Revised 4/15/2021

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 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 commonly found in the North Pacific. Genetic studies 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.* 2014; Weller *et al.* 2013). Brüniche-Olsen *et al*. (2018a) used nuclear single nucleotide polymorphisms (SNPs) from whales sampled off Sakhalin and Mexico breeding lagoons to conclude that genetic differentiation between the two regions was small, but statistically-significant, despite the presence of admixed individuals. These authors conclude that gray whale population structure is not determined by simple geography and may be in flux due to evolving migratory dynamics. Contemporary gray whale genomes, both eastern and western, contain less nucleotide diversity than most other marine mammals and evidence of inbreeding is greater in the Western Pacific than in the Eastern Pacific populations (Brüniche-Olsen *et al*. 2018b).

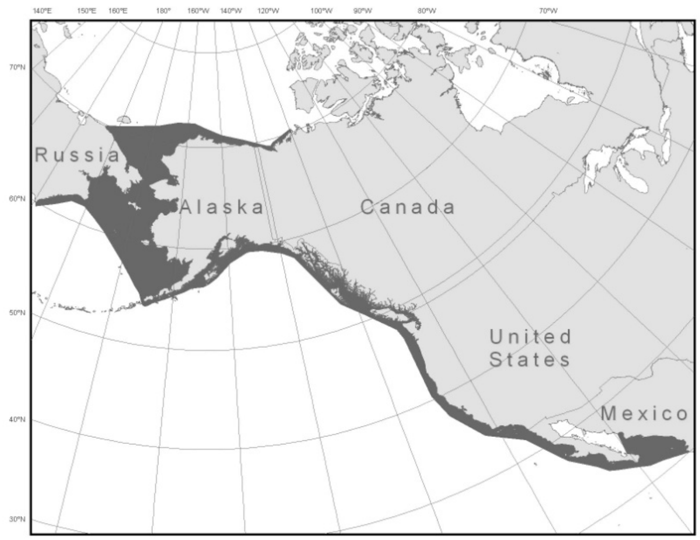

Figure 1. Approximate distribution of the Eastern North Pacific stock of gray whales (shaded area).

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, Urbán *et al.* 2019). Photographs of 379 individuals identified on summer feeding grounds off Russia (316 off Sakhalin; 150 off Kamchatka), were compared to 10,685 individuals identified in Mexico breeding lagoons. A total of 43 matches were found, including the following links: 14 Sakhalin-Kamchatka-Mexico, 25 Sakhalin-Mexico, and 4 Kamchatka-Mexico (Urban *et al.* 2019). The number of whales documented moving between the WNP and ENP represents 14% of gray whales identified off Sakhalin Island and Kamchatka according to Urban *et al.* (2019).

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 (Lagerquist *et al*. 2019; 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 whales and the rest of the ENP stock, 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.* (2014) assessed stock structure from different ENP feeding grounds using mtDNA and eight microsatellite markers. Significant mtDNA differentiation was found when samples from individuals (n=71) sighted over ≥2 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 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.* (2014) 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.* (2014). 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; Lagerquist *et al.* 2019; Frasier *et al.* 2011; Lang *et al.* 2014; IWC 2012), the status of the PCFG as a population stock is unresolved (Weller *et al.* 2013). A NMFS 2012 gray whale stock identification workshop included a review of photo-identification, genetic, and satellite tag data. The workshop report 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 PCFG stock status, 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 the rest of the ENP stock, the task force found no evidence to suggest that PCFG whales breed exclusively or primarily with each other, but interbreed with the rest of the ENP stock, 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 stock assessement 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 completed annual (2014-2018) range-wide workshops on the status of North Pacific gray whales. The primary objectives were to identify plausible stock structure hypotheses and create a foundation for developing range-wide conservation advice.

The Scientific Committee reported on the plausibility of various stock structure hypotheses in 2020 (IWC 2020). These hypotheses include up to three feeding groups or aggregations: the Pacific Coast Feeding Group (PCFG), the Western Feeding Group (WFG), and the North Feeding Group (NFG). The PCFG is defined above. The WFG consists of whales that feed off Sakhalin Island as documented via photo-ID. The NFG includes whales found feeding in the Bering and Chukchi Seas where photo-ID and genetic data are sparse. The IWC Scientific Committee's stock structure hypotheses also consider up to three extant breeding stocks: the Western Breeding Stock (WBS), the Eastern Breeding Stock (EBS), and a third unnamed stock that includes WFG whales that interbreed largely with each other while migrating to the Mexico wintering grounds. The IWC summarizes three 'high plausibility' hypotheses as follows:

Hypothesis 3a is characterized by maternal feeding ground fidelity, one migratory route/wintering region used by Sakhalin whales, and random mating. Under this hypothesis, a single breeding stock (EBS) exists that includes three feeding groups: NFG, PCFG, and WFG. Areas off Southern Kamchatka and the Northern Kuril Islands are used by some whales that belong to the WFG and some whales that belong to the NFG. Although two breeding stocks (WBS and EBS) may once have existed, the WBS is assumed to have been extirpated.

Hypothesis 4a is characterized by maternal feeding ground fidelity, one migratory route/wintering region used by Sakhalin whales, and non-random mating. Under this hypothesis, two breeding stocks exist and overwinter in Mexico. One breeding stock (EBS) includes NFG and PCFG whales, and a second, unnamed breeding stock includes WFG whales that mate largely with each other while migrating to Mexico. Areas off Southern Kamchatka and the Northern Kuril Islands are used by some whales that belong to the breeding stock comprised of WFG whales and some whales that belong to the NFG. Although a third breeding stock (the WBS) may once have existed, under this hypothesis the WBS is assumed to have been extirpated.

Hypothesis 5a is characterized by maternal feeding ground fidelity and two migratory routes/wintering grounds used by Sakhalin whales. Under this hypothesis, two breeding stocks exist: EBS and WBS. The EBS includes three feeding groups: PCFG, NFG, and the WFG that feeds off Northeastern Sakhalin Island. The WBS whales feed off Northeastern Sakhalin Island, Southern Kamchatka, the Northern Kuril Islands and other areas of the Okhotsk Sea and then migrate to the South China Sea to overwinter. Under this hypothesis, areas off Southern Kamchatka and the Northern Kuril Islands are used by the WFG, the NFG, and the feeding whales that are part of the WBS.

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) beginning in 2019 (which is ongoing), when large numbers of whales stranded from Mexico to Alaska (NOAA 2020a). Necropsies conducted on a subset of stranded whales indicated that many animals showed evidence of nutritional stress. NOAA is coordinating an independent team of scientists to review the stranding data and samples as part of the Working Group on Marine Mammal Unusual Mortality Events. NOAA continues to monitor the gray whale population through abundance and calf production surveys. The current UME is similar to that of 1999 and 2000, when large numbers of animals also stranded along the west coast of North America (Moore et al., 2001; Gulland et al., 2005). Stranding numbers during the 1999-2000 UME exceeded that of the current UME to date, although estimated population size at the time of the 1999-2000 UME was between 15,000 to 18,000 animals. During the 1999-2000 UME, >60% of the dead whales were adults, compared with previous years when calf strandings were more common. Several factors following the 1999-2000 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). Investigations on the causes of the current UME may yield similar conclusions. The ENP gray whale population has recovered to levels seen prior to the UME of 1999-2000 and the current estimate of abundance is the highest in the 1967-2015 time series (Fig. 2).

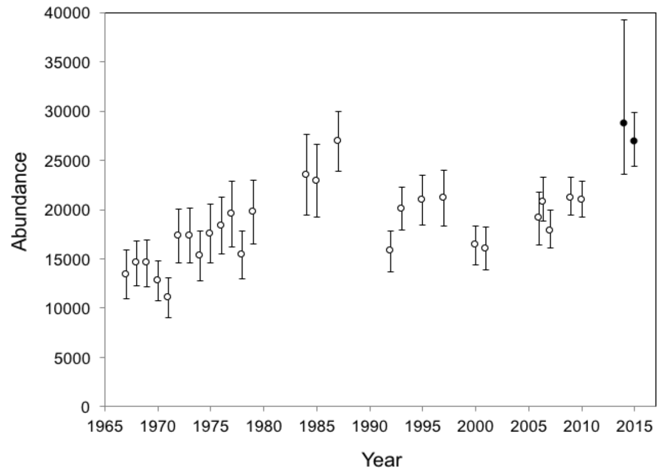

Figure 2. Estimated abundance of Eastern North Pacific gray whales from NMFS counts of migrating whales past Granite Canyon, California. Open circles represent abundance estimates and 95% confidence intervals reported by Laake *et al.* (2012) and Durban *et al.* (2015). Closed circles represent estimates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

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.* 2017), 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.

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), <u>times</u> 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

A total of 62 gray whale records involving human-caused deaths or serious injuries were assessed for the 5-year period 2014-2018 (Carretta *et al.* 2020). These included commercial fishery-related cases (n=50), vessel strikes (n=9), marine debris entanglements (n=2), and illegal hunts (n=1). These records are summarized in the report sections below.

Fisheries Information

The California large-mesh drift gillnet fishery for swordfish and thresher shark includes five observed entanglement records of gray whales from 9,085 observed fishing sets from1990-2018 (Carretta 2020). The estimated bycatch of gray whales in this fishery for the most recent 5-year period is 2.6 (CV=0.37) whales, or 0.52 whales annually (Carretta 2020). 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 13 opportunistically documented unidentified gillnet fishery entanglements of gray whales in U.S. west coast waters during the most recent 5 year period of 2014-2018, including one self-report from a set gillnet vessel operator (Carretta 2020, Carretta *et al*. 2020). 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 Mexico waters and carried south and/or north during annual migration.

Entanglement in commercial pot and trap fisheries is another source of gray whale mortality and serious injury (Carretta *et al.* 2018, 2020). 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.* 2018, 2020). 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 is 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 U.S. West Coast waters. 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 sources is given in Table 1 for the most recent 5-year period of 2014 to 2018 (Carretta *et al.* 2018b, 2020). Total observed and estimated entanglement-related human-caused mortality and serious injury for ENP gray whales is 9.3 whales annually, which includes PCFG entanglements (Table 1). The mean annual entanglement-related serious injury and mortality level for PCFG gray whales is 1.1 whales (Table 1). Gray whale serious injuries in unidentified fishing gear during 2014-2018 totaled 20.25, or 4 whales annually (Table 1, Carretta *et al*. 2020). Additionally, there were 21 *unidentfied whale* entanglements during 2014-2018, of which, 4.1 were prorated as gray whales using the method reported by Carretta (2018). Of these 4.1 entanglements, 1.2 occurred within the geographic and seasonal limit range considered to represent PCFG 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 3.9 x 0.75 = 2.9 additional ENP gray whale and 1.2 x 0.75 = 0.9 PCFG serious injuries occurred from the 21 unidentified whale entanglement cases during 2014-2018. This represents 0.6 ENP gray whales and 0.2 PCFG gray whales annually. The 5-year total of 2.9 prorated ENP gray whale serious injuries from 2014 to 2018 includes 1.2 prorated PCFG serious injuries as PCFG whales are included in abundance and PBR calculations for the larger ENP stock. Total ENP gray whale serious injury and mortality from Table 1 totals 9.3 whales annually, and 1.1 annually for PCFG gray whales.

Table 1. Entanglement mortality and serious injury of gray whales, 2014-2018 (Carretta 2020, Carretta *et al.* 2020). Entanglement in most 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.* 2020). Mortality and injury information, where possible, is assigned to either the ENP gray whale stock or PCFG whales. Total mortality and

injury of ENP gray whales includes records attributable to PCFG gray whales, because abundance estimates and calculated PBR for ENP gray whales includes PCFG whales.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed mortality (+ serious injury)	Estimated mortality (CV)	Mean annual takes 2014-2018 (CV)
CA/OR thresher shark/swordfish drift gillnet	2014-2018	observer	21%	ENP 1 (0)	2.6 (0.37)	0.52 (0.37) (ENP stock)
CA halibut and white seabass set gillnet	2014-2018	vessel self-report in 2015	n/a	ENP 0 (0.75)	n/a	ENP 0.15 (n/a)
CA Dungeness crab pot		strandings + sightings	n/a	ENP 1 (0.75)	n/a	ENP 0.35 (n/a)
WA Dungeness crab pot				ENP 3 (1.75) PCFG 0 (0.75)		ENP 0.95 (n/a) PCFG 0.15 (n/a)
Unidentified pot/trap fishery				ENP 1 (3.75) PCFG 0 (1.5)		ENP 0.95 (n/a)PCFG 0.3 (n/a)
Unidentified gillnet fishery				ENP 1 (9.5)		ENP 2.1 (n/a)
Unidentified fishery interactions involving *gray whales*				ENP 3 (15.25) PCFG 1 (1)		ENP 3.65 (n/a) PCFG 0.4 (n/a)
Unidentified fishery interactions involving *unidentified whales* prorated to gray whale				ENP 0 (2.9) PCFG 0 (1.2)		ENP 0.6 (n/a) PCFG 0.2 (n/a)
Totals				ENP 10 (34.65) PCFG 1 (4.45)		ENP 9.3 (n/a) PCFG 1.1 (n/a)

Subsistence/Native Harvest Information

Subsistence hunters in Russia, Canada, and the United States have traditionally harvested whales from the ENP stock, although only the Russian hunt has persisted in recent years (Huelsbeck 1988; Monks *et al*. 2001, Reeves 2002). NMFS has proposed to grant a waiver of the Marine Mammal Protection Act's moratorium on the take of marine mammals to allow the Makah Indian Tribe to take a limited number of Eastern North Pacific gray whales (NOAA 2019, 2020a, 2020b). The proposed rule includes a potential maximum removal of an average of 2.5 whales annually over a 10-year period (NOAA 2019). Proposed regulations include considerations of the estimated probabilities of a Makah hunt taking a WNP gray whale (Moore and Weller 2018) and safeguards to minimize the probability of taking either WNP or PCFG whales. The proposed rule states: "*there is about a 6 percent probability of hunters striking one WNP gray whale over the 10 years of the regulations (Moore and Weller, 2018). This probability is the most likely point estimate; the 95 percent confidence interval ranges from 3.0 percent to 9.3 percent. Stated another way, the most likely point estimates indicate that one in 17 10-year hunt periods (i.e., one year out of 170) would result in an individual WNP gray whale being struck by Makah hunters, if the Tribe made the maximum number of strike attempts allowed in even-year hunts and if ENP and WNP population sizes and migration patterns remained constant (Moore and Weller, 2018)*". A formal hearing occurred in November 2019 and NMFS is awaiting a recommended decision from the Administrative Law Judge overseeing that hearing (NOAA 2020b). The IWC Scientific Committee reviewed the proposed U.S. management plan for the Makah hunt of gray whales and stated that "*the performance of the Management Plan was adequate to meet the Commission's conservation objectives for the Pacific Coast Feeding Group, Western Feeding Group and Northern Feeding Group gray whales*" (IWC 2018).

In 2018, the IWC approved a 7-year Aboriginal Subsistence Whaling catch limit (2019-2025) of 980 gray whales landed, with an annual cap of 140 strikes (subject to a carry forward provision), for Russian and U.S. (Makah Indian Tribe) Native hunters 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: 124 in 2014, 125 in 2015, 120 in 2016, 119 in 2017 and 107 in 2018 (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 119 whales during the 5-year period from 2014 to 2018. The IWC reports a total of 4,013 gray whales harvested from annual aboriginal subsistence hunts for the 34-year period 1985 to 2018, which includes struck and lost whales. The estimated population size of ENP gray whales has increased during this same period (Fig. 2).

Other Mortality

Vessel strikes are a source of mortality and serious injury for gray whales. During the most recent five-year period, 2014-2018, serious injury and mortality of ENP gray whales attributed to vessel strikes totaled 9 animals (7 deaths and 2 serious injuries) or 1.8 whales annually (Carretta *et al.* 2020). Total vessel strike serious injury and mortality of gray whales observed in the PCFG range and season was 3 animals, or 0.6 whales per year (Carretta *et al.* 2020). Vessel strikes attributed to PCFG whales are also included in ENP totals. Additional mortality from vessel strikes probably goes unreported because the whales either do not strand, are undetected, or lack obvious signs of trauma.

Marine debris entanglements account for a small observed percentage of gray whale serious injuries and deaths. During 2014-2018, there were a total of 2 serious injuries/deaths, or 0.4 serious injuries/deaths annually attributed to marine debris entanglement for the ENP stock of gray whales (Carretta *et al*. 2020).

One gray whale was illegally killed in 2017 by Alaska native hunters. NOAA closed the investigation on this incident in 2018. The 5-year annual average for illegal hunts is 0.2 whales.

HABITAT CONCERNS

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

The Arctic climate is changing significantly, resulting in reductions in sea ice cover that are likely to affect gray whale populations (Perryman *et al.* 2002, Johannessen *et al.* 2004, Comiso *et al.* 2008, Gailey *et al.* 2020). For example, the summer range of gray whales has greatly expanded (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. Annual sea ice conditions in arctic foraging grounds have been linked to variability in gray whale calf survival and production in both Western (Gailey *et al*. 2020), and Eastern (Perryman *et al*. 2002) North Pacific populations. Following years of high sea-ice coverage on foraging grounds, calf survival and production decline. Decreased spatial and temporal access to foraging grounds as a result of heavy ice cover is hypothesized as the responsible factor.

Global climate change is 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 risk of oil spills and vessel strikes in this region. Gray whales demonstrate 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 2009 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 was above MNPL and therefore within the range of its optimum sustainable population (OSP).

The ongoing (UME) that began in 2019 resulted in elevated levels of stranded gray whales in poor body condition. NOAA continues to monitor this population through calf production surveys during the northbound migration and abundance surveys during the southbound migration (see Population Size). 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 2014-2018 data, the estimated annual level of human-caused mortality and serious injury for ENP gray whales includes Russian harvest (119), mortality and serious injury from commercial fisheries (9.3), marine debris (0.4), vessel strikes (1.8), and illegal hunts (0.2) totals 131 whales per year, which does not exceed the PBR (801). Therefore, the ENP stock of gray whales is not classified as a strategic stock.

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 from 2014 to 2018 includes mortality and serious injuries due to commercial fisheries (1.1/yr), and vessel strikes (0.6/yr), or 1.7 whales annually. This does not exceed the calculated PBR level of 3.5 whales for this population. However, observed levels of human-caused mortality and serious injury from commercial fisheries and vessel strikes for both ENP and PCFG whales represent minimum estimates because not all cases are detected.

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