore and was hunted by the Makah within a range of ten to fifteen miles." Ex. 277 at p. 21.

11.16. Numerous, remarkably similar reports of traditional Quileute sealing practices provide evidence that the Quileute were harvesting fur seals in substantial numbers each spring at the continental shelf break, 30 to forty miles from shore. Beatrice Black, born 1890, recalled that her brother "used to go out early as, as March, go out in the ocean, way out to get some seal…two or three months he'd go out…get as high as 100 seals each day hunting… They risk their lives going way out, forty miles out in the ocean in an open canoe. Three men in a canoe. Sometimes they'd be loaded with about five, six or ten seals." Ex. 017 at pdf p.1. Frachtenberg too reported that the "Quileute use special canoes for [sealing]; these canoes are dug-outs, made of cedar, and are manned by three people. The sealing season lasts from March until July, and the hunters very often go 30 and 40 miles out into the sea." Ex. B096.119. After reviewing testimony from numerous Quileute elders in 1945, the Ninth Circuit in *United States v. Moore* concluded the Quileute, "[w]hen first visited by white men," were regularly hunting pelagic fur seal herds as they migrated along the 100 fathom line to and from the Pribolofs. Ex. B118.4.

11.17. Robert Lee, who attested to having been out sealing to the "blue sea, reported to be forty miles," provided a description of traditional Quileute sealing practices that demonstrates a sophisticated adaptation to optimally exploiting fur seal physiology and behavior. According to Lee, Quileute sealers "leave the village before daylight, about 1:00 or 2:00 o'clock in the morning." The sealers take advantage of the prevailing "east wind….through sails, made of cedar bark," arriving at "the sealing grounds about daylight, when they speared the seal as they were sleeping on the water. Seals normally sleep in the daytime and the Indians say they can distinctly hear the seal snoring as they sleep on the surface. As the seals are speared they are dragged into the boat where they are taken ashore, when the hides are taken off for use or trading purposes and the meat used for food purposes." Ex. B100.5. Hal George, a Quileute born 1894, similarly recalled, "[Weather forecasters] would sit up after midnight to tell weather watching from up on the hill. Seal hunters sometimes took off at 2:00 AM. They wanted to get out to what was called xopasida (blue water) – the place where the ocean really gets deep." Ex. 220 at pdf p. 12. Jay Powell, in an article describing Quileute culture and "old ways," reported similar rituals and customs surrounding the Quileute whaling tradition. According to Powell,

> "Oldtime Quileutes used to go out in big sealing canoes called alotk [Ah-low-tk] and spear fur seals as they migrate north in great herds on their way to their 'pupping

> grounds' in the Pribolof Islands…. Fur seal hunting was considered to be real t'axilitowaskwa '*work that requires a strong spirit power*.' During the March moon, the old Weathermen would go up before dawn daily and sit on a bench located where the Senior Center is now. There, they would observe the dawn, clouds, wind, and waves…watching, listening, sniffing and chanting. It was their job to decide whether this would be a successful and safe day for the tribal sealers to go out. If so, several canoes would start out with four paddlers, one of whom was the harpooner. It took hours to go the 30-50 miles to the sealing grounds, pulling an empty canoe behind. If they were lucky, when they returned that two-canoe would be full, mounded up with fur seals. Fur seals are called kilados [KITH-ah-dos], but fur seal hunting is yashabal [yah-SHAH-bah-th]. That's the reason March is called yashabalktiyat.

Ex. 221 at pdf p. 175.

11.18. It is not possible to document the precise outer bounds at which the Quileute regularly harvested fur seals before and at treaty time. At the same time, the evidence demonstrates that aboriginal Quileute sealers, like the Quinault, concentrated at the continental shelf break adjacent to their territory, where the density of fur seals was greatest during the animals' annual migrations. This shelf break occurs somewhat closer to shore in Quinault territory than in Quileute territory – as close as 20 miles to shore at the Quinault canyon and upwards of 30 miles offshore further north. Ex. 267, 277; Tr. 3/9 at 66:9-18; 105:15-24 (Trites). These geographic markers, coupled with the ethnographic accounts, support a reasonable inference that the Quileute were fur sealing on a regular and customary basis up to 40 miles offshore at and before treaty time.

C. Quileute Indian Tribe's Northern Boundary

1. Tatoosh Island and Cape Flattery

12.1. Although the Quileute do not claim to have occupied inland territory north of Cape Alava, they assert that the tribe was accustomed at treaty time to fish at the banks off of Tatoosh Island, offshore of Cape Flattery at the far northwest corner of the Olympic Peninsula. The evidence, and inferences drawn from it, do not support this claim.

12.2. First, the Quileute's claim is inconsistent with Makah assertion of ownership of the fishing banks off of Cape Flattery. The Makah were the southernmost representatives of the Nootkan culture, which "carried the concept of ownership to an incredible extreme." Tr 3/25 at 142:24-143:6 (Renker); Ex. 44 at p. 247. Unlike the Quileute, who differentiated between private hereditary ownership of inland fishing sites and common ownership of ocean and coastal sites, Nootkan notions of property swept broadly. Philip Drucker, an authority on Nootkan ethnography, explained that "[n]ot only rivers and fishing places close at hand, but the waters of the sea for miles offshore, the land, houses, carvings on house posts, the right to marry in a certain way or the right to omit part of an ordinary marriage ceremony, names, songs, dances, medicines, and rituals, all were privately owned property." *Id.*

12.3. Historical records confirm that the Makah asserted exclusive ownership of waters off of Cape Flattery. In 1841, the Makah Chief George informed Captain Wilkes of the Wilkes expedition that he owned the area around Cape Flattery and that Wilkes did not have the right to be there. Ex. 14 at p. 262. Dr. Renker's testimony that Chief George "was the chief who would have owned Tatoosh Island at that time" was unrebutted at trial. Tr. 3/25 at 144:3-5 (Renker). Other historical records in the immediate post-treaty era show continued Makah assertions of exclusive ownership of the Cape Flattery fishing banks. Colonel Simmons, who was then Puget Sound Indian Agent, wrote in an 1858 report that the Makah "obtain[ed] an abundant livelihood by catching cod and halibut on the banks north and east of Cape Flattery." Ex. 275 at p. 231. According to Simmons, the Makah refused to allow four men who had established a nearby trading post to "fish on the banks," despite the men's congenial trading relationship with the tribe. *Id.* at p. 232. The Makah also objected to a new lighthouse on Tatoosh Island, asserting "that is on their land, and that [the Indian agents] have no right to put it there without their consent." *Id.*

12.4. The historical evidence further shows that the Makah and their Nootkan relatives asserted ownership of the halibut banks against Indian tribes as well as non-Indians. Gilbert Sproat, who was living among the Nootkan Indians of Vancouver Island, wrote in 1868 that “fishing tribes on both sides of the Straits of Fuca would drive away any other tribes which had not been accustomed to fish on the halibut banks.” Ex. 143 at p. 20. Agent McGlinn, who had jurisdiction over the Makah and the Quileute, similarly reported on the Makah’s longstanding claims of ownership over the halibut banks off of Cape Flattery. McGlinn attested in an 1891 report that the Makah “view[ed] with jealousy the encroachment if the white men on what they have always regarded as their exclusive possessions, and find for the first time in their history that white competition has overstocked, and will I am afraid eventually take from them a market of which heretofore they have had almost a monopoly.” Ex. 157 at pp. 448-49.

12.5. Ethnographers of the Makah are in accord with the tribe’s traditional assertion of exclusive ownership over these halibut banks. In the Makah Pacific Ocean U&A subproceeding, Dr. Lane attested to the existence of “specific halibut banks lying northwest of Tatoosh… Island, which were known to be Makah banks and which other groups didn’t fish at.” Ex. 323 at pdf p. 11. Dr. Lane reiterated this view in a 1991 report on Makah halibut fishing traditions, commenting that “[t]he Makah, like other Nootkan people, regarded the fishing banks as private property. One aspect of this proprietorship was the right to control use of the fisheries.” Ex. 140 at p. 9. Joshua Reid, in his Ph.D. dissertation on the Makah, likewise explained that “‘[o]utside resources’—called such because they were in marine spaces outside bays, inlets, and rivers—were the most important property rights, and only the highest-ranking chiefs owned them.” Ex. 255 at pp. 13-14. Judge Boldt too found that “[a]

special feature of the Makah environment was a rich supply of halibut to which the Makah had access by virtue of ownership of lucrative fishing banks respected by competing tribes….” FF 61.

12.6. Accounts of the history of conflict between the Makah and the Quileute are inconsistent with treaty-time use of the Cape Flattery halibut grounds by Quileute tribal members. Linguistic evidence, including mythic traditions, relates that the Quileute’s ancestors once inhabited the entire northwest Olympic Peninsula before being displaced by the Makah, who moved south from what is now Vancouver Island around 1,000 years before present. *See* Ex. 134 at pp. 94-99; Ex. 259 at p. 422. An oral history recounted to Joshua Reid by a Makah elder places the exclusion of the Quileute from the waters around Cape Flattery and Tatoosh Island in the sixteenth century. The elder recounted that Quileute “warriors had once pushed Makahs north across the strait, claiming Cape Flattery, Tatoosh Island, and the surrounding waters.” However, during the early sixteenth century, “the exiled Makahs…began encroaching upon the halibut banks stolen by Quilleutes.” Violent raids ensued, and the Makah ultimately drove the Quileute “south and thereafter excluded them from the waters and marine resources around Cape Flattery and Tatoosh Island.” Ex. 255 at pp. 89-90. Albert Regan recorded a similar oral history. *See* Ex. 251 at pp. 7-11.

12.7. Later accounts show violent conflicts between the Makah and the Quileute extending closer to treaty time. Edward Curtis, for instance, recounted a Makah raid on Quileute fishermen near James Island around 1845 in the midst of a decade-long period of hostilities between the tribes. Ex. 37 at pp. 9, 11; Tr. 3/25 at 140-41, 152 (Renker); *see also* Ex. 58(a) at pdf p. 178 (account by Frachteberg of conflict around 1850). These hostilities appear to have continued for some years post-treaty. *See, e.g.* Ex. 284 at pdf pp. 28-29, 275-76 (account by Swan of killing of Makah whalers by Quileute when they drifted into Quileute territory); Ex. 65 at p. 16 (account by Gibbs that hostilities between the tribes "have occurred within the memory of men born as late as 1863").

12.8. Documented improvements in the relationship between the tribes in the late 1800s correspond with the first documentation of Quileute use of the fishing banks off of Tatoosh Island. According to Pettit and Swan, hostilities lessened with the arrival of non-Indian officials and the establishment of reservations. Ex. 218 at p. 15, Ex. 290 at p. 51. In 1879, Captain Willoughby attributed the improvement of the relationship between the tribes to various factors, including several intermarriages. Ex. 352 at pp. 144-45. Frachtenberg and Powell both recounted the exchange of "peace brides" in the post-treaty era, which brought hostilities to an end. *See* Ex. 58(a) at pdf p. 178; Ex. 220 at p. 27. Frachtenberg also recounted the first Quileute fishing trips to Neah Bay occurring in this period. For instance, Sally Black informed him that "Makah basketry was introduced amon[g] the Quileute's some 40 years ago [circa 1976], after the wars between the two tribes had stopped. Quilieute women used to accompany their husbands and fathers to Neah Bay on fishing trips and while there, they learned the Neah Bay basketry and introduced it among the Quilieute." Ex. 58(a) at pdf p. 21. Frachtenberg recounted Quileute fishing trips to Neah Bay continuing into the early 1900s, documenting that "[a]t the present time, the Quileutes leave for Neah Bay in the first part of July, fishing there with trolling hooks and purse-seins." *Id.* at pdf p. 126.

12.9. Additional historical accounts show Quileute use of the Cape Flattery fishing grounds occurring on a seasonal basis from the late 1800s. Makah elder Harry McCarthy, born 1902, recalled Quileutes fishing at a camp called Midway on Tatoosh Island. Ex. 323 at p. 25. The Quileute Hal George also recalled being at Tatoosh Island as a child, helping to dry the Quileute halibut catch, around 1899 to 1901. Ex. 220 at pdf p. 72. Lillian Pullen, a Quileute born 1912, relayed that her first husband's family would visit their annual halibut camp at Tatoosh Island during the period around WWI. Ex. 220 at pdf p. 125. By contrast, the comparatively voluminous historical record of Makah fishing off of Cape Flattery is absent any reference to Quileute use of the fishing banks prior to the late 1800s. Instead, the sole references to Quileute presence in the area are to occasional visits by tribal members to Neah Bay, not to fishing activities in surrounding waters. *See, e.g.*, Ex. 178 at p. 283 (1887 affidavit by Swan in the Pullen land dispute attesting that he "frequently saw these Indians at Neah Bay"). It cannot, for all these reasons, be reasonably inferred from accounts of post-treaty Quileute use of Cape Flattery fishing banks that the same pattern existed at and before treaty time.

12.10. Indeed, the Quileute claim to treaty-time fishing at Tatoosh Island is based largely on an ambiguous 1879 statement by the Quileute Chief Tahahowtl. Chief Tahahowtl recounted that during the treaty negotiations in 1855, he informed Colonel Simmons that this land formerly extended "from the island of Upkowis opposite Kwedaitsatsit down the coast to the Hooh River." Ex. 281 at p. 162. The linguist Dr. Hoard opined at trial that the phrase translates to "island" or "promontory" across from "Makah place," which he located as Tatoosh Island. *See* Tr. 3/3 at 112-16, 119-20, 122-23 (Hoard); *see also* 3/25 at 176 (Renker) (explaining that "upkowis" is a Makah word meaning a promontory or piece of land projecting from a beach). For several reasons, Chief Tahahowtl's statement does not give rise to a reasonable inference that the Quileute were regularly fishing off of Cape Flattery at treaty times.

12.11. First, a claim by Chief Tahahowtl to Tatoosh Island would be entirely inconsistent with Makah assertions of proprietary ownership of the island and surrounding waters, outlined above, as well as with exclusive habitation by the Makah people of the coast south of Tatoosh Island to Cape Alava in the centuries leading up to the treaties. It is not reasonable to infer that Chief Tahahowtl meant to claim the entirety of Makah territory for the Quileute, from Cape Flattery across from Tatoosh Island down the coast to the Hoh River. Indeed, Col. Simmons himself did not appear to understand Chief Tahahowtl to be claiming lands all the way to Tatoosh Island and Cape Flattery during the treaty negotiations, because he did not adjust the cession boundary in the treaty to encompass such lands. *See* Tr. 3/25 at 179-80 (Renker). Second, assuming that Dr. Hoard's translation is accurate, "upkowis" could have referred to any number of islands or promontories, such as Ozette Island across from Cape Alava, that would be more in keeping with a Quileute territorial claim than Tatoosh Island. *See* Tr. 3/25 at pp. 176:20-23 (Renker). While Hal George identified "upkowis" as Tatoosh Island, Ex. 220 at pdf p. 47, this identification is not exclusive. According to Dr. Renker, the Makah themselves associated the term with two different sites – one about a mile north of Cape Johnson and another east of Cape Flattery. *See* 3/25 at 176:10-15 (Renker). Third, the language and context of Chief Tahahowtl's statement indicate that he was concerned with claiming lands for the purpose of treaty negotiations, which concerned land sales. *See* Tr. 3/25 at pp. 172-74 (Renker). Even if Chief Tahahowtl was referring to Tatoosh Island, his statement asserted a claim to land, not to uses of adjacent offshore waters for fishing purposes. *See* Tr. 3/4 at 40, 66 (Hoard).

2. Cape Alava

13.1. Like the Quileute's western boundary, the northernmost extent of Quileute fishing cannot be ascertained with either precision or certainty. Nonetheless, the treaty-time, ethnographic, and place name evidence together support a reasonable inference that the Quileute were fishing on a regular basis as far north as Cape Alava at and before treaty time.

13.2. First, it is reasonable to infer from the language of and statements attendant to the Treaties of Neah Bay and Olympia that the treaty negotiators on both sides understood aboriginal Quileute territory to extend as far north as Cape Alava. The treaties for the Makah and Quileute together denote a shared boundary between the aboriginal territories of the tribes, running eastward from the coast. The Treaty of Neah Bay identifies the Makah's southern territorial boundary as beginning on the coast at "Osett, or the Lower Cape Flattery, thence eastwardly along the line of lands occupied by the Kwe-deAh-tut or Kwill-eh-yute tribe of Indians." Ex. 298 at p. 1. The Treaty of Olympia likewise identifies the Quileute's northern boundary as "the southwest corner of the lands lately ceded by the Makah tribe of Indians to the United States, and running easterly with and along the southern boundary of the said Makah tribe to the middle of the coast range of mountains." Ex. 297 at p. 1. Colonel Simmons, who negotiated the Treaty of Olympia, later clarified his understanding of aboriginal Quileute territory to correspond to the boundaries identified in the treaties. In his 1960 Puget Sound Agency report, Simmons wrote, "The treaty of Olympia with the Qui-nai-elt and the Quillehute tribes remains only to be considered. These tribes occupy the sea-coast between Oxelt or old Cape Flattery, on the north, and the Qui-nai-elt river on the south." Ex. 276 at p. 195. Governor Stevens also affirmed this understanding of Quileute territory when he stated, in submitting the Treaty of Olympia to the Commission of Indian Affairs: "I herewith enclose the treaty made with the Qui-nai-elt and Quil-leh-ute Tribes of Indians on the Coast between Gray's Harbor and Cape Flattery," where "Cape Flattery" may refer to "Old" or "Lower Cape Flattery." Tr. 3/13 at 66:18-67:4 (Boxburger).

13.3. It is reasonable to infer that in placing this boundary at Ozette or old/lower Cape Flattery, the negotiators intended to locate the northernmost extent of aboriginal Quileute territory at or near Cape Alava. Tr. 3/13 at 66:12-14 (Boxburger). George Gibbs' 1855 map of the "Position of the Indian Tribes and the Lands Ceded by Treaty," illustrates the boundary between the Makah and the Quileute as beginning on the coast at "Osett," which it locates just north of Flattery Rocks in the vicinity of

Cape Alava. Ex B243.1. Arthur Howeattle expressed a similar understanding held by the Quileute, informing Dr. Frachtenberg that the Quileute's northern boundary was located at Ozette River, which spills into the Pacific just north of Cape Alava. Ex. 58(a) at pdf p. 53.

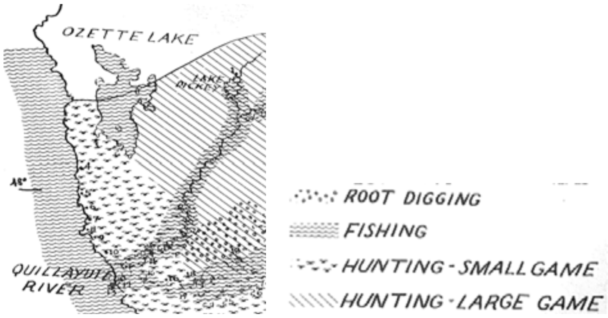
13.4. Government officials continued to locate the Quileute/Makah boundary in the vicinity of Cape Alava in the decades following the signing of the treaties. In 1872, R.H. Milroy, the Indian Agent for Quinault and Quileute, wrote that the lands ceded by the tribes extended "from a few miles south of Cape Flattery to a few miles north of Gray's Harbor." Ex. 168 at p. 339. A map published in 1876 at the direction of the U.S. Coast Survey and intended to "illustrate a paper by the late Geo. Gibbs" places Makah's southern boundary at the Ozette River, slightly north of Cape Alava. Ex. B088. James Swan, in his book "The Indians of Cape Flattery" gave a similar expression to Makah territory, informed by his experience living among the Makah between 1859 and 1866. Swan wrote,

> At the time of making the treaty between the United States and the Makah Indians in 1855…the [Makah] tribe claimed as their land, all that portion of the extreme northwest part of Washington Territory lying between Cape Flattery Rocks on the Pacific coast, fifteen miles south from Cape Flattery, and the Hoko River, about the same distance eastward from the Cape on the Strait of Fuca.

Ex. 290 at p.1. Dr. Boxburger testified at trial that Swan's description accurately places Flattery Rocks fifteen miles south of Cape Flattery, indicative of Swan's keen understanding of the coastline. Tr. 3/13 at 69:23-70:22 (Boxburger).

13.5. Ethnographers of the Quileute and the Makah have since located the boundary between the tribes in the vicinity of Cape Alava, consistent with these treaty-time understandings. In the 1990 *Handbook of North American Indians*, Dr. Renker and Dr. Erna Gunther published a map of Makah Territory that places its southern extent just south of Cape Alava. Ex. 249 at p. 423. Dr. Powell likewise reported that "aboriginal Quileute territory extended from south of Cape Alava to Destruction

Island." Ex. 226 at p. 431. Dr. Verne Ray and Dr. Nancy Lurie prepared a map of aboriginal territory for the ICC proceedings, based on their review of ethnographic accounts of the Quileute and their own field studies with the tribe. The map depicts Quileute ocean fishing activity extending northward along the coast to a location just south of Cape Alava and adjacent to the northernmost extent of Lake Ozette:



Ex. 120. Dr. Ray explained in his ICC testimony that "the shading over here on the ocean [to the west of Lake Ozette] indicates fishing activities. This would include bottom fishing for the various rock cod and flounders and so on." Ex. 243 at p. 240. Another ethnographer involved in the ICC proceedings likewise reported in a 1968 article that "Quileute informants insist that in aboriginal days their people fished and sealed almost to the mouth of the Ozette river." Tr. 3/25 at 14:22-17:2 (Boxburger).

13.6. Second, aboriginal Quileute fishing in the vicinity of Cape Alava can be inferred from evidence that the Quileute were fishing at Lake Ozette at and before treaty time. Judge Boldt's inclusion of Lake Ozette in the Quileute case area U&A is consistent with evidence presented at trial. *See* FF 108. In contrast to the Makah's exclusion of other tribes from the Cape Flattery halibut banks, the evidence shows that the Quileute and the Makah engaged in an amicable, shared use of Lake Ozette. Sextas Ward, born 1853, recounted to Edward Swindell that:

> when he was a small boy and a young man that the Quileute Indians used to fish at the lower or southern end of Lake Ozette; that the other end of the lake was used by the Ozette Indians who were different people than the Quileute;….that the Ozette Indians

> were friendly to the Quileutes and they did not have any trouble over both of them using the lake to obtain fish;…that he understands that when the treaty was made with Governor Stevens the Quileute Indians were supposed to be given the right to continue to use their old fishing place at Ozette Lake.

Ex. 293 at pp. 221-22. Ray and Lurie likewise concluded from their research that this shared use of the lake was a traditional practice, extending back before treaty time. Ray explained their decision to draw a boundary-line across the center of the lake in his ICC testimony:

> You will see that the fishing symbol covers all of Ozette Lake, and there was not in the minds of these people the feeling that there is somehow a dividing line across the middle of the lake, that they didn't dare follow the fish north or south…. I finally convinced myself this was the actual state of affairs, and I was much interested to see that later on, when I discovered the Frachtenberg manuscript, that he did precisely the same thing.

Ex. 243 at pp. 202-03. While Ray believed that each tribe should be able to fairly claim half of the lake for compensation purposes, the ICC ultimately denied compensation for the area to both tribes because of its joint use. Ex. 123 at p. 168; Tr. 3/13 at 72:20-73:11 (Boxburger). Arthur Howeattle likewise told Frachtenberg that he understood the Quileute to have "ceded to the Government the northern half of Lake Ozette" in signing the Treaty of Olympia. Ex. 58(a) at pdf p. 47. Because Arthur Howeattle was married to an Ozette woman, it is reasonable to infer that he was particularly knowledgeable about the history of shared use of the lake. *See* Tr. 4/1 at 100:12-101:6 (Renker).

13.7. The evidence shows that the Quileute did not constrain their fishing activities to Lake Ozette, but that they also fished along its adjacent coastline. Dr. Ray attested to this tradition before the ICC, explaining that the Quileute would fish up and down along the beach "covering a stretch of many miles" from their coastal village at Norwegian Memorial, located adjacent to the southern end of Lake Ozette. The Indians would travel back and forth along "the whole area in between Ozette Lake and the shores of the Pacific" for the purpose of hunting small game. "At other times, they would simply be hurrying down to the beach [from Lake Ozette] to get to their whaling station or something of that sort." Ex. 243 at p. 239. Aboriginal Quileute fishing along the coastline west of Lake Ozette can also be inferred from Judge Boldt's inclusion in the Quileute case area U&A of the "tidewater and saltwater areas" "adjacent" to Lake Ozette and the other inland water bodies at which the Quileute traditionally fished. FF. 108.

13.8. Third, evidence of Quileute place names is consistent with regular Quileute fishing as far north as Cape Alava. Dr. Ray provided a compilation of Quileute village sites to the ICC along with his maps, locating the northernmost of the sixteen identified Quileute coastal villages at Norwegian Memorial. Ex. 119.1. It is reasonable to infer, as this Court did in locating the southern boundary of the Makah's ocean U&A at Norwegian Memorial ten miles south of the southernmost Makah village at Ozette, that the Quileute villagers living at Norwegian Memorial were fishing in the waters north as well as south and west of their home. *See U.S. v. Washington*, 626 F.Supp. at 1467; Tr. 4/1 at 172:17-19 (Renker). It is further apparent that Ray's compilation does not provide a full picture of Quileute use of the coastline. Ray himself testified that he is certain that his map does not include all of the "village or camp sites that were used in 1855." Ex. 243 at p. 130. While similarly acknowledging that "most of the Quileute names have been forgotten," Jay Powell and William Penn added several other Quileute place names to Ray's list. One such site, which translates as "hair seal-skin float," is located at White Rock between Cape Alava and Sand Point. Another Quileute site, translated as "Sea lion hunting place," is located north of Norwegian Memorial. Ex. 224, pp. 104, 108. These use-oriented place names associate the area in between Cape Alava and Norwegian Memorial with traditional Quileute sea mammal harvest activities. According to Powell and Penn, it is appropriate to assume that many of these names "are of great age," reflecting a long history of Quileute seafaring traditions taking place along this coastline. *Id.* at p. 107.[4]

III. CONCLUSIONS OF LAW

A. Legal Standards

1.1. This case arises under the Court's continuing jurisdiction, retained under the Permanent Injunction set forth in Final Decision # 1, to consider "the location of any of a tribe's usual and accustomed fishing grounds not specifically determined by Final Decision # 1." *Final Decision 1*, 384 F.Supp. at 419. In making this determination, the Courts steps into the place occupied by Judge Boldt when he set forth U&As for fourteen tribes including the Quileute and Quinault within the original case area. The Court accordingly applies the same evidentiary standards applied by Judge Boldt in Final Decision # 1 and elaborated in the ensuing forty years of subproceedings.

1.2. In accordance with these standards, the Court has found that the Quinault Indian Nation and the Quileute Indian Tribe bear the burden to establish the location of their usual and accustomed grounds and stations under the Treaty of Olympia. Order on Motions for Partial Summary Judgment, Dkt. # 304 at pp. 23-25. In determining whether these tribes have met their burden, the Court bases its findings "upon a preponderance of the evidence found credible and inferences reasonably drawn therefrom." *Id.* at 384 F.Supp. at 348.

1.3. Available evidence of treaty-time fishing activities is "sketchy and less satisfactory than evidence available in the typical civil proceeding." *U.S. v. Lummi Indian Tribe*, 841 F.2d 317, 321 (9th Cir. 1988) ("*Lummi*"). What documentation does exist is "extremely fragmentary and just

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[4] Two archaeological sites located in this area, one at Sand Point and the other at White Rock, may reflect either Makah or Quileute occupancy. *See* 4/6 at 170:16-172:6 (Wessen); Tr. 4/7 at 8:4-11:6 (Wessen). As such, it is not possible to infer from the archaeological record alone which tribe occupied this coastal area prior to treaty time.

happenstance." *Id.* at 318. As Judge Boldt observed, "[i]n determining usual and accustomed fishing places the court cannot follow stringent proof standards because to do so would likely preclude a finding of any such fishing areas." *U.S. v. Wash.*, 459 F.Supp. 1020, 1059 (W.D. Wash. 1975). "Accordingly, the stringent standard of proof that operates in ordinary civil proceedings in relaxed." *Lummi*, 841 F.2d at 318.

1.4. In sum, the Quileute and Quinault may rely on both direct evidence and reasonable inferences drawn from documentary exhibits, expert testimony, and other relevant sources to show the probable location and extent of their U&As. *U.S. v. Wash.*, 626 F.Supp. 1404, 1531 (W.D. Wash. 1985). In evaluating whether or not the tribes have met their burden, the Court gives due consideration to the fragmentary nature and inherent limitations of the available evidence while making its findings on a more probable than not basis.

1.5. Under the Treaty of Olympia, the Quinault and Quileute reserved the "right of taking fish," at all of their "usual and accustomed grounds and stations." The term "usual and accustomed" grounds and stations encompasses "every fishing location where members of a tribe customarily fished from time to time at and before treaty times, however distant from the then usual habitat of the tribe, and whether or not other tribes then also fished in the same water." *Final Decision 1*, 384 F.Supp. at 332. Excluded from a tribe's U&A are "unfamiliar locations and those used infrequently or at long intervals and extraordinary occasions." *Id.* In other words, the term "usual and accustomed" was "probably used in [its] restrictive sense, not intending to include areas where use was occasional or incidental." *Id.* at 356.

1.6. Evidence of the probable distances to which a tribe had the capability to travel at treaty-time is insufficient on its own to establish U&A. *Makah*, 730 F.2d at 1318 (affirming 40-mile offshore U&A

despite recognizing that the “Makahs probably were capable of traveling to 100 miles from shore in 1855”). So too is evidence that a tribe occasionally trolled incidental to traveling through an area. *See Final Decision 1*, 384 F.Supp. at 353 (“Such occasional and incidental trolling was not considered to make the marine waters traveled thereon the usual and accustomed fishing grounds of the transiting Indians.”); *Upper Skagit Indian Tribe v. Wash.*, 590 F.3d 1020, 1022 (9th Cir. 2010) (“The term ‘customarily’ does not include ‘occasional and incidental’ fishing or trolling incidental to travel.”).

1.7. When it comes to determining a tribe’s treaty-time offshore fishing grounds in the Pacific Ocean, this Court has recognized that it is not possible to document the precise outer limits of these areas with particularity. *Makah*, 626 F.Supp. at 1467. Rather than setting forth general “grounds” and specific “stations,” the Court has found it appropriate to demarcate an offshore U&A based on the outermost distance to which the tribes customarily navigated their canoes for the purpose of “tak[ing] fish” at and before treaty time. *Id.* (delineating Makah offshore U&A as the entire area enclosed within the longitudinal line running forty miles offshore, from the State of Washington’s boundary in the north to Norwegian Memorial in the south); *see also* Memorandum Opinion on Motion for Reconsideration, Dkt. # 8763, p. 2 (Jan. 27, 1983) (explaining that demarcating the extent of the Makah’s U&A with certainty in this way is “appropriate for present day administration of the treaty right”).

B. Treaty Interpretation

2.1. As set forth above, the parties to this subproceeding dispute the scope of evidence relevant to ascertain the Quileute and Quinault’s Pacific Ocean U&As. At issue is whether evidence of a tribe’s regular, treaty-time whaling and sealing practices can be the basis for establishing the tribe’s offshore

U&A. The nature of this dispute requires the Court to address the scope of the "right of taking fish," as this term was used in the Treaty of Olympia.

2.2. In interpreting the treaty fishing clause, the Court cannot simply look to the ordinary meaning of the words used in the Treaty of Olympia as they are understood today. That is, the Court's interpretation of the word "fish" neither begins nor ends with today's commonly accepted biological definitions. Rather, the Court's interpretation of this treaty fishing clause is constrained by a set of legal principles set forth in this and other cases involving adjudication of tribal treaty rights.

2.3. First, the canons of construction for Indian treaties require that the Court give a "broad gloss" on the Indians' reserved fishing rights. *Washington v. Washington State Commercial Passenger Fishing Vessel Ass'n* ("*Fishing Vessel*"), 443 U.S. 658, 679 (1979). In *Worcester v. State of Georgia*, the United States Supreme Court first set forth the fundamental principle that "[t]he language used in treaties with the Indians should never be construed to their prejudice….If words be made use of which are susceptible of a more extended meaning than their plain import, as connected with the tenor of the treaty, they should be considered as used only in the latter sense….How the words of the treaty were understood by this unlettered people, rather than their critical meaning, should form the rule of construction." *Worcester v. State of Ga.*, 31 U.S. (6 Pet.) 515, 832 (1832). The principle that treaty terms are to be construed in favor of the tribes stems from the indubitable recognition that the parties to these treaties were "not on an equal footing." *Choctaw Nation v. U.S.*, 119 U.S. 1, 28 (1886). As the Supreme Court later set forth, "superior justice" requires that the inequality in bargaining power between the treaty parties "be made good by…look[ing] only to the substance of the right, without regard to technical rules[.]" *Id.*; *United States v. Winans*, 198 U.S. 371, 380-81 (1905).

2.4. Where words used in a treaty may admit to more than one meaning, the canons of Indian treaty construction require that any such "ambiguities…be resolved from the standpoint of the Indians." *Winters v. U.S.*, 207 U.S. at 576-77 (1919); *see also Confederated Tribes of Chehalis Indian Reservation v. State of Wash.*, 96 F.3d 334, 340 (9th Cir. 1996) ("Any ambiguities must be resolved in favor of the Indians."). The rule of liberal construction of treaties in favor of the tribes is "rooted in the unique trust relationship between the United States and the Indians." *Oneida County v. Oneida Indian Nation*, 470 U.S. 226, 247 (1985). In giving effect to the terms of the treaties, the Court must therefore endeavor to, as nearly as possible, construe the terms to have that meaning that would have been understood by the tribes represented at the treaty negotiations. *Tulee v. State of Wash.*, 315 U.S. 684, 684-85 (1942) ("It is our responsibility to see that the terms of the treaty are carried out, so far as possible, in accordance with the meaning they were understood to have by the tribal representatives at the council and in a spirit which generously recognizes the full obligation of this nation to protect the interests of a dependent people.").

2.5. These canons have guided the construction of the fishing rights provision in the Stevens Treaties from the very first decision in this case. In Final Decision # 1, Judge Boldt explained that "[e]ach of the basic fact and law issues in this case must be considered and decided in accordance with the treaty language reserving fishing rights to the plaintiff tribes, interpreted in the spirit and manner directed in the above quoted language of the United States Supreme Court." *Final Decision 1*, 384 F.Supp. at 331. These principles have continued to guide each of the many subsequent decisions in which this Court has been called upon to interpret specific terms within the fishing rights provision. *See, e.g., U.S. v. Wash.*, 774 F.2d 1470, 1481 (9th Cir. 1985) (drawing on the canons of Indian treaty construction in giving a "properly liberal construction" to the term "citizens of the Territory"); *U.S. v.*

Wash., 20 F.Supp. 3d 828, 896 (W.D. Wash. 2007) ("*Culverts*") (emphasizing the importance of construing a Stevens Treaty "not according to the technical meaning of its words to learned lawyers, but in the sense in which they would naturally be understood by the Indians" (quoting *Fishing Vessel*, 443 U.S. at 675-77)).

2.6. Second, the Court's interpretation is guided by the "reserved rights doctrine," which requires the Court to view those rights that were possessed by the tribes prior to the treaties and not specifically granted away as being reserved to the tribes. The Supreme Court set forth this doctrine in *United States v. Winans*, in language quoted by Judge Boldt in Final Decision # 1, 384 F.Supp. at 331. Reviewing the circumstances under which one of the Stevens Treaties was negotiated, the Supreme Court determined that the vital rights encapsulated in the fishing rights provision preexisted the treaty and were reserved by the tribes in treating with the United States:

> The right to resort to the [usual and accustomed] fishing places in controversy was a part of larger rights possessed by the Indians, upon the exercise of which there was not a shadow of impediment, and which were not much less necessary to the existence of the Indians than the atmosphere they breathed…. The treaty was not a grant of rights to the Indians but a grant of right from them – a reservation of those not granted.

198 U.S. at 381. In accordance with this doctrine, any subsistence right exercised by the tribes prior to the treaties is to be viewed as a right reserved by the tribes unless explicitly relinquished. *See U.S. v. Adair*, 723 F.2d 1394, 1413 (9th Cir. 1983) ("A corollary of these principles, also recognized by the Supreme Court, is that when a tribe and the government negotiate a treaty, the tribe retains all rights not expressly ceded to the Government in the treaty so long as the rights retained are consistent with the tribe's sovereign dependent status.").

2.7. This Court has since continued to recognize the "right of taking fish" as a reserved right and declined to read restrictions into it absent an explicit grant of subsistence rights away to the United

States from the tribes during the treaty negotiations. *See, e.g., U.S. v. Wash.*, 18 F.Supp.3d 1172, 1218 (W.D. Wash. 1991) ("[R]ights which were already possessed by the Indians and not granted to the United States were reserved by the Indians."); *Culverts*, 20 F.Supp.3d at 897-88 (recognizing that "Stevens specifically assured the Indians that they would have access to their normal food supplies now and in the future").

2.8. Third, the reserved rights doctrine has produced the corollary principle that this Court is to interpret the "right of taking fish" without any limitation or differentiation as to species. Since Final Decision # 1, courts interpreting the Stevens Treaties have declined to require species-specific findings for usual and accustomed fishing grounds. *See U.S. v. Wash*, 157 F.3d 630, 631-32 (9th Cir. 1998) (*Shellfish*). Judge Boldt in 1978, for instance, held that the usual and accustomed grounds and stations for herring were co-extensive with those previously adjudicated for salmon. *U.S. v. Wash.*, 459 F.Supp. 1020, 1049 (W.D. Wash. 1978). In the *Shellfish* proceeding, this Court set forth the foundation for this principle: "Because the 'right of taking fish' must be read as a reservation of the Indians' pre-existing rights, and because the right to take *any* species, without limit, preexisted the Stevens Treaties, the Court must read the 'right of taking fish' without any species limitation." *U.S. v. Wash.*, 873 F.Supp. 1422, 1430 (W.D. Wash. 1994) (*Shellfish*) (emphasis in original). The Ninth Circuit affirmed in relevant part, rejecting the State's argument that the right of taking fish is limited to those species actually harvested by the tribes at treaty-time: "With all deference to the State, there is no language in the Treaties to support its position: the Treaties make no mention of any specifies-specific or technology-based restrictions on the Tribes' rights." *Shellfish*, 157 F.3d at 643. *See also U.S. v. Wash.*, 19 F.Supp. 3d 1126, 1130 (W.D. Wash. 1994) (concluding "as a matter of law that usual and accustomed grounds and stations do not vary with the species of fish, and that usual and accustomed grounds and stations for non-anadromous fish are coextensive with those of anadromous fish"); *Midwater Trawlers Co-Op. v. U.S. Dep't of Commerce*, 282 F.3d 710, 716-17 (9th Cir. 2002) (affirming that "[t]he term 'fish' as used in the Stevens Treaties encompassed all species of fish, without exclusion and without requiring specific proof").

2.9. Guided by these principles, this Court directly addressed the breadth of the term "fish" in the *Shellfish* proceeding. In declining to limit the "right of taking fish" to those species harvested by the tribes prior to signing the treaties, the Court explained that "had the parties to the Stevens Treaties intended to so limit the right, they would not have chosen the word 'fish,' a word which fairly encompasses every form of aquatic animal life. 'Fish' has perhaps the widest sweep of any words the drafters could have chosen, and the Court will not deviate from its plain meaning." *Shellfish*, 873 F.Supp. at 1430. The Ninth Circuit affirmed, agreeing with the district court's description of the broad sweep of the word "fish" as used in the treaties and noting that a more restrictive reading of the fishing rights provision would be contrary to the tribes' reservation of their pre-existing subsistence rights. *Shellfish*, 157 F.3d at 643-44.

2.10. Applying these principles to the case at hand, the Court looks first to indicia of the meaning that the Quileute and Quinault attached to the word "fish" when their representatives negotiated the Treaty of Olympia in 1855. As set forth above, a capacious understanding of this word was in broad, popular circulation at the time that the treaty was negotiated, as evidenced by Webster's 1828 American Dictionary defining the word as "[a]n animal that lives in the water" and the numerous judicial decisions discussing "fish" and "fisheries" in ways that embraced sea mammals. *See, e.g.*, *In re Fossat*, 69 U.S. 649, 692 (1864) ("For all purposes of common life, the whale is called a fish, though natural history tells us that he belong to another order of animals."); *Ex parte Cooper*, 143 U.S.

472, 499 (1892) (discussing “seal fisheries”); *The Coquitlam*, 77 F. 744, 747 (9th Cir. 1986) (discussing “seal fishing”); *Knight v. Parsons*, 14 F. Cas. 776, 777 (D. Mass. 1855) (construing a contract to allow parties to “sell the fish” harvested in the “whale fisheries”).

2.11. More to the point, it is clear from the linguistic evidence that the tribal signatories to the treaty drew no distinctions between groups of aquatic species and would have understood the term “fish” to encompass at least those aquatic animals on which they relied for their subsistence purposes. The Quileute word “?aàlita?” and the Quinault word “Kémken” express this breadth, encompassing a spectrum of meanings from all “food” to all “fish” to “salmon” in particular. The negotiators could have used species-specific words, such as salmon, that were available in the common Chinook jargon negotiating medium and in all the parties’ native languages. As this Court has previously explained, that the parties to the treaties chose instead to use the sweeping word “fish” in lieu of more tailored language indicates an intended breadth of the subsistence provision that should not be circumscribed on the basis of post hoc understandings and linguistic drift.

2.12. A construction of the term “fish” to include sea mammals likewise follows from the context in which the treaties were set forth. As expressed in the reserved rights doctrine, the Quinault and Quileute, in agreeing to cede large swaths of their land, reserved the right to continue to fish as they had always done, in the locations where they were accustomed to harvest aquatic resources at and before entering into their treaty. The various promises and assurances made to them by the U.S. treaty negotiators underscore the mutually agreed purpose to restrict the tribes only as to the location of their homes: in the words of Governor Stevens, the U.S. treaty commission intended the tribes to continue “to take fish where you have always done so and in common with the whites.” Apart from a proviso restricting the tribes’ right to “take shell-fish from any beds staked or cultivated by citizens,” there is no indication anywhere in the language of the treaty or the evidence surrounding the negotiations of an intent to circumscribe this most important of usufructuary rights.

2.13. It is likewise clear that prior to the Treaty of Olympia, the Quinault and the Quileute were harvesting marine mammals on a usual and accustomed basis from the Pacific Ocean. The several assurances given to the tribes during the Chehalis River negotiations of their continued ability to harvest drift whales evidence the U.S. negotiators' intent to draft the treaties to encompass the taking of whales. As these tribes did not explicitly relinquish the right to continue this traditional practice, it follows that they reserved the right to continue to harvest marine mammals as they had long done. That the tribes continued to harvest whales and seals in the decades following the Treaty of Olympia with active encouragement of federal officials and special dispensations on account of their tribal status shows that both sides believed the right to harvest sea mammals to have been reserved to the tribes.

2.14. Together these findings lead inexorably to the conclusion that "fish" as used in the Treaty of Olympia encompasses sea mammals and that evidence of customary harvest of whales and seals at and before treaty time may be the basis for the determination of a tribe's U&A. That the tribes are not now permitted by conservation restrictions to carry out this marine mammal harvest is of no moment with respect to adjudication of their U&As. As this Court has oft explained, a tribe's U&A for the harvest of any one aquatic species is coextensive with its U&A for any other aquatic species. *See U.S. v. Wash.*, 19 F.Supp. 3d 1126, 1130 (W.D. Wash. 1994). This principle holds as true for marine mammals as it does for non-anadromous fish, for anadromous fish, and for shellfish.

2.15. This Court's decision to so hold is unaffected by the differences in language between the Treaty of Olympia and the Treaty of Neah Bay. As set forth above, these treaties were negotiated by different individuals and in different contexts. Colonel Simmons, who negotiated the Treaty of Olympia, lacked the authority to tailor provisions in the way that Governor Stevens was able to do when negotiating the Treaty of Neah Bay. The loss of the minutes for the Treaty of Olympia negotiations makes it impossible to discern what exactly was promised to the tribes and what specific assurances were requested or made. In the absence of such information, the Court must look to other evidence of the meaning understood by the tribal parties and the rights they reserved, guided by the canons requiring liberal construction in favor of the tribes.

2.16. Finally, this Court's decision is likewise unaffected by the Makah's 1982 ocean U&A determination. Having carefully reviewed the orders by Judge Craig, the findings of Magistrate Judge Cooper on which the determinations were based, and the briefing and official transcripts from the Makah's ocean U&A subproceeding, the Court is persuaded that neither questions of treaty interpretation generally nor the scope of the "right of taking fish" in particular were raised. Rather, prior to the Court's ruling that U&As for non-anadromous fish were coextensive with those for anadromous fish, the parties had no reason to seek a judicial interpretation of the scope of "fish" because they were focused on evidence of salmon fishing. The representations by the parties, and the reactions by the Court, show that the scope of "fish" was not at issue. After Judge Cooper's initial ruling that the Makah's western boundary extended 100 miles offshore, the U.S. filed an objection in which it disputed "how far west the Makah Tribe's usual and accustomed salmon fishing grounds in the Pacific Ocean extended at the time of the treaty." Dkt. # 8698 at p. 2. After the district court issued an order limiting the Makah's western boundary to 40 miles offshore, the Makah moved for reconsideration. At a telephonic hearing, the Makah argued that it was sufficient for the Court to infer from the tribe's capability to travel 100 miles offshore that it actually did so to fish for salmon. Dkt. # 8984 at pp. 5-6. The Court disagreed, stating:

> As to my conclusion, the evidence I believe [Judge Cooper] heard in reaching his conclusion the Makahs fished for salmon 100 miles out at treaty times, simply shows it was feasible to go 100 miles to fish for salmon, for anything out there, explore or whatever. That, to me, is not evidence of usual and accustomed fishing in a given area.

Id. at p. 7. It was not until the shellfish proceeding over a decade later that this Court addressed the scope of the word "fish," giving it the broad construction affirmed by the Ninth Circuit and reaffirmed herein.

2.17. Moreover, Judge Craig's decision as to the Makah U&A ultimately turned on the sufficiency of the evidence proffered by the Makah to establish their U&A, not on a legal determination of what evidence would be deemed relevant. Judge Craig's Order cited solely to a 1977 report by Dr. Barbara Lane on "Makah Marine Navigation and Traditional Makah Offshore Fisheries." *Makah*, 626 F.Supp. at 1467; Ex. 143 (1977 Makah Report by Dr. Lane). While Dr. Lane's report contained evidence from which the Court could infer that the Makah fished 30 to 40 miles offshore at treaty time, *see id.*, the only evidence showing that the Makah fished distances greater than 40 miles came from post-treaty sources. *See* Ex. 143 at p. 10 ("It is known that the Makah fished at greater distances than thirty or forty miles offshore in post-treaty times."). Among this post-treaty evidence were reports that the Makah whaled and sealed at distances up to 100 miles in the late nineteenth century. *Id.* at p. 13 (citing reports from 1894 and 1897 of Makah offshore sealing); *Makah*, 626 F.Supp. at 1467 (citing same). This evidence, as Judge Craig determined, showed only that the Makah would have had the capability to travel distances up to 100 miles at treaty time—not that they customarily did so for their subsistence harvest. *Id.* (holding that "it is clearly erroneous to conclude that the Tribes customarily traveled such distances [up to 100 miles offshore] to fish" at treaty time). The Ninth Circuit agreed. Reviewing evidence that the Makah traveled up to 100 miles around 1900 and probably fished up to 40 miles offshore in the 1850s, it concluded that "[t]hese facts do not show that their usual and accustomed fishing areas went out 100 miles in 1855. There is no basis for an inference that they customarily fished as far as 100 miles from shore at treaty time." *Makah*, 730 F.2d at 1318. Neither of these opinions excluded evidence of sea mammal harvest. Rather, they restricted the Makah's U&A to the distance that the tribe had demonstrated it *customarily* traveled to harvest aquatic resources at and before the time it signed its treaty.

2.18. Indeed, it is clear from briefs later submitted by tribal parties to this case – including the Makah – that they did not view the Court's prior rulings as having excluded evidence of marine mammal harvest from U&A determinations. In a brief submitted in the *Shellfish* proceeding, the Makah and others argued:

> The type of fishing activities this Court has considered in determining the boundaries of usual and accustomed grounds and stations also shows that all fishing activities should be taken into account. This Court has frequently considered more than just salmon fishing in establishing usual and accustomed areas. For example, in adjudicating the Quileute Tribe's usual and accustomed areas, the Court noted that in portions of its area the Quileutes caught smelt, bass…seal, sea lion, porpoise, and whale. 384 F.Supp. at 372, FF 108….The Makah usual and accustomed areas were originally determined with reference to salmon, halibut, whale, and seal. 384 F.Supp. at 363, FF 61.

Dkt. # 13696, Joint Tribal Trial Brief (March 21, 1994), at p. 8; *see also* Dkt. # 12958 (March 31, 1993) (memorandum by Makah and other tribes, arguing that the common understanding of "fish" as an animal that lives in the water should control). Just as Judge Boldt saw no reason in Final Decision # 1 to distinguish marine mammal from finfish harvest in setting forth tribal U&As, the Court sees no reason today to restrict the usufructuary rights reserved by the tribes based on a modern taxonomic distinction that they did not draw. The "superior justice" that guides the Court's enforcement of the treaties permits no such result. *Choctaw Nation*, 119 U.S. at 28.

2.19. The Court accordingly determines that the Quinault and Quileute's usual and accustomed fishing locations encompass those grounds and stations where they customarily harvested marine mammals – including whales and fur seals – at and before treaty time.

C. Pacific Ocean U&A Boundaries at Issue

3.1. On the basis of these legal standards and foregoing findings of fact, the Court concludes that the western boundary of the Quinault Indian Nation's usual and accustomed fishing ground in the Pacific Ocean is 30 miles from shore.

3.2. The Court likewise concludes that the western boundary of the Quileute Tribe's usual and accustomed fishing ground in the Pacific Ocean is 40 miles offshore and the northern boundary of the Quileute Tribe's usual and accustomed fishing ground is a line drawn westerly from Cape Alava.

3.3. The Court makes these determinations on the basis of the extensive evidence presented at trial showing the furthest distances to which the tribes customarily traveled to harvest aquatic resources including finfish, fur seals, and whales, at treaty time. While the Quinault and Quileute may have occasionally harvested these resources at distances upward of the boundaries set forth herein, the evidence presented at trial does not support a reasonable inference that they customarily did so at treaty-time.

3.4. The Court did not receive evidence at trial specifying the longitudes associated with the U&A boundaries determined herein. Accordingly, and in order to delineate the boundaries with certainty, the Court directs counsel for the Quinault and the Quileute to file notice with the Court of the precise longitudinal coordinates associated with the boundaries set forth herein. Notice shall be filed within ten (10) judicial days of the entry of this Order. The Makah and Interested Parties including the State of Washington may file a concise response within five (5) judicial days after the initial notices are filed if they so desire.

Dated this 9th day of July 2015.

RICARDO S. MARTINEZ
UNITED STATES DISTRICT JUDGE

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RESEARCH LETTER

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Causes and impacts of the 2014 warm anomaly in the NE Pacific

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Key Points:
- Anomalous atmospheric forcing in the NE Pacific in winter 2013–2014
- Weak seasonal cooling due to reduced heat fluxes and anomalous advection
- SST anomalies have impacts on the ecosystem and air temperatures

Supporting Information:
- Figures S1 and S2
- Figure S1
- Figure S2

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Abstract Strongly positive temperature anomalies developed in the NE Pacific Ocean during the boreal winter of 2013–2014. Based on a mixed layer temperature budget, these anomalies were caused by lower than normal rates of the loss of heat from the ocean to the atmosphere and of relatively weak cold advection in the upper ocean. Both of these mechanisms can be attributed to an unusually strong and persistent weather pattern featuring much higher than normal sea level pressure over the waters of interest. This anomaly was the greatest observed in this region since at least the 1980s. The region of warm sea surface temperature anomalies subsequently expanded and reached coastal waters in spring and summer 2014. Impacts on fisheries and regional weather are discussed. It is found that sea surface temperature anomalies in this region affect air temperatures downwind in Washington state.

1. Introduction

Offshore sea surface temperatures (SSTs) in the NE Pacific were remarkably warm during the winter of 2013–2014. By February 2014, peak temperature anomalies of the near-surface (upper ~100 m) waters were greater than 2.5°C (Figures 1a–1c), while temperature anomalies were below normal in the immediate vicinity of the coast. The largest anomalies exceeded 3 standard deviations (Figure 1c and Figure S1 in the supporting information), and were the greatest observed in this region for the month of February since at least the 1980s and possibly as early as 1900. The warm anomaly in winter was most prominent in the south central part of the Gulf of Alaska but extended to the continental shelf. By May 2014 the region of anomalously warm SST extended into the coastal zone, and anomalously warm SSTs persisted throughout the NE Pacific Ocean through March 2015. In recognition of its extensive and extraordinary magnitude and its potential for impacting both the regional weather and fisheries, the lead author referred to the anomaly as “The Blob” in his 3 June 2014 newsletter for the Office of the Washington State Climatologist, and it has since taken on this moniker in the general press.

The development of extraordinarily warm SST anomalies in winter 2014 is linked to a highly anomalous weather pattern, as characterized by the distribution of anomalous sea level pressure (SLP). During the period of October 2013 through January 2014, much higher than normal SLP was present in the mean over the eastern North Pacific (Figure 2), with a peak magnitude approaching 10 hPa. For the region of 55–45°N and 150–130°W, this was a record high value for the years of 1949–2014 (about 2.6 standard deviations above normal for the period of October through January) with the next largest value being about 2.2 standardized units above normal during October 1978 to January 1979. A similar pattern of anomalous SLP occurred during January through March of 2013, accompanied by anomalous warming that lasted into the summer of 2013 (Figure 1c). Our focus here is on the winter of 2013–2014 because it was so extreme, as illustrated by the time series shown in Figure 1c.

As we will show, the unusually high SLP in the region of interest impacted the wind-forced currents and wind-generated mixing, as well as the surface heat loss due to the combination of evaporation, conduction, and net shortwave (solar) and infrared radiation. The objectives of the present paper are twofold: (1) to diagnose the mechanisms that caused the wintertime warming in the NE Pacific (NEP) and (2) to examine implications of this type of anomaly for the ecosystem in the Gulf of Alaska and for seasonal weather in the Pacific Northwest.

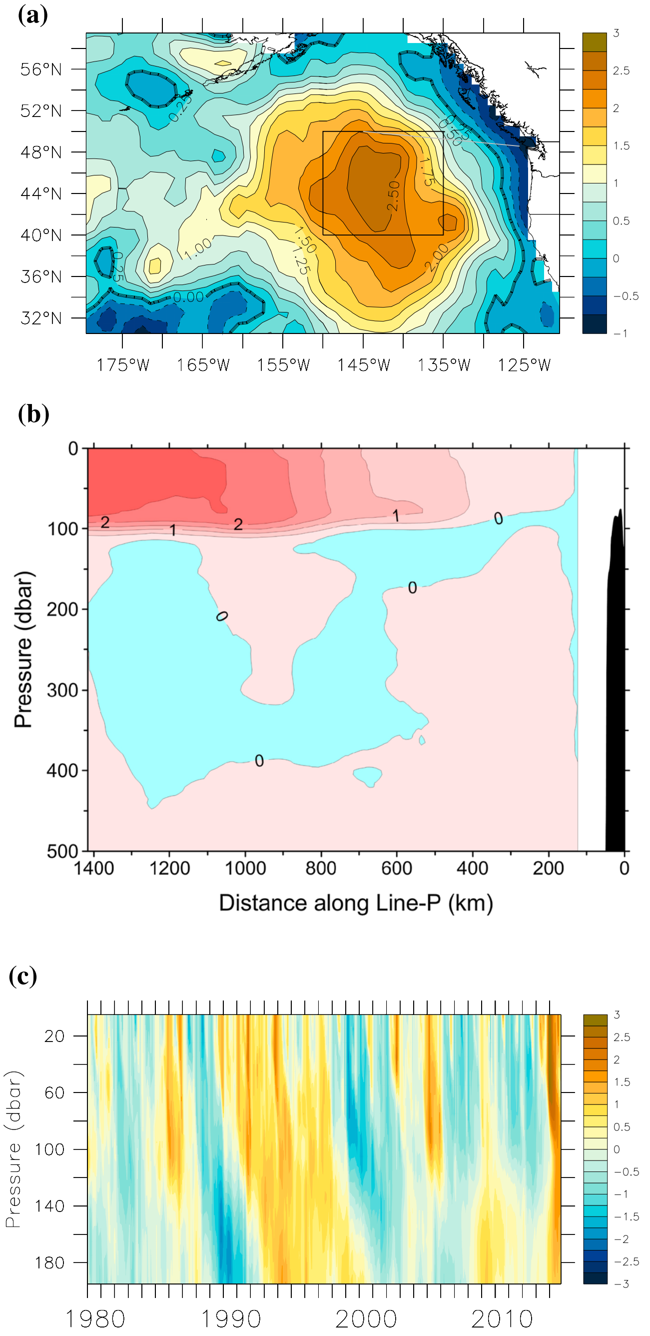

Figure 1. (a) Sea surface temperature anomalies (°C) in NE Pacific Ocean for February 2014. Anomalies are calculated relative to the mean from 1981 to 2010. (b) Upper ocean temperature anomalies (°C) along "Line P" (heavy gray line shown in part a) from 48°34.5N, 125°30.0°W to 50°145°W for February 2014. Anomalies are relative to the mean from 1956–1991. (c) Monthly temperature anomalies (normalized) from the surface to 200 m averaged over the area of 50 to 40°N, 150 to 135°W (indicated by the box shown in part a) for the period of January 1980 through November 2014.

2. Data and Methods

Our analysis of the processes responsible for the wintertime warming in the region of interest in the NE Pacific is based on data from the National Centers for Environmental Prediction (NCEP) Global Ocean Data Assimilation System (GODAS) for the period of 1980 to early 2014, as available at http://www.esrl.noaa.gov/psd/data/gridded/data.godas.html. This system is based on the Geophysical Fluid Dynamics Laboratory (GFDL) Modular Ocean Model (MOM v.3) numerical ocean model with assimilation of ocean profile information from expendable bathythermographs, moored buoys and Argo profiling floats, and surface fluxes from the NCEP Reanalysis 2. For more information on GODAS, see *Behringer and Xue* [2004] and *Behringer* [2007].

We consider the heating of a volume bounded by 40°N and 50°N, 150°W and 135°W, and the air-sea interface to the depth where the density is 0.03 kg m^{-3} greater than at the surface for the upper and lower boundaries. The depth defined by the bottom boundary condition here is often referred to as the "mixed layer depth," above which the waters are generally mixed and similar in properties to those found at the sea surface. We use a density-based definition for the mixed layer to account for the potential effects of salinity on the stratification. The value of 0.03 kg m^{-3} is based on inspection of density profiles from GODAS for the region of interest and is consistent with a definition used by *de Boyer Montegut et al.* [2004]. Temperature of the water in this box can be changed due to air-sea heat exchanges across the top surface (i.e., net surface heat fluxes), heat exchanges across the east, west, north, and south sides of the box (i.e., horizontal advection), and heat exchanges across the bottom boundary (i.e., vertical advection and mixing).

3. Results

Here we use time series of 4 month (October–January) mean values for a variety of quantities for the region of 40–50°N, 150–135°W to put 2013–2014 in historical context. From the atmospheric forcing perspective, we

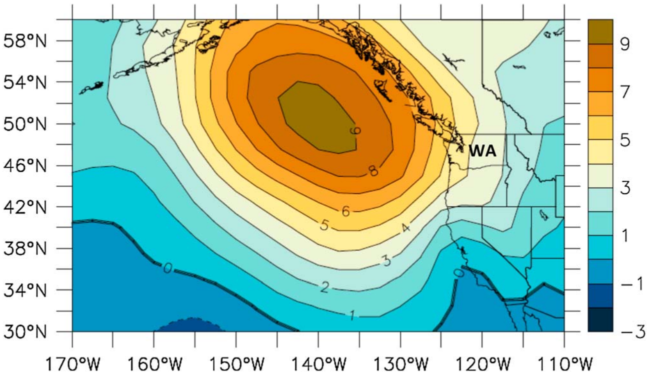

Figure 2. Mean sea level pressure anomalies (hPa) in the NE Pacific Ocean for the period of October 2013 through January 2014. Anomalies are calculated relative to the mean from 1981 to 2010.

consider the wind speed cubed, which relates to the power delivered by the atmosphere to the ocean for turbulent mixing, and the wind stress curl, which relates to the flux of vorticity to the upper ocean (Figure 3, top). The wind speed cubed was a record minimum during 2013–2014 and the wind stress curl was negative, which has precedence but is still quite unusual. From the ocean response perspective, the deepening of the mixed layer, i.e., the change in depth from September to February, was less than any previous winter during the analysis period, and the static stability at the base of the mixed layer was a record maximum (Figure 3, bottom). Based on the data sets considered here, the winter of 2013–2014 was an extreme for the region of interest.

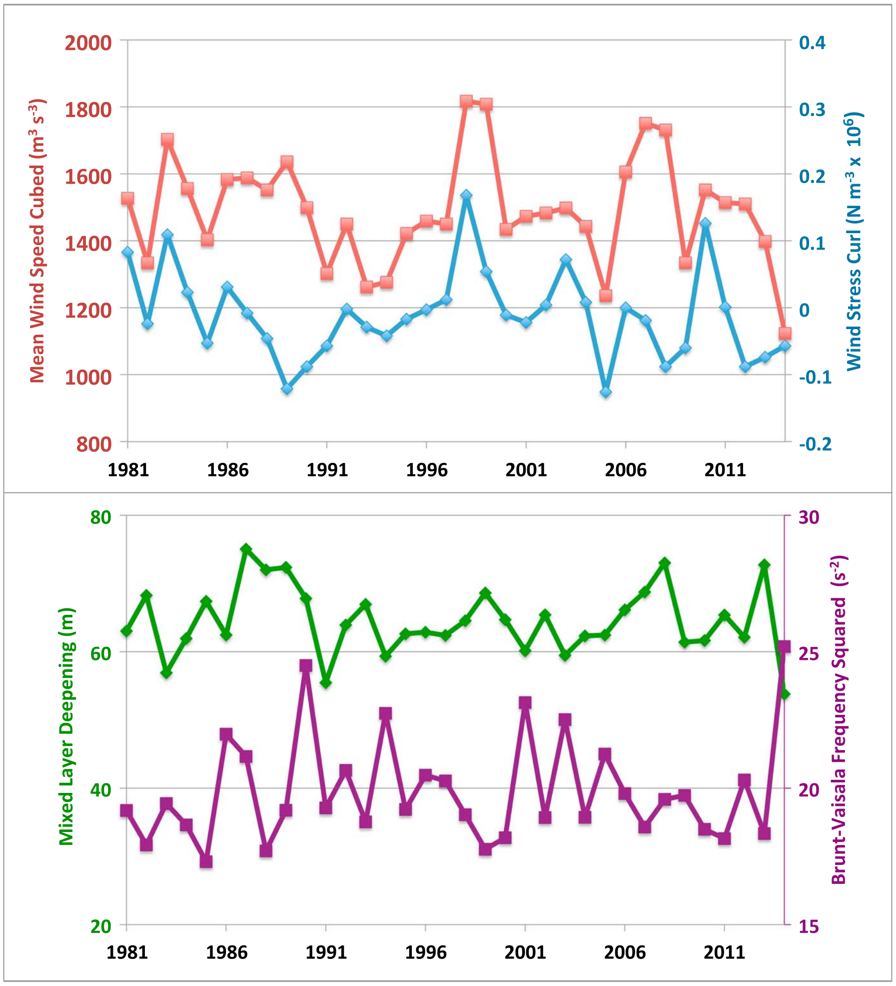

Figure 3. (top) Time series of seasonal mean (October–January) wind speed cubed (red) and wind stress curl (blue) for the area of 50–40°N, 150–135°W. (bottom) Time series of mean seasonal mixed layer deepening (September to February; green) and stratification at the base of the mixed layer (February; purple) for the area of 50–40°N, 150–135°W. The years refer to January–February values.

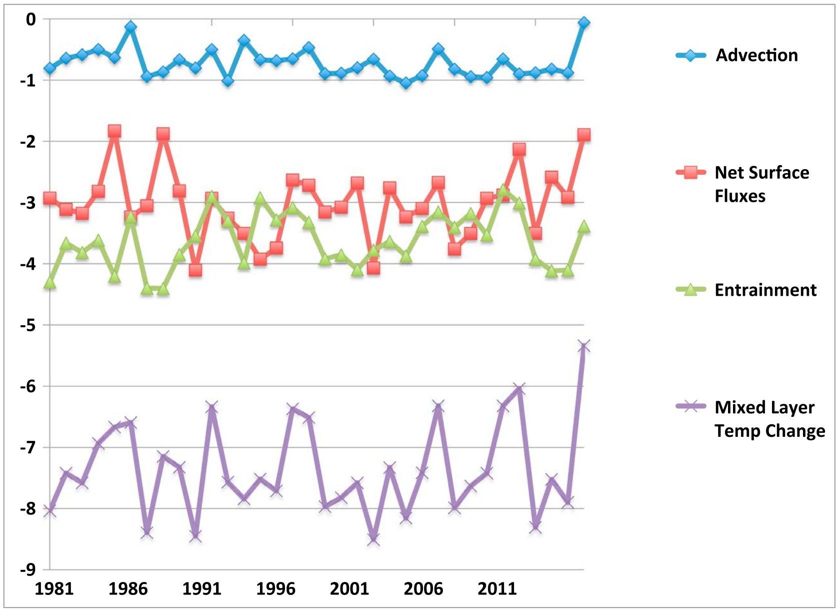

Figure 4. Seasonal values of the mixed layer temperature change from September to February for the area of 50–40°N, 150–135°W (°C; purple) and budget terms contributing to this temperature change. The black arrow points to the value for 2013–2014. Budget terms include horizontal advection (blue), net surface heat fluxes (red), and entrainment (light green). Values represent degrees (C) of temperature change associated with the individual terms.

Further insight into development of the “blob” can be gained through consideration of winter averages of the terms in a mixed layer temperature budget (Figure 4), using the framework of equation (2) in *Cronin et al*. [2013], but in an area-averaged versus point sense, with advection expressed as in *Lee et al*. [2004]. Local cooling of 5.5°C from October 2013 to February 2014 was about 30% lower than the mean, and the smallest magnitude in this record extending back to 1980. The net surface heat fluxes caused about 2°C of cooling in 2013–2014 versus a normal value of about 3°C over the 4 month period. The net effect of the heat exchange at the base of the mixed layer, often termed as entrainment and here estimated as a residual, was close to normal. It bears noting that the deduced heat fluxes due to entrainment were actually weaker than normal, but the actual cooling rate associated with the fluxes across the mixed layer was typical because these fluxes were distributed over a relatively thin mixed layer. The horizontal advection term was near zero; this term generally accounts for about 1°C cooling. The large interannual temperature anomaly thus appears to be due to a combination of anomalous advection and reduced surface heat loss.

The task now is to explain variations in the budget terms. The anomalous horizontal advection is due in part to anomalous wind-forced (Ekman) currents acting on the climatological upper ocean temperature gradient. For the southern portion of the high SLP anomaly, weaker than normal winds from the west induced anomalously weak Ekman transports of colder water from the north. An additional contribution was made by a near-normal eastward component of the current acting on a preexisting zonal gradient in the SST anomaly distribution. As shown in Figure 4, horizontal advection of heat is typically a very weak process in the NE Pacific, although it can play a role in interannual variability [*Large*, 1996]. For the 2014 event, the anomalous advection appears to be an order one process.

The net surface heat fluxes comprise the turbulent fluxes of sensible and latent heat and the radiative (solar and infrared) fluxes. During Oct 2013-March 2014, the reduced surface heat flux out of the ocean appears to be primarily associated with the turbulent flux terms. The extremely weak surface heat losses might seem somewhat surprising as one might expect that the warm SST would cause increased surface heat losses. Instead, it appears that the anomaly in the turbulent heat fluxes can be attributed partly to the wind speeds (Figure 3, top), which were the lowest in the record extending back to 1980 and the second lowest during the period of 1949–2014.

The influence of the shallower mixed layer depth during the fall to early winter of 2013–2014 may have also meant that the momentum supplied by the surface wind stress would be that much more effective toward generating mixed layer currents. This would tend to enhance the vertical shear across the base of the mixed layer, thus maintaining typical cooling rates due to entrainment despite the weaker winds. It should be noted that the GODAS surface heat flux is anomalously positive (22 $W\,m^{-2}$) relative to the NOAA Station Papa mooring observations at 50°N, 145°W [*Cronin et al.*, 2012] in November 2013 and January–February 2014 (Figure S2). If the GODAS fluxes were adjusted by this bias, then the residual term involving the heat flux at the base of the mixed layer would be less negative than usual, again consistent with the reduced wind speeds. The wind stress curl and hence Ekman pumping anomalies were negative, which also is consistent with relatively weak entrainment.

In summary, the near-surface temperature anomalies that exceeded 2°C in the NE Pacific during winter 2013–2014 can be accounted for by anomalous vertical processes (air-sea heat exchanges and possibly vertical mixing across the base of the mixed layer) and oceanic horizontal advection associated with the anomalous weather pattern in the 4 month period leading up to the time of the maximum SST anomaly.

4. Biological Impacts

The region of warm SST anomalies in winter 2013–2014 spread into the coastal domain of Alaska and northern British Columbia in May 2014 and then into the nearshore waters of the U.S. Pacific Northwest in September 2014. The NE Pacific's anomalously warm water in spring, summer, and fall 2014 was coincided with a variety of unusual biological events and species sightings. From the bottom-up forcing perspective, *Whitney* [2015] documented extremely low chlorophyll levels during the late winter/spring of 2014 in the region of the warm anomalies, presumably due to suppressed nutrient transports into the mixed layer. Examples of dramatic species range shifts in summer and fall 2014 that have come to our attention include the following: (1) a skipjack tuna caught near the mouth of the Copper River in July [*Medred*, 2014]; (2) ocean sunfish and a thresher shark caught in summertime surveys off the coast of SE Alaska, where distributions of juvenile salmon and pomfret were also much different than usual (W. Fournier, personal communication, 2014); (3) a record high northern diversion rate of Fraser River sockeye salmon, i.e., the proportion of adults returning around the north versus south side of Vancouver Island [*Gallagher*, 2014]; (4) rhinoceros auklets in British Columbia preying on Pacific saury (associated with subtropical waters) rather than sand lance (associated with subarctic waters) in summer (J. Zamon, personal communication, 2014), (5) high catches of albacore tuna near the coast of WA and OR during summer and fall 2014; (6) juvenile pompano collected during surveys near the mouth of the Columbia River in summer (L. Weitkamp, personal communication, 2014); and (7) widespread strandings of Velella from British Columbia to California in July and August. There was also a massive influx of dead or starving Cassin's Auklets onto PNW beaches from October to December 2014 [*Opar*, 2015]. The list is much more illustrative than comprehensive but does suggest that the physical oceanographic conditions had substantial and widespread impacts on the ecosystem. The full ecosystem response remains to be determined, but it is liable to be profound, as occurred in the California Current during a period of weak coastal upwelling in 2005 (Warm Ocean Conditions in the California Current in Spring/Summer 2005: Causes and Consequences, *GRL* special issue, 2006).

5. Impacts on Seasonal Weather of the Pacific Northwest

The spatial extent and duration of the warm water anomalies that developed in the winter of 2013–2014 suggests the potential for a regional atmospheric response. Here we examine the strength of the relationship between the SST in the area of interest and the weather in the continental Pacific Northwest, which is downwind in the prevailing sense.

Our approach consists of a comparison between the mean SST during February in the study area with the mean surface air temperature in Washington state (indicated with "WA" in Figure 2) during the following spring months of March through May for the years of 1948–2014. A scatterplot of the relationship between these variables is shown in Figure 5; the linear correlation coefficient between them is 0.42. Similar results were found for other times of the year and for thermodynamic properties such as moist static energy in the atmos-pheric boundary layer, with slightly higher correlation coefficients for con-temporaneous comparisons.

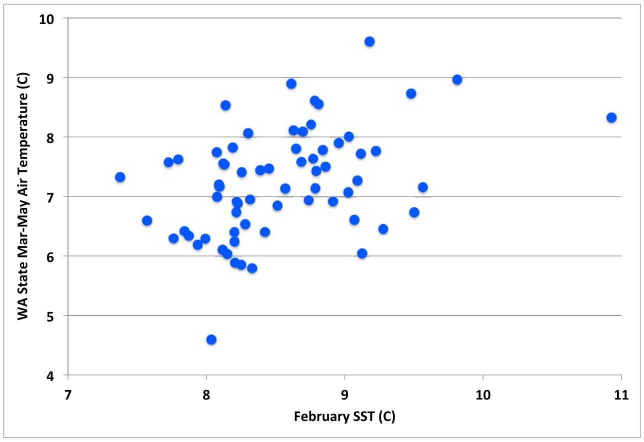

Figure 5. March–May air temperatures in Washington state (°C; *y* axis) versus February sea surface temperature (°C; *x* axis) averaged for the area of 50–40°N, 150–135°W. The year of 2014 is represented by the dot near the right-hand border of the figure.

On the other hand, the relationship between offshore SST and precipitation down-stream was negligible (not shown), presumably because of the SST's lack of influence on the regional-scale atmospheric circulation.

6. Final Remarks

A prominent mass of positive temperature anomalies developed in the NE Pacific Ocean during winter of 2013–2014. This development can be attributed to strongly positive anomalies in SLP, which served to suppress the loss of heat from the ocean to the atmosphere, and leads to a lack of the usual cold advection in the upper ocean. The extra mixed layer heat persisted through the summer of 2014 and may have represented a significant contribution to the unusually warm summer (in some locations record high temperatures) observed in the continental Pacific Northwest. The linkage between the upper ocean temperature and downstream temperatures over the coastal region of the Pacific Northwest may provide a secondary source of predictability for seasonal weather forecasts. In particular, it suggests that coupled atmosphere-ocean models such as NCEP's Coupled Forecast System model may need to properly handle the evolution of the upper ocean in the NE Pacific because of its regional influences.

The present analysis does not focus on the cause(s) of the anomalous atmospheric forcing. A broad region extending from the North Pacific across North America is known to be subject to the effects of teleconnections from the tropical Pacific in association with El Niño–Southern Oscillation (ENSO) events, i.e., the "atmospheric bridge" [e.g., *Alexander et al*., 2002; *Lau and Nath*, 1996]. But such an explanation fails to account for the winter of 2013–2014 since ENSO was in a neutral phase. On the other hand, SST anomalies in the far western tropical Pacific, and accompanying deep cumulus convection, appear to account for a significant portion of the anomalous circulation [*Seager et al*., 2014; *Hartmann*, 2015; *Lee et al*., 2015] that occurred in the winters of both 2012–2013 and 2013–2014, with intrinsic atmospheric variability probably an additional important factor.

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