GRAY WHALE (*Eschrichtius robustus*): Eastern North Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Once common throughout the Northern Hemisphere, the gray whale was extinct in the Atlantic by the early 1700s (Fraser 1970; Mead and Mitchell 1984), but recent single sightings in the Mediterranean Sea in 2010 and off Namibia in 2013 are documented (Scheinin *et al.* 2011, Elwen and Gridley 2013). Gray whales are only commonly found in the North Pacific. Genetic comparisons indicate there are distinct "Eastern North Pacific" (ENP) and "Western North Pacific" (WNP) population stocks, with differentiation in both mtDNA haplotype and microsatellite allele frequencies (LeDuc *et al.* 2002; Lang *et al.* 2011a; Weller *et al.* 2013).

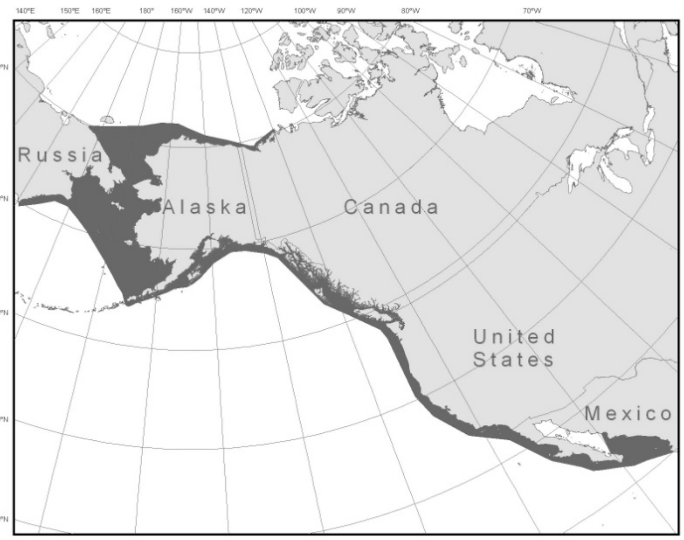

Figure 1. Approximate distribution of the Eastern North Pacific stock of gray whales (shaded area).

During summer and fall, most whales in the ENP population feed in the Chukchi, Beaufort and northwestern Bering Seas (Fig. 1). An exception to this is the relatively small number of whales that summer and feed along the Pacific coast between Kodiak Island, Alaska and northern California (Darling 1984, Gosho *et al.* 2011, Calambokidis *et al.* 2017). Three primary wintering lagoons in Baja California, Mexico are utilized, and some females are known to make repeated returns to specific lagoons (Jones 1990). Genetic substructure on the wintering grounds is indicated by significant differences in mtDNA haplotype frequencies between females (mothers with calves) using two primary calving lagoons and females sampled in other areas (Goerlitz *et al.* 2003). Other research has identified a small, but significant departure from panmixia between two lagoons using nuclear data, although no significant differences were identified using mtDNA (Alter *et al.* 2009).

Tagging, photo-identification and genetic studies show that some whales identified in the WNP off Russia have been observed in the ENP, including coastal waters of Canada, the U.S. and Mexico (Lang 2010; Mate *et al.* 2011; Weller *et al.* 2012; Urbán *et al.* 2013, Mate *et al.* 2015). In combination, these studies have documented approximately 30 gray whales observed in both the WNP and ENP. Despite this geographic overlap, significant mtDNA and nDNA differences are found between whales in the WNP and those summering in the ENP (LeDuc *et al.* 2002; Lang *et al.* 2011a).

In 2010, the IWC Standing Working Group on Aboriginal Whaling Management Procedure noted that different names had been used to refer to gray whales feeding along the Pacific coast, and agreed to designate animals that spend the summer and autumn feeding in coastal waters of the Pacific coast of North America from California to southeast Alaska as the "Pacific Coast Feeding Group" or PCFG (IWC 2012). This definition was further refined for purposes of abundance estimation, limiting the geographic range to the area from northern California to northern British Columbia (from 41°N to 52°N), and limiting the temporal range from June 1 to November 30, and counting only those whales seen in more than one year within this geographic and temporal range (IWC 2012). The IWC adopted this definition in 2011, but noted that "not all whales seen within the PCFG area at this time will be PCFG whales and some PCFG whales will be found outside of the PCFG area at various times during the year." (IWC 2012).

Photo-identification studies between northern California and northern British Columbia provide data on the abundance and population structure of PCFG whales (Calambokidis *et al.* 2017). Gray whales using the study area in summer and autumn include two components: (1) whales that frequently return to the area, display a high degree of intra-seasonal "fidelity" and account for a majority of the sightings between 1 June and 30 November. Despite movement and interchange among sub-regions of the study area, some whales are more likely to return to the same sub-region where they were observed in previous years; (2) "visitors" from the northbound migration that are sighted only in one year, tend to be seen for shorter time periods in that year, and are encountered in more limited areas. Photo-identification (Gosho *et al.* 2011; Calambokidis *et al.* 2017) and satellite tagging (Mate *et al.* 2010; Ford *et al.* 2012) studies have documented some PCFG whales off Kodiak Island, the Gulf of Alaska and Barrow, Alaska, well to the north of the pre-defined 41°N to 52°N boundaries used in PCFG abundance estimation analyses. Lagerquist *et al.* (2019) noted that PCFG whales tagged in autumn in northern California and Oregon waters utilized feeding areas from northern California to Icy Bay, Alaska, with one male remaining in the vicinity of the California/Oregon border for almost a year. The highest use areas for these tagged whales were identified as northern California, central Oregon, and southern Washington waters.

Frasier *et al.* (2011) found significant differences in mtDNA haplotype distributions between PCFG and ENP gray whales, in addition to differences in long-term effective population size, and concluded that the PCFG qualifies as a separate management unit under the criteria of Moritz (1994) and Palsbøll *et al.* (2007). The authors noted that PCFG whales probably mate with the rest of the ENP population and that their findings were the result of maternally-directed site fidelity of whales to different feeding grounds.

Lang *et al.* (2011b) assessed stock structure of ENP whales from different feeding grounds using both mtDNA and eight microsatellite markers. Significant mtDNA differentiation was found when samples from individuals (n=71) sighted over two or more years within the seasonal range of the PCFG were compared to samples from whales feeding north of the Aleutians (n=103), and when PCFG samples were compared to samples collected off Chukotka, Russia (n=71). No significant differences were found when the same comparisons were made using microsatellite data. The authors concluded that (1) the significant differences in mtDNA haplotype frequencies between the PCFG and whales sampled in northern areas indicates that use of some feeding areas is being influenced by internal recruitment (e.g., matrilineal fidelity), and (2) the lack of significance in nuclear comparisons suggests that individuals from different feeding grounds may interbreed. The level of mtDNA differentiation identified, while statistically significant, was low and the mtDNA haplotype diversity found within the PCFG was similar to that found in the northern strata. Lang *et al.* (2011b) suggested this could indicate recent colonization of the PCFG but could also be consistent with external recruitment into the PCFG. An additional comparison of whales sampled off Vancouver Island, British Columbia (representing the PCFG) and whales sampled at the calving lagoon at San Ignacio also found no significant differences in microsatellite allele frequencies, providing further support for interbreeding between the PCFG and the rest of the ENP stock (D'Intino *et al.* 2012). Lang and Martien (2012) investigated potential immigration levels into the PCFG using simulations and produced results consistent with the empirical (mtDNA) analyses of Lang *et al.* (2011b). Simulations indicated that immigration of >1 and <10 animals per year into the PCFG was plausible, and that annual immigration of 4 animals/year produced results most consistent with empirical data.

While the PCFG is recognized as a distinct feeding aggregation (Calambokidis *et al.* 2017; Mate *et al.* 2010; Frasier *et al.* 2011; Lang *et al.* 2011b; IWC 2012), the status of the PCFG as a population stock remains unresolved (Weller *et al.* 2013). A NMFS gray whale stock identification workshop held in 2012 included a review of available photo-identification, genetic, and satellite tag data. The report of the workshop states "there remains a substantial level of uncertainty in the strength of the lines of evidence supporting demographic independence of the PCFG." (Weller *et al.* 2013). The NMFS task force, charged with evaluating stock status of the PCFG, noted that "both the photo-identification and genetics data indicate that the levels of internal versus external recruitment are comparable, but these are not quantified well enough to determine if the population dynamics of the PCFG are more a consequence of births and deaths within the group (internal dynamics) rather than related to immigration and/or emigration (external dynamics)." Further, given the lack of significant differences found in nuclear DNA markers between PCFG whales and ENP whales, the task force found no evidence to suggest that PCFG whales breed exclusively or primarily with each other, but interbreed with ENP whales, including potentially other PCFG whales. Additional research to better identify recruitment levels into the PCFG and further assess the stock status of PCFG whales is needed (Weller *et al.* 2013). In contrast, the task force noted that WNP gray whales should be recognized as a population stock under the MMPA, and NMFS prepared a separate report for WNP gray whales in 2014. Because the PCFG appears to be a distinct feeding aggregation and may one day warrant consideration as a distinct stock, separate PBRs are calculated for the PCFG to assess whether levels of human-caused mortality are likely to cause local depletion.

The IWC Scientific Committee has conducted a series of annual (2014-2018) range-wide workshops on the status of North Pacific gray whales. The primary objective was not to determine a single 'best' stock structure hypothesis (unless definitively supported by existing data) but rather to identify plausible hypotheses consistent with the suite of available data. The goal is to create a foundation for developing range-wide conservation advice. The primary hypotheses deemed as most plausible considered two separate 'breeding stocks' or biological populations (western and eastern). These hypotheses include: (a) "Hypothesis 3a" which assumes that while two breeding stocks (western and eastern) may once have existed, the western breeding stock is extirpated. Whales show matrilineal fidelity to feeding grounds, and the eastern breeding stock includes three feeding aggregations: Pacific Coast Feeding Group, Northern Feeding Group, and a Western Feeding Group; and (b) "Hypothesis 5a" which assumes that both breeding stocks are extant and that the western breeding stock feeds off both coasts of Japan and Korea and in the northern Okhotsk Sea west of the Kamchatka Peninsula. Whales feeding off Sakhalin include both whales that are part of the extant western breeding stock and remain in the western North Pacific year-round, plus whales that are part of the Eastern breeding stock and migrate between Sakhalin and the eastern North Pacific.

POPULATION SIZE

Systematic counts of gray whales migrating south along the central California coast have been conducted by shore-based observers at Granite Canyon most years since 1967 (Fig. 2). The most recent estimate of abundance for the ENP population is from the 2015/2016 southbound survey and is 26,960 (CV=0.05) whales (Durban *et al.* 2017) (Fig. 2).

Photographic mark-recapture abundance estimates for PCFG gray whales between 1998 and 2015, including estimates for a number of smaller geographic areas within the IWC-defined PCFG region (41°N to 52°N), are reported in Calambokidis *et al.* (2017). The 2015 abundance estimate for the defined range of the PCFG between 41°N to 52°N is 243 whales (SE=18.9; CV= 0.08).

Eastern North Pacific gray whales experienced an unusual mortality event (UME) in 1999 and 2000, when large numbers of emaciated animals stranded along the west coast of North America (Moore *et al.*, 2001; Gulland *et al.*, 2005). Over 60% of the dead whales were adults, compared with previous years when calf strandings were more common. Several factors following this UME suggest that the high mortality rate observed was a short-term, acute event: 1) in 2001 and 2002, strandings decreased to levels below UME levels (Gulland *et al.*, 2005); 2) average calf production returned to levels seen before 1999; and 3) in 2001, living whales no longer appeared emaciated. Oceanographic factors that limited food availability for gray whales were identified as likely causes of the UME (LeBouef *et al.* 2000; Moore *et al.* 2001; Minobe 2002; Gulland *et al.* 2005), with resulting declines in survival rates of adults during this period (Punt and Wade 2012). The population has recovered to levels seen prior to the UME of 1999-2000 and the current estimate of abundance is the highest that has been recorded in the 1967-2015 time series (Fig. 2).

Minimum Population Estimate

The minimum population estimate (N_{MIN}) for the ENP stock is calculated from Equation 1 from the PBR Guidelines (Wade and Angliss 1997): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the 2015/2016 abundance estimate of 26,960 and its associated CV of 0.05 (Durban *et al.* 2013), N_{MIN} for this stock is 25,849.

The minimum population estimate for PCFG gray whales is calculated as the lower 20th percentile of the log-normal distribution of the 2015 mark-recapture estimate of 243 (CV=0.08), or 227 animals.

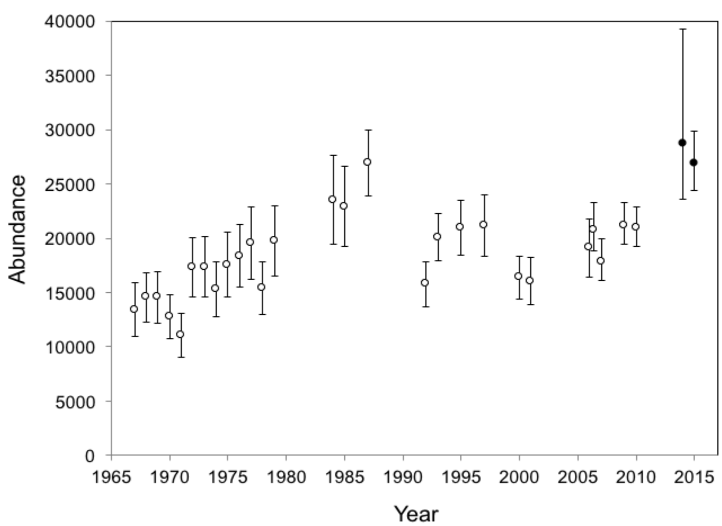

Figure 2. Estimated abundance of Eastern North Pacific gray whales from NMFS counts of migrating whales past Granite Canyon, California. Open circles represent abundance estimates and 95% confidence intervals reported by Laake *et al.* (2012) and Durban *et al.* (2015). Closed circles represent estimates and 95% posterior highest density intervals reported by Durban *et al.* (2017) for the 2014/2015 and 2015/2016 migration seasons.

Current Population Trend

The population size of the ENP gray whale stock has increased over several decades despite an UME in 1999 and 2000 (see Fig. 2). Durban *et al.* (2017) noted that a recent 22% increase in ENP gray whale abundance over 2010/2011 levels is consistent with high observed and estimated calf production (Perryman *et al.* 2017). Recent increases in abundance also support hypotheses that gray whales may experience more favorable feeding conditions in arctic waters due to an increase in ice-free habitat that might result in increased primary productivity in the region (Perryman *et al.* 2002, Moore 2016). Abundance estimates of PCFG whales increased from 1998 through 2004, remained stable for the period 2005-2010, and have steadily increased during the 2011-2015 time period (Calambokidis *et al.* 2017).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Using abundance data through 2006/07, an analysis of the ENP gray whale population led to an estimate of Rmax of 0.062, with a 90% probability the value was between 0.032 and 0.088 (Punt and Wade 2012). This value of Rmax is also applied to PCFG gray whales, as it is currently the best estimate of Rmax available for gray whales in the ENP.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the ENP stock of gray whales is calculated as the minimum population size (25,849), times one-half of the maximum theoretical net population growth rate (½ x 6.2% = 3.1%), times a recovery factor of 1.0 for a stock above MNPL (Punt and Wade 2012), or 801 animals per year.

The potential biological removal (PBR) level for PCFG gray whales is calculated as the minimum population size (227 animals), times one half the maximum theoretical net population growth rate (½ x 6.2% = 3.1%), times a recovery factor of 0.5 (for a population of unknown status), resulting in a PBR of 3.5 animals per year. Use of the recovery factor of 0.5 for PCFG gray whales, rather than 1.0 used for ENP gray whales, is based on uncertainty regarding stock structure and guidelines for preparing marine mammal stock assessments which state that "Recovery factors of 1.0 for stocks of unknown status should be reserved for cases where there is assurance that N_{min}, R_{max}, and the kill are unbiased and where the stock structure is unequivocal" (NMFS 2005, Weller *et al.* 2013). Given uncertainties in external versus internal recruitment levels of PCFG whales, the equivocal nature of the stock structure, and the small estimated population size of the PCFG, NMFS will continue to use the default recovery factor of 0.5 for PCFG gray whales.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

The California large-mesh drift gillnet fishery for swordfish and thresher shark includes 4 observed entanglement records of gray whales from 8,845 observed fishing sets over the 27-year period 1990-2016 (Carretta *et al.* 2018a). The estimated bycatch of gray whales in this fishery for the most recent 5-year period is 2.1 (CV=0.76) whales, or 0.4 whales annually (Carretta *et al.* 2018a). By comparison, the more coastal set gillnet fishery for halibut and white seabass has no observations of gray whale entanglements from over 10,000 observed sets for the same time period. This compares with 11 opportunistically documented gillnet entanglements of gray whales in U.S. west coast waters during the most recent 5 year period of 2012-2016, including one self-report from a set gillnet vessel operator (Carretta *et al.* 2018b). The origin of the gillnet gear for the remaining 10 entanglements is unknown. Alaska gillnet fisheries also interact with gray whales, but these fisheries largely lack observer programs. Some gillnet entanglements involving gray whales along the coasts of Washington, Oregon, and California may involve gear set in Alaska and/or Mexican waters and carried south and/or north during the annual migration.

Table 1. Entanglement mortality and serious injury of gray whales, 2012-2016 (Carretta *et al.* 2018a, 2018b). Fractional bycatch estimates in swordfish drift gillnets during 2014-2016 result from a model that incorporates all years of observer data for bycatch prediction, thus bycatch estimates can be positive even when no bycatch is observed. Entanglement in other fisheries is derived from strandings and at-sea sightings of entangled whales and thus represent minimum impacts because they are documented opportunistically (Carretta *et al.* 2018b). Mortality and injury information, where possible, is assigned to either the ENP gray whale stock or PCFG whales. Total ENP mortality and injury also includes records attributable to PCFG gray whales, as PCFG gray whales are included in the abundance estimates for ENP gray whales and thus, the calculated PBR for ENP gray whales also includes PCFG animals.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed mortality (+ serious injury)	Estimated mortality (CV)	Mean annual takes 2012-2016 (CV)
CA/OR thresher shark/swordfish drift gillnet	2012	observer	19%	0 (0)	0 (n/a)	0.4 (0.76) (ENP stock)
	2013		37%	1 (0)	1 (n/a)	
	2014		24%	0 (0)	0.1 (5.9)	
	2015		20%	0 (0)	0.7 (2.1)	
	2016		18%	0 (0)	0.5 (2.4)	
	2012-2016		23%	ENP 1 (0)	2.1 (0.76)	

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed mortality (+ serious injury)	Estimated mortality (CV)	Mean annual takes 2012-2016 (CV)
CA halibut and white seabass set gillnet	2012-2016	vessel self-report	n/a	ENP 0 (0.75)	n/a	ENP 0.15 (n/a)
CA Dungeness crab pot		strandings + sightings	n/a	ENP 2 (1.75) PCFG 1 (0)	n/a	ENP 0.75 (n/a) PCFG 0.2 (n/a)
OR Dungeness crab pot				ENP 0 (0.75)		ENP 0.15 (n/a)
Cod pot fishery				ENP 0 (0.75)		ENP 0.15 (n/a)
Unidentified pot/trap fishery				ENP 1 (8.75) PCFG 0 (1.5)		ENP 1.9 (n/a) PCFG 0.3 (n/a)
Unidentified gillnet fishery				ENP 3 (5.5)		ENP 1.7 (n/a)
Unidentified fishery interactions				ENP 2 (13) PCFG 0 (1)		ENP 3.0 (n/a) PCFG 0.2 (n/a)
Marine debris entanglement				ENP 1 (0.75)		ENP 0.35 (n/a)
Tribal crab pot gear	2012-2016	self-report	n/a	ENP 0 (0.75) PCFG 0 (0.75)		ENP 0.15 (n/a) PCFG 0.15 (n/a)
Totals				ENP 10 (32.75) PCFG 1 (3.25)		ENP 8.7 (n/a) PCFG 0.85 (n/a)

Entanglement in commercial pot and trap fisheries along the U.S. west coast is another source of gray whale mortality and serious injury (Carretta *et al.* 2018b). Most data on human-caused mortality and serious injury of gray whales are from strandings, including at-sea reports of entangled animals alive or dead (Carretta *et al.* 2018b). Strandings represent only a fraction of actual gray whale deaths (natural or human-caused), as reported by Punt and Wade (2012), who estimated that only 3.9% to 13.0% of gray whales that die in a given year end up stranding and being reported. This estimate of carcass detection, however, also included sparsely-populated coastlines of Baja California, Canada, and Alaska, for which the rate of carcass detection would be expected to be low. Since most U.S. cases of human-caused serious injury and mortality are documented from Washington, Oregon, and California waters, the Punt and Wade (2012) estimate of carcass recovery is not applicable to most documented cases. An appropriate correction factor for undetected anthropogenic mortality and serious injury of gray whales is unavailable.

A summary of human-caused mortality and serious injury from fishery and marine debris sources is given in Table 1 for the most recent 5-year period of 2012 to 2016 (Carretta *et al.* 2018b). Total observed and estimated entanglement-related human-caused mortality and serious injury for ENP gray whales is 8.7 whales annually, which includes PCFG entanglements (Table 1). The mean annual entanglement-related serious injury and mortality level for PCFG gray whales is 0.85 whales, based on one observed death in CA Dungeness crab pot gear and three serious injuries in other fishing gear (Table 1). In addition to the mortality and serious injury totals listed above, there were 5 non-serious entanglement injuries of gray whales (Carretta *et al.* 2018b). Three non-serious injuries involved ENP gray whales, each with one record associated with the following sources: CA Dungeness crab pot fishery, unknown Dungeness crab pot fishery, and unidentified fishery interaction. During the same period, there were two non-serious injuries involving PCFG whales, one in tribal crab pot gear and the other in an unidentified gillnet fishery.

Unidentified whales represent approximately 15% of entanglement cases along the U.S. West Coast, (Carretta 2018). Observed entanglements may lack species IDs due to rough seas, distance from whales, or a lack of cetacean identification expertise. In previous stock assessments, these unidentified entanglements were not assigned to species, which results in underestimation of entanglement risk, especially for commonly-entangled species. To remedy this negative bias, a cross-validated species identification model was developed from known-species entanglements (‘model data’). The model is based on several variables (location + depth + season + gear type + sea surface temperature) collectively found to be statistically-significant predictors of known-species entanglement cases (Carretta 2018). The species model was used to assign species ID probabilities for 21 unidentified whale entanglement cases (‘novel data’) during 2012-2016. The sum of species assignment probabilities for this 5-year period result in an additional 5.8 gray whale entanglements for 2012-2016. Of these 5.8 entanglements, only 0.8 occurred within the geographic range and seasonal limits considered to represent PCFG gray whales, while the remaining 5 are considered to be ENP gray whales. Unidentified whale entanglements typically involve whales seen at-sea with unknown gear configurations that are prorated to represent 0.75 serious injuries per entanglement case. Thus it is estimated that at least 5 x 0.75 = 3.75 additional ENP gray whale and 0.8 x 0.75 = 0.6 PCFG serious injuries are represented from the 21 unidentified whale entanglement cases during 2012-2016. This represents 0.75 ENP gray whales and 0.1 PCFG gray whales annually. The 0.1 PCFG gray whales annually are added to ENP totals as PCFG whales are included in abundance and PBR calculations for the larger ENP stock. Thus, unidentified whale entanglements represent 0.85

ENP gray whales annually. Total serious injury and mortality from Table 1 totals 8.7 whales annually, pluse 0.85 annually from prorated unidentified whale entanglements, or 9.6 ENP whales annually.

Subsistence/Native Harvest Information

Subsistence hunters in Russia and the United States have traditionally harvested whales from the ENP stock in the Bering Sea, although only the Russian hunt has persisted in recent years (Huelsbeck 1988; Reeves 2002). In 2005, the Makah Indian Tribe requested authorization from NOAA/NMFS, under the MMPA and the Whaling Convention Act, to resume limited hunting of gray whales for ceremonial and subsistence purposes in the coastal portion of their usual and accustomed (U&A) fishing grounds off Washington State (NMFS 2015). The spatial overlap of the Makah U&A and the summer distribution of PCFG whales has management implications. The hunt proposal by the Makah Tribe includes time/area restrictions designed to reduce the probability of killing a PCFG whale and to focus the hunt on whales migrating to/from feeding areas to the north. The Makah proposal also includes catch limits for PCFG whales that result in the hunt being terminated if these limits are met. Also, observations of gray whales moving between the WNP and ENP highlight the need to estimate the probability of a gray whale observed in the WNP being taken during a Makah hunt (Moore and Weller 2013). NMFS has prepared a draft environmental impact statement (DEIS) on the proposed hunt (NMFS 2015) and the IWC has evaluated the potential impacts of the proposed hunt and other human-caused mortality sources on PCFG whales. The IWC concluded, with certain qualifications, that the proposed hunt meets the Commission's conservation objectives (IWC 2013). The Scientific Committee has continued to investigate stock structure of north Pacific gray whales and has convened five workshops on the subject between 2014 and 2018. The objective of the workshops has been to develop a series of range-wide stock structure hypotheses, using all available data sources (*e.g.* photo-ID, genetics, tagging), that can be tested within a modelling framework (IWC 2017).

In 2018, the IWC approved a 7-year quota (2019-2025) of 980 gray whales landed, with an annual cap of 140, for Russian and U.S. (Makah Indian Tribe) aboriginals based on the joint request and needs statements submitted by the U.S. and the Russian Federation. The U.S. and the Russian Federation have agreed that the quota will be shared with an average annual harvest of 135 whales by the Russian Chukotka people and 5 whales by the Makah Indian Tribe. Total takes by the Russian hunt during the past five years were: 143 in 2012, 127 in 2013, 124 in 2014, 125 in 2015, and 120 in 2016 (International Whaling Commission). There were no whales taken by the Makah Indian Tribe during that period because their hunt request is still under review. Based on this information, the annual subsistence take averaged 128 whales during the 5-year period from 2012 to 2016. The IWC reports a total of 3,787 gray whales harvested from annual aboriginal subsistence hunts for the 32-year period 1985 to 2016, which includes struck and lost whales. The estimated population size of ENP gray whales has increased during this same period (Fig. 2).

Other Mortality

Ship strikes are a source of mortality and serious injury for gray whales. During the most recent five-year period, 2012-2016, serious injury and mortality of ENP gray whales attributed to ship strikes totaled 4 animals (including 4 deaths and 2 non-serious injuries) or 0.8 whales annually (Carretta *et al.* 2018b). Total ship strike serious injury and mortality of gray whales observed in the PCFG range and season was 2 animals, or 0.4 whales per year (Carretta *et al.* 2018b). Ship strikes attributed to PCFG whales are also included in ENP totals. Additional mortality from ship strikes probably goes unreported because the whales either do not strand, are undetected, or lack obvious signs of trauma.

HABITAT CONCERNS

Nearshore industrialization and shipping congestion throughout gray whale migratory corridors represent risks due to increased likelihood of exposure to pollutants and ship strikes, as well as a general habitat degradation.

Evidence indicates that the Arctic climate is changing significantly, resulting in a reductions in sea ice cover that are likely to affect gray whale populations (Johannessen *et al.* 2004, Comiso *et al.* 2008). For example, the summer range of gray whales has greatly expanded in the past decade (Rugh *et al.* 2001). Bluhm and Gradinger (2008) examined the availability of pelagic and benthic prey in the Arctic and concluded that pelagic prey is likely to increase while benthic prey is likely to decrease in response to climate change. They noted that marine mammal species that exhibit trophic plasticity (such as gray whales which feed on both benthic and pelagic prey) will adapt better than trophic specialists.

Global climate change is also likely to increase human activity in the Arctic as sea ice decreases, including oil and gas exploration and shipping (Hovelsrud *et al.* 2008). Such activity will increase the chance of oil spills and ship strikes in this region. Gray whales have demonstrated avoidance behavior to anthropogenic sounds associated with oil and gas exploration (Malme *et al.* 1983, 1984) and low-frequency active sonar during acoustic playback experiments (Buck and Tyack 2000, Tyack 2009). Ocean acidification could reduce the abundance of shell-forming organisms (Fabry *et al.* 2008, Hall-Spencer *et al.* 2008), many of which are important in the gray whales' diet (Nerini 1984).

STATUS OF STOCK

In 1994, the ENP stock of gray whales was removed from the List of Endangered and Threatened Wildlife (the List), as it was no longer considered endangered or threatened under the Endangered Species Act (NMFS 1994). Punt and Wade (2012) estimated the ENP population was at 85% of carrying capacity (K) and at 129% of the maximum net productivity level (MNPL), with a probability of 0.884 that the population is above MNPL and therefore within the range of its optimum sustainable population (OSP).

Even though the stock is within OSP, abundance will fluctuate as the population adjusts to natural and human-caused factors affecting carrying capacity (Punt and Wade 2012). It is expected that a population close to or at carrying capacity will be more susceptible to environmental fluctuations (Moore *et al.* 2001). The correlation between gray whale calf production and environmental conditions in the Bering Sea may reflect this (Perryman *et al.* 2002; Perryman and Weller 2012). Overall, the population nearly doubled in size over the first 20 years of monitoring, and has fluctuated for the last 30 years, with a recent increase to over 26,000 whales. Carrying capacity for this stock was estimated at 25,808 whales in 2009 (Punt and Wade 2012), however the authors noted that carrying capacity was likely to vary with environmental conditions.

Based on 2012-2016 data, the estimated annual level of human-caused mortality and serious injury for ENP gray whales includes Russian harvest (128), mortality and serious injury from commercial fisheries (9.6), marine debris (0.35), ship strikes (0.8) totals 139 whales per year, which does not exceed the PBR (801). Therefore, the ENP stock of gray whales is not classified as a strategic stock.

The IWC completed an implementation review for ENP gray whales (including the PCFG) in 2012 (IWC 2013) and concluded that harvest levels (including the proposed Makah hunt) and other human caused mortality are sustainable, given the population abundance (Laake *et al.* 2012, Punt and Wade 2012).

PCFG gray whales do not currently have a formal status under the MMPA. Abundance estimates of PCFG whales increased from 1998 through 2004, remained stable during 2005-2010, and have steadily increased from 2011-2015 (Calambokidis *et al.* 2017). Total annual human-caused mortality of PCFG gray whales during the period 2012 to 2016 includes mortality and serious injuries due to commercial fisheries (0.7/yr), tribal fisheries (0.15/yr), ship strikes (0.4/yr), plus unidentified whale entanglements assigned as PCFG gray whales (0.1), or 1.35 whales annually. This does not exceed the calculated PBR level of 3.5 whales for this population. Levels of human-caused mortality and serious injury resulting from commercial fisheries and ship strikes for both ENP and PCFG whales represent minimum estimates as recorded by stranding networks or at-sea sightings because not all cases are detected or documented.

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