Alaska Marine Mammal Stock Assessments, ~~2019~~2020

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PREFACE

On 30 April 1994, Public Law 103-238 was enacted allowing significant changes to provisions within the Marine Mammal Protection Act (MMPA). Interactions between marine mammals and commercial fisheries are addressed under three new sections. This new regime replaced the interim exemption that ~~has~~had regulated fisheries-related incidental takes since 1988. Section 117, Stock Assessments, required the establishment of three regional scientific review groups to advise and report on the status of marine mammal stocks within Alaska waters, along the Pacific Coast (including Hawaii), and along the Atlantic Coast (including the Gulf of Mexico). This report provides information on the marine mammal stocks of Alaska under the jurisdiction of the National Marine Fisheries Service.

Each stock assessment includes, when available, a description of the stock's geographic range; a minimum population estimate; current population trends; current and maximum net productivity rates; optimum sustainable population levels and allowable removal levels; estimates of annual human-caused mortality and serious injury through interactions with commercial, recreational, and subsistence fisheries, takes by subsistence hunters, and other human-caused events (e.g., entanglement in marine debris, ship strikes); and habitat concerns. The commercial fishery interaction data will be used to evaluate the progress of each fishery towards achieving the MMPA's goal of zero fishery-related mortality and serious injury of marine mammals.

The Stock Assessment Reports should be considered working documents, as they are updated as new information becomes available. The Alaska Stock Assessment Reports were originally developed in 1995 (Small and DeMaster 1995). Revisions have been published for the following years: 1996 (Hill et al. 1997), 1998 (Hill and DeMaster 1998), 1999 (Hill and DeMaster 1999), 2000 (Ferrero et al. 2000), 2001 (Angliss et al. 2001), 2002 (Angliss and Lodge 2002), 2003 (Angliss and Lodge 2004), 2005 (Angliss and Outlaw 2005), 2006 (Angliss and Outlaw 2007), 2007 (Angliss and Outlaw 2008), 2008 (Angliss and Allen 2009), 2009 (Allen and Angliss 2010), 2010 (Allen and Angliss 2011), 2011 (Allen and Angliss 2012), 2012 (Allen and Angliss 2013), 2013 (Allen and Angliss 2014), 2014 (Allen and Angliss 2015), 2015 (Muto et al. 2016), 2016 (Muto et al. 2017), 2017 (Muto et al. 2018), ~~and~~ 2018 (Muto et al. 2019), and 2019 (Muto et al. 2020). Each Stock Assessment Report is designed to stand alone and is updated as new information becomes available. The MMPA requires Stock Assessment Reports to be reviewed annually for stocks designated as strategic, annually for stocks where there is significant new information available, and at least once every 3 years for all other stocks. NMFS reviewed ~~N~~new information for 28 stocks in the Alaska Region in 2019-2020 and revised 23 Stock Assessment Reports under NMFS' jurisdiction: all 15 strategic stocks (Western U.S. Steller sea lions~~,~~; northern fur seals~~,~~; bearded seals~~,~~; ringed seals~~,~~; Cook Inlet beluga whales~~,~~; AT1 Transient killer whales~~,~~; Southeast Alaska, Gulf of Alaska, and Bering Sea stocks of harbor porpoise~~,~~; sperm whales~~,~~; Western North Pacific and Central North Pacific stocks of humpback whales~~,~~; fin whales~~,~~; North Pacific right whales~~,~~; and bowhead whales) and 8 non-strategic stocks (spotted seals; ribbon seals; Beaufort Sea, Eastern Chukchi Sea, Eastern Bering Sea, and Bristol Bay stocks of beluga whales; and Gulf of Alaska, Aleutian Islands, and Bering Sea Transient and West Coast Transient stocks of killer whales)~~was reviewed in 2018-2019. This review, and a review of other stocks, led to the revision of the following stock assessments for the 2019 document: Western U.S. and Eastern U.S. stocks of Steller sea lions; northern fur seals; harbor seals; bearded seals; ringed seals; Cook Inlet stock of beluga whales; Northern Resident and AT1 Transient stocks of killer whales; Southeast Alaska, Gulf of Alaska, and Bering Sea stocks of harbor porpoise; sperm whales; Western North Pacific and Central North Pacific stocks of humpback whales; fin whales; North Pacific right whales; and bowhead whales.~~ The Stock Assessment Reports for all of the Alaska stocks, however, are included in this document to provide a complete reference. Those sections of each Stock Assessment Report containing significant changes are listed in Appendix 1. The authors solicit any new information or comments which would improve future Stock Assessment Reports.

New abundance estimates were calculated for the following Alaska stocks in the 2020 Stock Assessment Reports. For explanations of why estimates have changed, see the individual report for each stock:

- Western U.S. Steller sea lions: The updated best model estimated count in 2019, derived from aerial photographic and land-based surveys in 2018 and 2019, is 52,932 sea lions. This is a decrease from the previous estimate of 53,624. The model estimated count is not a total population abundance estimate because the count has not been corrected for animals at sea during the surveys or for pups that are born before or die after the surveys.
- Eastern Pacific northern fur seals: The updated best abundance estimate, derived from counts on Sea Lion Rock in 2014, St. Paul and St. George Islands in 2014, 2016, and 2018, and Bogoslov Island in 2015, is 608,143 northern fur seals. This is a decrease from the previous estimate of 620,660.
- Eastern Chukchi Sea beluga whales: The updated best abundance estimate, derived from aerial surveys in summer 2017 in the Beaufort Sea (in an area and time period in which the Beaufort Sea and Eastern Chukchi Sea stocks do not overlap, as determined from satellite-tag data), is 13,305 beluga whales.

This is a decrease from the previous estimate of 20,752, derived from aerial surveys of the northeastern Chukchi and Alaska Beaufort seas in 2012.

- Eastern Bering Sea beluga whales: The updated best abundance estimate, derived from aerial surveys in 2017, is 9,242 beluga whales. This is an increase from the previous estimate of 6,994.
- Bristol Bay beluga whales: The updated best abundance estimate, derived from aerial surveys in 2016, is 2,040 beluga whales. This is an increase from the previous estimate of 1,926.
- Cook Inlet beluga whales: The updated best estimate of abundance in 2018, derived using a new analytical method on aerial survey data from 2014, 2016, and 2018, is 279 beluga whales. This is a decrease from the previous estimate of 327.
- West Coast Transient killer whales: The updated best estimate of abundance in 2018, derived from an analysis of photo-identification data from 1958 to 2018 for a subset of whales in British Columbia waters, is 349 killer whales. This is an increase from the previous estimate of 243, derived for a subset of whales in the inside waters of Southeast Alaska, British Columbia, and northern Washington.
- Bering Sea harbor porpoise: An abundance estimate for harbor porpoise in the eastern Bering Sea, derived from vessel surveys in association with pollock stock assessment surveys in 2008, is 5,713 harbor porpoise. However, this estimate is for only a small portion of the range of this stock and, because the survey data are more than 8 years old, the minimum population estimate (N_{MIN}) is now considered unknown and the potential biological removal (PBR) is considered undetermined.

The U.S. Fish and Wildlife Service (USFWS) has management authority for polar bears, sea otters, and walruses. Copies of the stock assessments for these species are included in Appendix ~~8~~4 of this document for your convenience.

Ideas and comments from the Alaska Scientific Review Group (SRG) have significantly improved this document from its draft form. The authors wish to express their gratitude for the thorough reviews and helpful guidance provided by the Alaska Scientific Review Group members: John Citta, Beth Concepcion, Thomas Doniol-Valcroze, ~~Ari Friedlaender,~~ Mike Miller, Greg O'Corry-Crowe (Co-Chair in 2019-2020), Lorrie Rea, Megan Peterson (Co-Chair in 2019-2020), Eric Regehr, and Kate Stafford. We would also like to acknowledge the contributions from the NMFS Alaska Regional Office and the Communications Program of the Alaska Fisheries Science Center.

The information contained within the individual Stock Assessment Reports stems from a variety of sources. Where feasible, we have attempted to ~~utilize~~use only published material. When citing information contained in this document, authors are reminded to cite the original publications, when possible.

CONTENTS*

*NMFS Stock Assessment Reports and Appendices revised in ~~2019~~2020 are in boldface.

STELLER SEA LION (*Eumetopias jubatus*): Western U.S. Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Steller sea lions range along the North Pacific Rim from northern Japan to California (Loughlin et al. 1984) (Fig. 1). Outside of the breeding season (late May to July), ~~L~~large numbers of individuals, especially juveniles and males, disperse widely ~~outside of the breeding season (late May to July)~~, probably to access seasonally important prey resources (Jemison et al. 2018). This results in marked seasonal patterns of abundance in some parts of the range and potential for intermixing ~~in foraging areas~~ of animals that were born in different ~~areas~~regions (Sease and York 2003; Baker et al. 2005; Jemison et al. 2013, 2018; Hastings et al. 2019). ~~There is an exchange of sea lions across the stock boundary (144°W; dashed line in Fig. 1), especially due to the wide-ranging seasonal movements of juveniles and adult males (Baker et al. 2005; Jemison et al. 2013, 2018).~~ During the breeding season, sea lions, especially adult females, typically return to their natal rookery or a nearby breeding rookery to breed and pup (Raum-Suryan et al. 2002, Hastings et al. 2017). ~~However, mixing of mostly breeding females from Prince William Sound to Southeast Alaska began in the 1990s and two new, mixed-stock rookeries were established (Gelatt et al. 2007; Jemison et al. 2013, 2018; O'Corry-Crowe et al. 2014).~~

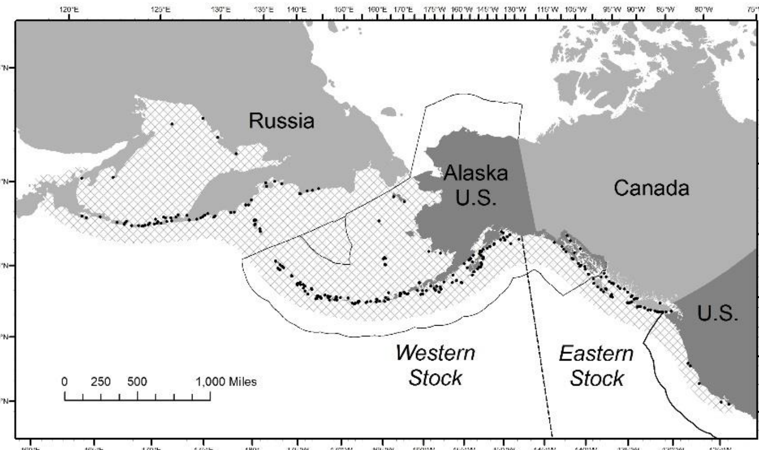

Figure 1. Generalized distribution (crosshatched area) of Steller sea lions in the North Pacific and major U.S. haulouts and rookeries (50 CFR 226.202, 27 August 1993), as well as active Asian and Canadian (British Columbia) haulouts and rookeries (points: Burkanov and Loughlin 2005, Olesiuk 2008). A black dashed line (144°W) indicates the stock boundary (Loughlin 1997) and a black line delineates the U.S. Exclusive Economic Zone.

Loughlin (1997) considered the following information when classifying stock structure based on the phylogeographic approach of Dizon et al. (1992): 1) Distributional data: geographic distribution continuous, yet a high degree of natal site fidelity and low (<10%) exchange rate of breeding animals among rookeries; 2) Population response data: substantial differences in population dynamics (York et al. 1996); 3) Phenotypic data: differences in pup mass (Merrick et al. 1995, Loughlin 1997); and 4) Genotypic data: substantial differences in mitochondrial DNA (Bickham et al. 1996). Based on this information, two ~~separate stocks~~distinct population segments (DPSs) of Steller sea lions were recognized ~~with~~in the U.S. ~~waters~~: ~~an~~the Eastern ~~U.S. stock~~DPS, which includes animals born east of Cape Suckling, Alaska (144°W), and ~~a~~the Western ~~U.S. stock~~DPS, which includes animals born at and west of Cape Suckling (Loughlin 1997; Fig. 1). However, ~~Jemison et al. (2013, 2018) determined~~ there is regular movement of Steller sea lions, especially juveniles and males outside the breeding season, ~~from~~between the ~~w~~Western ~~Distinct Population Segment (~~DPS~~)~~ (males and females equally) and the ~~e~~Eastern DPS (almost exclusively males) across the DPS boundary (Jemison et al. 2013, 2018; Hastings et al. 2019). In this report, the ~~w~~Western DPS is equivalent to the ~~w~~Western stock and the ~~e~~Eastern DPS is equivalent to the ~~e~~Eastern stock.

Mixing of mostly breeding females occurred between Prince William Sound and northern Southeast Alaska, beginning in the 1990s (Gelatt et al. 2007; Jemison et al. 2013, 2018; O'Corry-Crowe et al. 2014; Rehberg et al. 2018). In 1998 a single Steller sea lion pup was observed on Graves Rock just north of Cross Sound in Southeast Alaska, and within 15 years (2013) pup counts increased to 551 (DeMaster 2014). Movements of animals marked as pups in both stocks corroborate the extensive genetic research findings for a strong separation between the two currently recognized stocks (Jemison et al. 2013, 2018). Mitochondrial and microsatellite analysis of pup tissue samples collected at Graves Rock in 2002 revealed that approximately 70% of the pups had mtDNA haplotypes that were consistent with those found in the Western stock (Gelatt et al. 2007). Similarly, a rookery to the south on the White Sisters Islands, where pups were first noted in 1990, was also sampled in 2002 and approximately 45% of those pups had Western stock haplotypes (O'Corry-Crowe et al. 2014). Hastings et al. (2019) estimated that a minimum of 38% and 13% of animals in the North Outer Coast-Glacier Bay and Lynn Canal-Frederick Sound regions in northern Southeast Alaska, respectively, carry genetic information unique to the Western stock. Collectively, this information demonstrates that these two most recently established rookeries in northern Southeast Alaska were partially to predominately established by Western stock females (Jemison et al. 2013, 2018; O'Corry-Crowe et al. 2014; Rehberg et al. 2018; Hastings et al. 2019).

O'Corry-Crowe et al. (2014) concluded that the results of their study of the genetic characteristics of pups born on these new rookeries "demonstrates that resource limitation may trigger an exodus of breeding animals from declining populations, with substantial impacts on distribution and patterns of genetic variation." Jemison et al. (2018) also found that movement of Prince William Sound females east to these rookeries was negatively correlated with density: the population's declines prior to the early 2000s likely spurred these animals to move east in search of better foraging opportunities. This movement also revealed that this event is rare because colonists dispersed across an evolutionary boundary, suggesting that the causative factors behind recent declines are unusual or of larger magnitude than normally occur (O'Corry-Crowe et al. 2014). Thus, although recent colonization events in the northern part of the Eastern stock indicate movement of Western sea lions (especially adult females) into this area, the mixed part of the range remains geographically distinct (Jemison et al. 2013, 2018), and the discreteness between the Eastern and Western stocks remains. Movement of Western stock sea lions south of these rookeries and Eastern stock sea lions moving to the west is less common (Jemison et al. 2013, O'Corry-Crowe et al 2014).

Hybridization among subspecies and species along a contact zone such as a stock boundary is not unexpected as the ability to interbreed is an ancestral condition, whereas reproductive isolation would be considered a recently derived condition. As stated by NMFS and the U.S. Fish and Wildlife Service (USFWS) in a 1996 response to a previous comment regarding stock discreteness policy (61 FR 47222), "The Services do not consider it appropriate to require absolute reproductive isolation as a prerequisite to recognizing a distinct population segment" or stock. The fundamental concept overlying this distinctiveness is the collection of morphological, ecological, behavioral, and genetic evidence for stock differences initially described by Bickham et al. (1996) and Loughlin (1997) and supported by Baker et al. (2005), Harlin-Cognato et al. (2006), Hoffman et al. (2006, 2009), O'Corry-Crowe et al. (2006), and Phillips et al. (2009, 2011).

Steller sea lions that breed in Asia are considered part of the ~~w~~Western stock in the 2008 Steller sea lion Recovery Plan (NMFS 2008). Steller sea lions seasonally inhabit coastal waters of Japan in the winter and breeding rookeries of ~~w~~Western stock animals outside of the U.S. are currently only located in Russia (Burkanov and Loughlin 2005). Analyses of genetic data differ in their interpretation of separation between Asian and Alaska sea lions. Based on analysis of mitochondrial DNA, Baker et al. (2005) found evidence of a genetic split between the Commander Islands (Russia) and Kamchatka that would include Commander Island sea lions within the Western U.S. stock and animals west of there in an Asian stock. However, Hoffman et al. (2006) did not support an Asian/~~w~~Western stock split based on their analysis of nuclear microsatellite markers indicating high rates of male gene flow. Berta and Churchill (2012) concluded that a putative Asian stock is "not substantiated by microsatellite data since the Asian stock groups with the ~~w~~Western stock." All genetic analyses (Baker et al. 2005; Harlin-Cognato et al. 2006; Hoffman et al. 2006, 2009; O'Corry-Crowe et al. 2006) confirm a strong separation between ~~w~~Western and ~~e~~Eastern stocks, and O'Corry-Crowe et al. (2006) identified structure at the level of different oceanic regions within the Aleutian Islands. There may be sufficient morphological differentiation to support elevating the two recognized stocks to subspecies (Phillips et al. 2009), although a review by Berta and Churchill (2012) characterized the status of these subspecies assignments as "tentative" and requiring further attention before their status can be determined. Work by Phillips et al. (2011) addressed the effect of climate change, in the form of glacial events, on the evolution of Steller sea lions and reported that the effective population size at the time of the event determines the impact of change on the population. The results suggested that during historic glacial periods, dispersal events were correlated with historically low effective population sizes, whereas range fragmentation type events were correlated with larger effective population sizes. This work again reinforced the stock delineation concept by noting that ancient population subdivision likely led to the sequestering of most mtDNA haplotypes as stock or subspecies-specific (Phillips et al. 2011).

~~In 1998 a single Steller sea lion pup was observed on Graves Rock just north of Cross Sound in Southeast Alaska, and within 15 years (2013) pup counts had increased to 551 (DeMaster 2014). Mitochondrial and microsatellite analysis of pup tissue samples collected in 2002 revealed that approximately 70% of the pups had mtDNA haplotypes that were consistent with those found in the western stock (Gelatt et al. 2007). Similarly, a rookery to the south on the White Sisters Islands, where pups were first noted in 1990, was also sampled in 2002 and approximately 45% of those pups had western stock haplotypes (O'Corry-Crowe et al. 2014). Collectively, this information demonstrates that these two most recently established rookeries in northern Southeast Alaska have been~~

partially to predominately established by western stock females (Jemison et al. 2013, 2018; Rehberg et al. 2018). While movements of animals marked as pups in both stocks support these genetic results (Jemison et al. 2013, 2018), overall the observations of marked sea lion movements corroborate the extensive genetic research findings for a strong separation between the two currently recognized stocks. O'Corry-Crowe et al. (2014) concluded that the results of their study of the genetic characteristics of pups born on these new rookeries "demonstrates that resource limitation may trigger an exodus of breeding animals from declining populations, with substantial impacts on distribution and patterns of genetic variation. It also revealed that this event is rare because colonists dispersed across an evolutionary boundary, suggesting that the causative factors behind recent declines are unusual or of larger magnitude than normally occur." Thus, although recent colonization events in the northern part of the eastern stock indicate movement of western sea lions (especially adult females) into this area, the mixed part of the range remains geographically distinct (Jemison et al. 2013), and the overall discreteness of the eastern from the western stock remains distinct. Movement of western stock sea lions south of these rookeries and eastern stock sea lions moving to the west is less common (Jemison et al. 2013, O'Corry-Crowe et al 2014). Hybridization among subspecies and species along a contact zone such as now occurs near the stock boundary is not unexpected as the ability to interbreed is a primitive condition whereas reproductive isolation would be derived. In fact, as stated by NMFS and the U.S. Fish and Wildlife Service (USFWS) in a 1996 response to a previous comment regarding stock discreteness policy (61 FR 47222), "*The Services do not consider it appropriate to require absolute reproductive isolation as a prerequisite to recognizing a distinct population segment*" or stock. The fundamental concept overlying this distinctiveness is the collection of morphological, ecological, behavioral, and genetic evidence for stock differences initially described by Bickham et al. (1996) and Loughlin (1997) and supported by Baker et al. (2005), Harlin-Cognato et al. (2006), Hoffman et al. (2006, 2009), O'Corry-Crowe et al. (2006), and Phillips et al. (2009, 2011).

POPULATION SIZE

The wWestern stock of Steller sea lions decreased from -220,000 to 265,000 animals in the late 1970s to less than 50,000 in 2000 (Loughlin et al. 1984, Loughlin and York 2000, Burkanov and Loughlin 2005). Since 2003, the abundance of the wWestern stock has increased, but there has been considerable regional variation in trend (Sease and Gudmundson 2002; Burkanov and Loughlin 2005; Fritz et al. 2013, 2016). Abundance surveys to count Steller sea lions are conducted in late June through mid-July starting approximately 10 days after the mean pup birth dates in the survey area (4-14 June) after approximately 95% of all pups are born (Pitcher et al. 2001, Kuhn et al. 2017). Modeled counts and trends are reported for the total wWestern stock in Alaska and the six regions (eastern, central, and western Gulf of Alaska and eastern, central, and western Aleutian Islands) that compose this geographic range. The boundaries for the six regions were identified based on metapopulation analysis of survey count data collected from 1976 to 1994 (York et al. 1996). The most recent comprehensive aerial photographic and land-based surveys of western Steller sea lions in Alaska were conducted during the 2017 and 2018 breeding seasons (Sweeney et al. 2017, 2018).

NMFS uses raw counts collected during the period from 1978 through 2019 to model counts and annual rates of change of non-pups and pups for regional aggregations using agTrend (Johnson and Fritz 2014). Using this model produces two types of count estimates: predicted and realized counts. Predicted counts are used to estimate trends and account for both observation and process errors. Realized counts use the standardized variance of raw counts at each site throughout the time series to estimate survey counts we could expect to collect if we had completely surveyed all sites. Therefore, the more complete the survey, the more similar raw counts are to realized counts, which is evident by smaller confidence intervals. Modeled counts, like raw counts, do not account for animals at sea; however, pup counts are considered a census of live pups as they are generally not in the water during the survey period.

Demographic multipliers (e.g., pup production multiplied by 4.5) and corrections for proportions of each age-sex class that are hauled out during the day in the breeding season (when aerial surveys are conducted) have been proposed as methods to estimate total population size from pup and/or non-pup counts (Calkins and Pitcher 1982, Higgins et al. 1988, Milette and Trites 2003, Maniscalco et al. 2006). There are several factors which make using demographic multipliers problematic when applied to counts of Western Steller sea lions in Alaska, including the lack of vital (survival and reproductive) rate information for the western and central Aleutian Islands, the large variability in abundance trends across the range (see Current Population Trend section below and Pitcher et al. 2007), and the large uncertainties related to reproductive status and foraging conditions that affect proportions hauled out (see review in Holmes et al. 2007).

The most recent comprehensive aerial photographic and land-based surveys of Western Steller sea lions in Alaska were conducted during the 2018 (Aleutian Islands west of Shumagin Islands) and 2019 (Southeast Alaska and Gulf of Alaska east of Shumagin Islands) breeding seasons (Sweeney et al. 2018, 2019). Using the method of

~~Johnson and Fritz (2014; agTrend) and survey counts from 1978 through 2018,~~ The ~~w~~Western Steller sea lion pup and non-pup model-predicted counts in Alaska in ~~2018~~2019 were ~~modeled to be 11,842~~12,581 (95% credible interval of ~~10,659~~11,308-~~13,238~~14,051) and ~~41,782~~40,351 (~~37,370~~35,886-~~46,822~~44,884), respectively. ~~Demographic multipliers (e.g., pup production multiplied by 4.5) and proportions of each age-sex class that are hauled out during the day in the breeding season (when aerial surveys are conducted) have been proposed as methods to estimate total population size from pup and/or non-pup counts (Calkins and Pitcher 1982, Higgins et al. 1988, Milette and Trites 2003, Maniscalco et al. 2006). There are several factors which make using demographic multipliers problematic when applied to counts of western Steller sea lions in Alaska, including the lack of vital (survival and reproductive) rate information for the western and central Aleutian Islands, the large variability in abundance trends across the range (see Current Population Trend section below and Pitcher et al. 2007), and the large uncertainties related to reproductive status and foraging conditions that affect proportions hauled out (see review in Holmes et al. 2007).~~

Methods used to survey Steller sea lions in Russia differ from those used in Alaska, with less use of aerial photography and more use of skiff surveys and cliff counts for non-pups and ground counts for pups (Burkanov 2018a). Since 2015, the use of drones has allowed more survey effort to collect aerial imagery, similar to survey methods used for the Alaska range (Burkanov 2018a). The most recent total count of live pups on rookeries in Russia is available from counts conducted in 2016 and 2017, which totaled 5,629 pups, about 11% more than the 5,073 pups counted in 2013 and 2015 (Burkanov 2018b). Rookery pup counts represent more than 95% of pup counts at all sites (including haulouts) but are underestimates of total pup production. Modeled counts and trends are reported for non-pups only (there are not robust data available to model pup counts) for the six regions (Commander Islands, east Kamchatka, Kuril Islands, northern part of Sea of Okhotsk, Sakhalin Island, and western Bering Sea) that compose the geographic range in Russia (Fig. 2). In 2017, the non-pup count was modeled to be 13,691 (95% credible interval of 12,225-15,133) in Russia (Burkanov 2017, Johnson 2018).

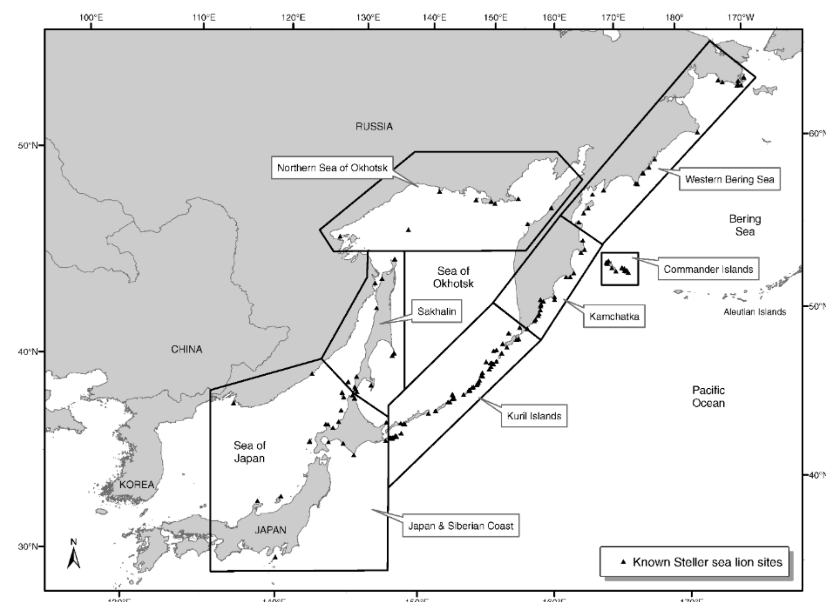

Figure 2. Steller sea lion survey regions along the Asian coast (Burkanov and Loughlin 2005).

Minimum Population Estimate

The minimum population estimate (N_{MIN}) can be defined by the 20th percentile of a log-normal distribution based on a population abundance estimate for the stock (Wade 1994). Because current population size (N) and a pup multiplier to estimate N are not known we cannot produce an abundance estimate. With agTrend we can produce a sum of non-pup and pup modeled counts, which don't account for non-pups at sea, or animals that are born or die after the survey. Therefore, the summed count estimate is lower than an abundance estimate and we should not use the 20th percentile of this number. ~~Because current population size (N) and a pup multiplier to~~

~~estimate N are not known, w~~We ~~will~~ use the best estimate of the total count of ~~w~~Western Steller sea lions in Alaska as the minimum population estimate (N_{MIN}). The agTrend model (Johnson and Fritz 2014) was used to estimate ~~w~~Western Steller sea lion pup and non-pup counts of ~~11,842~~12,581 and ~~41,782~~40,351, respectively, in Alaska in ~~2018~~2019 (Sweeney et al. ~~2018~~2019). These sum to ~~53,624~~52,932, which will be used as the N_{MIN} for the U.S. portion of the ~~w~~Western stock of Steller sea lions (NMFS 2016).~~ The N_{MIN} estimate is the model estimated count – not a total population abundance estimate – because the count has not been corrected for animals that were at sea during, or for pups born after, the surveys.~~

Current Population Trend

The first reported trend counts (sums of counts at consistently surveyed, large sites used to examine population trends) of Steller sea lions in Alaska were made in 1956-1960. Those counts indicated that there were at least 140,000 (no correction factor applied) sea lions in the Gulf of Alaska and Aleutian Islands (Merrick et al. 1987). Subsequent surveys indicated a major population decrease, first detected in the eastern Aleutian Islands in the mid-1970s (Braham et al. 1980). Counts from 1976 to 1979 totaled about 110,000 sea lions (no correction factor applied). The decline appears to have spread eastward to Kodiak Island during the late 1970s and early 1980s, and then westward to the central and western Aleutian Islands during the early and mid-1980s (Merrick et al. 1987, Byrd 1989). During the late 1980s, counts in Alaska overall declined at ~~~~~approximately 15% per year (NMFS 2008) which prompted the listing (in 1990) of the species as threatened range-wide under the Endangered Species Act (ESA). Continued declines in counts of ~~w~~Western Steller sea lions in Alaska in the 1990s (Sease et al. 2001) led NMFS to change the ESA listing status to endangered in 1997 (NMFS 2008). Surveys in Alaska in 2002, however, were the first to note an increase in counts, which suggested that the overall decline of ~~w~~Western Steller sea lions stopped in the early 2000s (Sease and Gudmundson 2002).

Johnson and Fritz's (2014) agTrend model estimated regional and overall trends in counts of pups and non-pups in Alaska using data collected at all sites with at least two non-zero counts, rather than relying solely on counts at "trend" sites (also see Fritz et al. 2013, 2016). Using agTrend, modeled~~ count data collected from 1978 through 2018~~ count data from 1978 to 2019 were used to produce trends for the total Western DPS in Alaska, east of Samalga Pass, and the central, western, and eastern Gulf of Alaska regions.

Model results indicate~~s~~d that pup and non-pup counts of ~~w~~Western stock Steller sea lions in Alaska were at their lowest levels in 2002 and have increased at ~~1.52~~1.63% y^{-1} and ~~2.05~~1.82% y^{-1}, respectively, between 2002 and ~~2018~~2019 (Table 1; Fig. 3; Sweeney et al. ~~2018~~2019). However, there are strong regional differences across the range in Alaska, with positive trends in the Gulf of Alaska and the eastern Aleutian Islands region, including eastern Bering Sea (east of Samalga Pass, ~~approximately~~ ~170°W), and generally negative trends to the west of Samalga Pass, in the central and western Aleutian Islands (Table 1; Figs. 4 and 5).~~ Non-pup trends from 2002 to 2018 in Alaska have a longitudinal gradient with highest rates of increase generally in the east and steadily decreasing rates to the west (Table 1).~~

~~**Table 1.** Trends (annual rates of change expressed as % y^{-1} with 95% credible interval) in counts of western Steller sea lion pups and non-pups (adults and juveniles) in Alaska, by region, for 2002 to 2018 (Sweeney et al. 2018).~~

~~**Region**~~	~~**Latitude Range**~~	~~**Pups**~~			~~**Non-pups**~~		
		~~**Trend**~~	~~**-95%**~~	~~**+95%**~~	~~**Trend**~~	~~**-95%**~~	~~**+95%**~~
~~Western Stock in Alaska~~	~~144°W-172°E~~	~~1.52~~	~~0.94~~	~~2.08~~	~~2.05~~	~~1.46~~	~~2.66~~
~~E of Samalga Pass~~	~~144°-170°W~~	~~2.90~~	~~2.23~~	~~3.55~~	~~3.07~~	~~2.35~~	~~3.82~~
~~Eastern Gulf of Alaska~~	~~144°-150°W~~	~~2.29~~	~~0.58~~	~~4.11~~	~~3.99~~	~~1.88~~	~~6.15~~
~~Central Gulf of Alaska~~	~~150°-158°W~~	~~3.01~~	~~1.53~~	~~4.58~~	~~4.16~~	~~3.13~~	~~5.23~~
~~Western Gulf of Alaska~~	~~158°-163°W~~	~~3.36~~	~~2.12~~	~~4.64~~	~~2.92~~	~~1.48~~	~~4.36~~
~~Eastern Aleutian Islands~~	~~163°-170°W~~	~~2.54~~	~~1.67~~	~~3.46~~	~~1.76~~	~~0.50~~	~~3.07~~
~~W of Samalga Pass~~	~~170°W-172°E~~	~~-2.08~~	~~-3.13~~	~~-0.79~~	~~-1.22~~	~~-2.20~~	~~-0.25~~
~~Central Aleutian Islands~~	~~170°W-177°E~~	~~-1.6~~	~~-2.75~~	~~-0.21~~	~~-0.53~~	~~-1.64~~	~~0.50~~
~~Western Aleutian Islands~~	~~172°-177°E~~	~~-6.47~~	~~-7.42~~	~~-5.57~~	~~-6.47~~	~~-7.81~~	~~-5.21~~

Table 1. Trends (annual rates of change expressed as % y^{-1} with 95% credible interval) in counts of Western Steller sea lion pups and non-pups (adults and juveniles) in Alaska, by regional areas. The rates reported for the Western DPS in Alaska; east of Samalga Pass; and eastern, central, and western Gulf of Alaska were calculated for the period from 2002 to 2019 (Sweeney et al. 2019). The rates reported for west of Samalga Pass and eastern, central, and western Aleutian Islands were calculated for the period from 2002 (when the Western DPS as a whole began to rebound) to 2018 (Sweeney et al. 2018).

Region	**Latitude Range**	**Pups**			**Non-pups**		
		Trend	**-95%**	**+95%**	**Trend**	**-95%**	**+95%**
Western DPS in Alaska	144°W-172°E	1.63	1.12	2.16	1.82	1.29	2.38
East of Samalga Pass	144°-170°W	2.90	2.37	3.53	2.71	2.05	3.35
Eastern Gulf of Alaska	144°-150°W	2.68	1.08	4.36	3.32	1.42	5.24
Central Gulf of Alaska	150°-158°W	3.08	1.76	4.35	3.40	2.53	4.32
Western Gulf of Alaska	158°-163°W	3.37	2.25	4.52	2.77	1.47	4.01
Eastern Aleutian Islands	163°-170°W	2.54	1.67	3.46	1.76	0.50	3.07
West of Samalga Pass	170°W-172°E	-2.08	-3.13	-0.79	-1.22	-2.20	-0.25
Central Aleutian Islands	170°W-177°E	-1.60	-2.75	-0.21	-0.53	-1.64	0.50
Western Aleutian Islands	172°-177°E	-6.47	-7.42	-5.57	-6.47	-7.81	-5.21

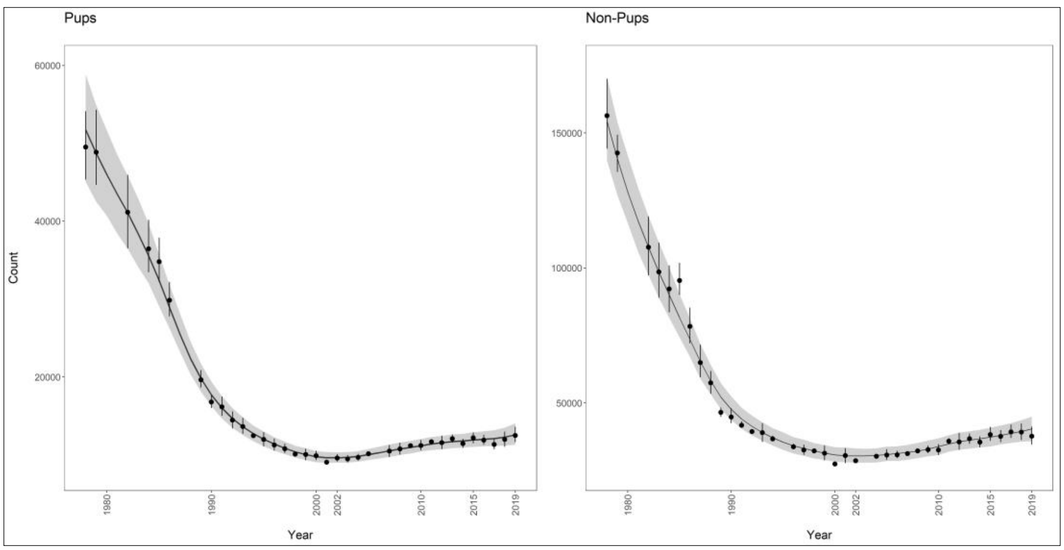

Figure 3. Realized and predicted counts of W~~w~~estern Steller sea lion pups (left) and non-pups (right) in Alaska, from 1978 to ~~2018~~2019. Realized counts are represented by points and vertical lines (95% credible intervals). Predicted counts are represented by the black line surrounded by the gray 95% credible interval.

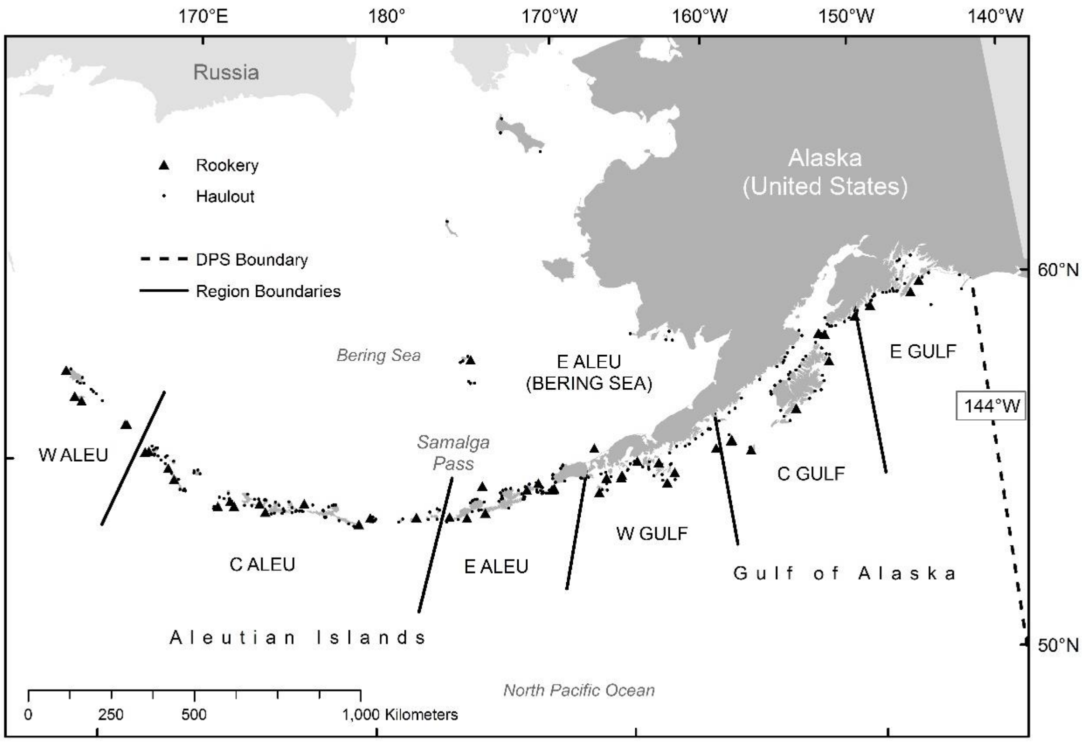

Figure 4. Regions of Alaska used for ~~w~~Western Steller sea lion population trend estimation. E GULF, C GULF, and W GULF are eastern, central, and western Gulf of Alaska regions, respectively. E ALEU, C ALEU, and W ALEU are eastern, central, and western Aleutian Islands regions, respectively (AFSC-MML-Alaska Ecosystems Program 2016).

In 2019, Western DPS ~~S~~survey effort was focused in the ~~Aleutian Islands in 2018~~Gulf of Alaska (Sweeney et al. 2019).~~ Non-pup and pup counts in the western Aleutians have been in a steep decline overall (-6.47% y^{-1}; Fig. 5). However, modeled realized counts show that there was a period of stability in this region from 2014 to 2016 (and potentially an increase in pup counts), followed by a decline between 2016 and 2018 (Sweeney et al. 2016, 2017, 2018).~~Between 2015 and 2017, pup counts declined in the eastern (-33%) and central (-18%) Gulf of Alaska, counter to the continuous increases observed in both regions since 2002 (Sweeney et al. 2017). These declines may have been due to changes in availability of prey associated with warm ocean temperatures that occurred in the northern Gulf of Alaska from 2014 to 2016 (Bond et al. 2015, Peterson et al. 2016, von Biela et al. 2019, Yang et al. 2019). There was also a movement of approximately 1,000 non-pups from the eastern to the central Gulf of Alaska regions, although the combined non-pup count in these two regions remained relatively stable between 2015 and 2017 (western Gulf of Alaska did not appear to change; Sweeney et al. 2017). In 2019, pup counts rebounded to 2015 levels; however, there was a decline in non-pup counts in the eastern, central, and western Gulf of Alaska regions. (Sweeney et al. 2019).

No new data were collected for the Aleutian Islands in the 2019 survey, but the 2020 survey effort will be focused in this area. In 2018, survey effort was focused in the Aleutian Islands with some opportunistic surveys in the Gulf of Alaska (Sweeney et al. 2018). The area west of Samalga Pass was significantly declining, especially in the western Aleutian Islands region. The eastern Aleutian Islands region pups and non-pups have showed signs of recovery and have been increasing since the early 2000s.

Since part of the Western stock began to recover in the early 2000s, ~~N~~net movement between the ~~e~~Eastern and ~~w~~Western stocks appears to be small during the breeding season (Jemison et al. 2018)~~,~~. For example, there was ~~with~~ an estimated net 75 sea lions that mov~~ing~~ed from east to west in 2016 (Jemison et al. 2013, Fritz et al. 2016). Very few females moved from Southeast Alaska to the Western stock, while approximately 500 were estimated to move from west to east (net increase in the east). Males moved in both directions, but with a net increase in the west. As a result, trends in counts estimated from breeding season surveys should be relatively insensitive, at a stock level, to inter-stock movements.~~ Very few females move from Southeast Alaska to the western stock while~~

~~approximately 500 were estimated to move from west to east (net increase in the east). Males move in both directions but with a net increase in the west. This pattern of movement is supported by mitochondrial DNA evidence that indicated that the newest rookeries in northern Southeast Alaska (eastern stock) were colonized in part by western females (Gelatt et al. 2007, O'Corry-Crowe et al. 2014).~~

~~Pup counts in the eastern (-33%) and central (-18%) Gulf of Alaska declined sharply between 2015 and 2017, counter to the continuous increases observed in both regions since 2002. These declines may have been due to changes in availability of prey associated with warm ocean temperatures that occurred in the northern Gulf of Alaska from 2014 to 2016 (Bond et al. 2015, Peterson et al. 2016). Virtually no new data were collected for these regions in the 2018 survey but the 2019 survey effort will be focused in the Gulf of Alaska, which should yield more precise and accurate estimates of counts and trends for this area.~~

Burkanov and Loughlin (2005) estimated the Russian Steller sea lion population (pups and non-pups) declined approximately 52% from the 1970s to the 1990s. Johnson (2018) estimated the non-pup count in Russia declined -1.3% y^{-1} between 2002 and 2017; however, just as in the U.S. portion of the ~~w~~Western stock, there ~~are~~were significant regional differences in population trend in Russia (Table 2; Fig. 6; Burkanov 2018a, Johnson 2018). The significant decline in non-pup counts appears to be primarily driven by the decline in the Kurils which, traditionally, represents the largest area in terms of non-pup counts (Burkanov 2018a, Johnson 2018). Moreover, it seems ~~like~~ the statistically significant decline in the Kurils is the result of the 2015 survey, where there appear~~s~~ed to be a large reduction in comparison to previous years (Fig. 6; Johnson 2018). Pup production appear~~s~~ed to ~~be~~ declin~~ing~~e in most areas where breeding occurs in Russia (Kuril Islands, eastern Kamchatka, the Commander Islands, and parts of the Sea of Okhotsk-Iony rookery); only Tuleny Island (Sakhalin region) and part of the Sea of Okhotsk (Yamsky Islands rookery) ~~have~~ had increasing pup counts between 2006 and 2017 (Burkanov 2018a, 2018b).

Table 2. Trends (annual rates of change expressed as % y^{-1} with 95% credible interval) in non-pup counts for the Asian stock (Russia) of Steller sea lions and by region, from 2002 to 2017 (Johnson 2018). See Figure 2 for regions.

Region	**Trend**	**-95%**	**+95%**
Asian stock (Russia)	-1.3	-2.6	-0.1
Commander Islands	-0.6	-2.6	1.2
Kamchatka	-0.8	-3.0	1.5
Kuril	-4.1	-5.4	-2.8
Northern Sea of Okhotsk	0.9	-2.0	4.0
Sakhalin	0.9	-2.3	5.4
Western Bering Sea	-1.1	-16.1	10.2

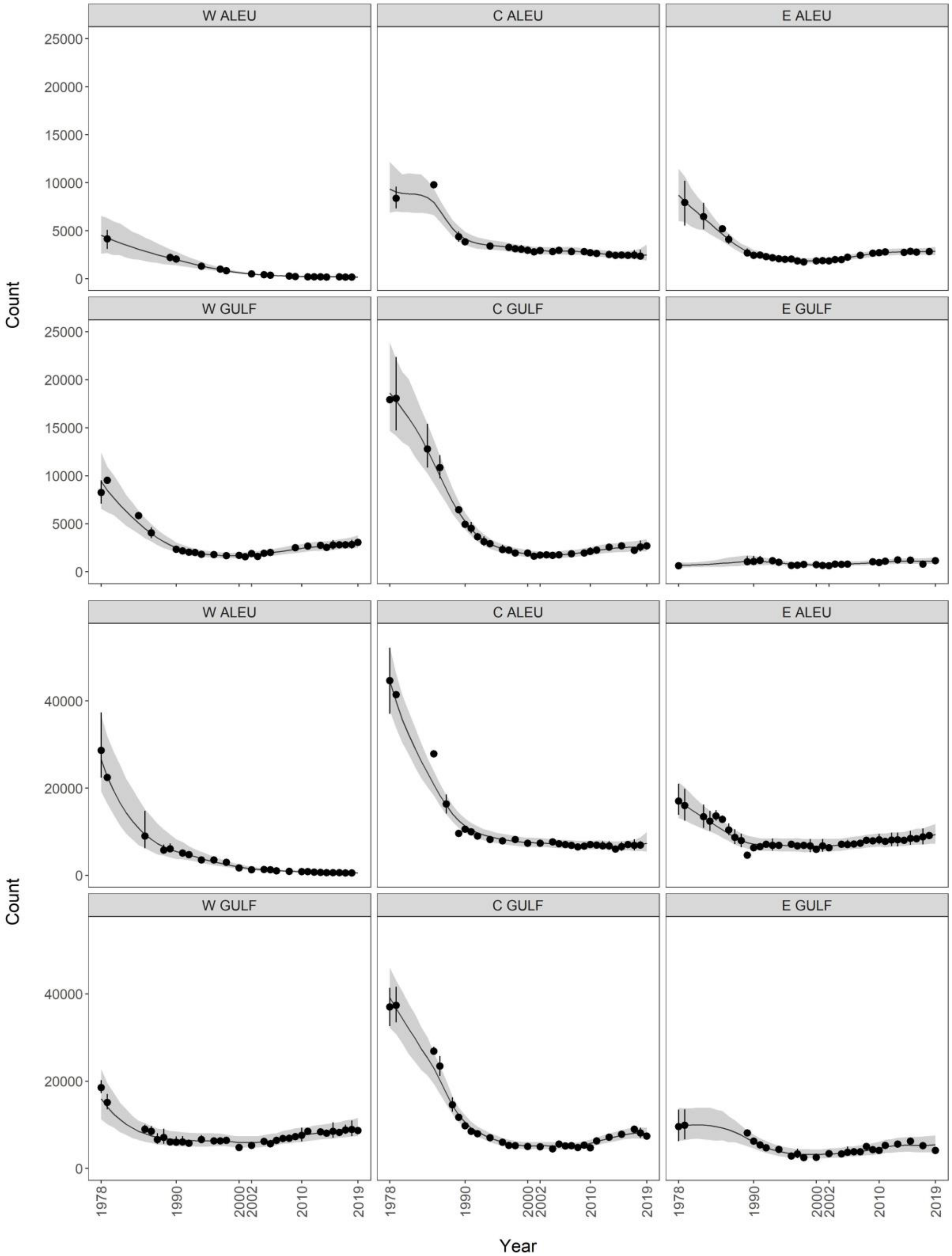

Figure 5. Realized and predicted counts of Steller sea lion pups (~~left~~top) and non-pups (~~right~~bottom) in the six regions that compose the W~~w~~estern stock in Alaska, 1978 to ~~2018~~2019. Realized counts are represented by points and vertical lines (95% credible intervals). Predicted counts are represented by the black line surrounded by the gray 95% credible interval (~~Fritz et al. 2016,~~ Sweeney et al. 2018, 2019).

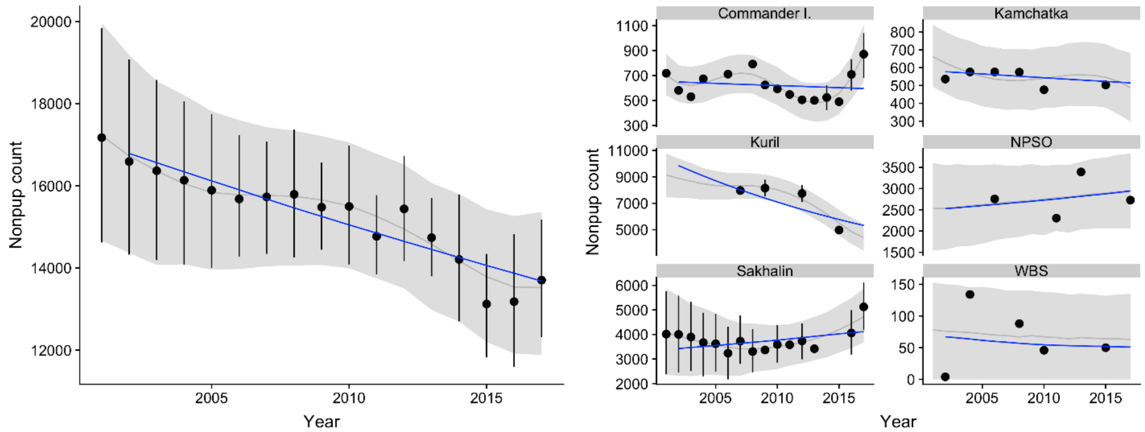

Figure 6. Realized and predicted counts of Russian Steller sea lion non-pups in Russia (left) and by region (right; Fig. 2), 2002 to 2017. Realized counts are represented by points and vertical lines (95% credible intervals). Predicted counts are represented by the black line surrounded by the gray 95% credible interval. The blue line represents the trend based on constant average growth for the entire Asian stock as a whole.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

There are no estimates of the maximum net productivity rate (R_{MAX}) for Steller sea lions. Until additional data become available, the default pinniped maximum theoretical net productivity rate ~~for pinnipeds~~ of 12% will be used for this stock (NMFS 2016).

POTENTIAL BIOLOGICAL REMOVAL

Potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.1, the default value for stocks listed as endangered under the ESA (NMFS 2016). Thus, for the U.S. portion of the ~~w~~Western stock of Steller sea lions, PBR ~~=~~is ~~322~~318 sea lions (~~53,624~~52,932 × 0.06 × 0.1).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals between ~~2013~~2014 and ~~2017~~2018 is listed, by marine mammal stock, in ~~Delean et al. (2020)~~Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. The minimum estimated mean annual level of human-caused mortality and serious injury for Western U.S. Steller sea lions between ~~2013~~2014 and ~~2017~~2018 is ~~247~~255 sea lions: ~~36~~38 in U.S. commercial fisheries, ~~0.6~~0.8 in unknown (commercial, recreational, or subsistence) fisheries, ~~2.8~~3.2 in marine debris, ~~4~~3.6 due to other causes (~~arrow strike, entangled in hatchery net,~~ illegal shooting, mortality incidental to Marine Mammal Protection Act (MMPA)-authorized research), and ~~204~~209 in the Alaska Native subsistence harvest. No observers have been assigned to several fisheries that are known to interact with this stock and estimates of entanglement in fishing gear and marine debris based solely on stranding reports in areas west of 144°W longitude may underestimate the entanglement of ~~w~~Western stock animals that travel to parts of Southeast Alaska. Due to a lack of available resources, NMFS is not operating the Alaska Marine Mammal Observer Program (AMMOP) focused on marine mammal interactions that occur in fisheries managed by the State of Alaska. The most recent data on Steller sea lion interactions with state-managed fisheries in Alaska are from the Southeast Alaska salmon drift gillnet fishery in 2012 and 2013 (Manly 2015), a fishery in which the ~~vast~~ majority of the Steller sea lions taken are likely to be from the ~~e~~Eastern stock, although sea lions carrying Western genetic material could be as high as 38% (Hastings et al. 2019). Counts of annual illegal gunshot mortality in the Copper River Delta should be considered minimums as they are based solely on aerial carcass surveys ~~in~~from 2015 ~~and 2016~~ to 2018, no data are available for ~~2012 to~~ 2014, a cause of death for all carcasses found was not determined, and it is not likely that all carcasses are detected. Disturbance of Steller sea lion haulouts and rookeries can potentially cause disruption of reproduction, stampeding, or increased exposure to predation by marine predators (NMFS 2008; see also NMFS 1990, 1997). Effects of disturbance are highly variable and difficult to predict. Data are not available to estimate potential impacts from non-monitored activities, including disturbance near rookeries without 3-nmi no-entry buffer zones. Potential threats most likely to result in direct human-caused mortality or serious injury of this stock include subsistence harvest, incidental take, illegal shooting, disturbance at rookeries that could cause stampedes, and entanglement in fishing gear and marine debris.

Fisheries Information

Information ~~(including observer programs, observer coverage, and observed incidental takes of marine mammals)~~ for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is ~~presented~~available in Appendi~~ces~~x 3~~-6~~ of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

Based on historical reports and their geographic range, Steller sea lion mortality and serious injury could occur in several fishing gear types, including trawl, gillnet, longline, and troll fisheries. However, observer data are limited. Of these fisheries, only trawl fisheries are regularly observed and gillnet fisheries have had limited observations in select areas over short time frames and with modest observer coverage. Consequently, there are little to no data on Steller sea lion mortality and serious injury in non-trawl fisheries. Therefore, the potential for fisheries-caused mortality and serious injury may be greater than is reflected in existing observer data.

Between ~~2013~~2014 and ~~2017~~2018, mortality and serious injury of ~~w~~Western Steller sea lions was observed in 10 of the federally-managed commercial fisheries in Alaska that are monitored for incidental mortality and serious injury by fisheries observers: Bering Sea/Aleutian Islands Atka mackerel trawl, Bering Sea/Aleutian Islands flatfish trawl, Bering Sea/Aleutian Islands Pacific cod trawl, Bering Sea/Aleutian Islands pollock trawl, Bering Sea/Aleutian Islands Pacific cod longline, Gulf of Alaska Pacific cod trawl, Gulf of Alaska Pacific cod longline, Gulf of Alaska flatfish trawl, Gulf of Alaska rockfish trawl, and Gulf of Alaska pollock trawl fisheries, resulting in a mean annual mortality and serious injury rate of ~~21~~22 sea lions (Table 3; Breiwick 2013; MML, unpubl. data).

AMMOP observers monitored the Alaska State-managed Prince William Sound salmon drift gillnet fishery in 1990 and 1991, recording two incidental mortalities in 1991, extrapolated to 29 (95% CI: 1-108) for the entire fishery (Wynne et al. 1992; Table 3). No incidental mortality or serious injury was observed during 1990 for this fishery (Wynne et al. 1991), resulting in a mean annual mortality rate of 15 sea lions ~~(CV = 1.0)~~ for 1990 and 1991. It is not known whether this incidental mortality and serious injury rate is representative of the current rate in this fishery.

Between 2014 and 2018, Steller sea lion mortality resulting from entanglements in commercial longline gear (1 in 2015), commercial salmon seine net (1 in 2018), and ~~entanglement in~~ unidentified commercial gear (1 in 2017) was reported to the NMFS Alaska Region marine mammal stranding network ~~between 2013 and 2017~~ (~~Delean et al. 2020~~Young et al. in press), resulting in a mean annual mortality and serious injury rate of ~~0.4~~0.6 sea lions in commercial gear (Table 4). This mortality and serious injury estimate results from an actual count of verified human-caused deaths and serious injuries and is a minimum because not all entangled animals strand nor are all stranded animals found, reported, or have the cause of death determined.

The minimum estimated mean annual mortality and serious injury rate in U.S. commercial fisheries between ~~2013~~2014 and ~~2017~~2018 is ~~36~~38 Steller sea lions from this stock (~~36~~37 from observer data + ~~0.4~~0.6 from stranding data) (Tables 3 and 4). No observers have been assigned to several fisheries that are known to interact with this stock, thus, the estimated mortality and serious injury is likely an underestimate of the actual level.

Table 3. Summary of incidental mortality and serious injury of Western U.S. Steller sea lions due to U.S. commercial fisheries between ~~2013~~2014 and ~~2017~~2018 (or the most recent data available) and calculation of the mean annual mortality and serious injury rate (Wynne et al. 1991, 1992; Breiwick 2013; MML, unpubl. data). N/A indicates that data are not available. Methods for calculating percent observer coverage are described in Appendix ~~6~~3 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality (CV)	Mean estimated annual mortality
Bering Sea/Aleutian Is. Atka mackerel trawl	~~2013~~ 2014 2015 2016 2017 2018	obs data	~~99~~ 100 100 98 100 100	~~0~~ 0 0 0 1 5	~~0~~ 0 0 0 1 (0.06) 5.1 (0.08)	~~0.2~~1.2 (CV = ~~0.06~~0.07)
Bering Sea/Aleutian Is. flatfish trawl	~~2013~~ 2014 2015 2016 2017 2018	obs data	~~100~~ 100 100 99 100 100	~~7~~ 5 6 9 13 8	~~7.0~~ 5.0 (0.02) 6.0 (0.02) 9.0 (0.02) 13 (0.01) 8.0 (0.02)	~~8.0~~8.2 (CV = 0.01)
Bering Sea/Aleutian Is. Pacific cod trawl	~~2013~~ 2014 2015 2016 2017 2018	obs data	~~80~~ 80 72 68 68 73	~~1~~ 0 0 0 1 1	~~1.5~~ 0 0 0 1 (0) 1 (0)	~~0.5~~0.4 (CV = 0~~.33~~)
Bering Sea/Aleutian Is. pollock trawl	~~2013~~ 2014 2015 2016 2017 2018	obs data	~~98~~ 98 99 99 99 99	~~5~~ 2 1 13 6 6	~~5.1~~ 2.0 (0.1) 1 (0.07) 13 (0.03) 6.1 (0.05) 6.1 (0.04)	~~5.5~~5.7 (CV = 0.02)
Bering Sea/Aleutian Is. pollock trawl	2017	obs data	99	1[a]	N/A	0.2 (CV = N/A)
Bering Sea/Aleutian Is. Pacific cod longline	~~2013~~ 2014 2015 2016 2017 2018	obs data	~~66~~ 64 62 57 58 55	~~0~~ 1 3 0 1 0	~~0~~ 1.7 (0.63) 4.9 (0.36) 0 1.6 (0.6) 0	1.6 (CV = 0.28)
Gulf of Alaska Pacific cod longline	~~2013~~ 2014 2015 2016 2017 2018	obs data	~~29~~ 31 36 30 40 29	~~0~~ 0 1 0 0 0	~~0~~ 0 1.3 (0.5) 0 0 0	0.3 (CV = 0.5~~0~~)
Gulf of Alaska Pacific cod trawl	~~2013~~ 2014 2015 2016 2017 2018	obs data	~~10~~ 12 13 13 11 25	~~0~~ 0 0 1 0 0	~~0~~ 0 0 10 (0.9) 0 0	2.0 (CV = 0.9)

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality (CV)	Mean estimated annual mortality
Gulf of Alaska flatfish trawl	~~2013~~ 2014 2015 2016 2017 2018	obs data	~~46~~ 47 54 39 56 34	~~0~~ 0 0 (+1)[~~a~~b] 0 0 0	~~0~~ 0 0 (+1)[~~b~~c] 0 0 0	0 (+0.2)[~~c~~d] (CV = N/A)
Gulf of Alaska rockfish trawl	~~2013~~ 2014 2015 2016 2017 2018	obs data	~~95~~ 96 93 98 98 95	~~0~~ 0 0 (+1)[~~a~~b] 0 0 0	~~0~~ 0 0 (+1)[~~b~~c] 0 0 0	0 (+0.2)[~~c~~d] (CV = N/A)
Gulf of Alaska pollock trawl	~~2013~~ 2014 2015 2016 2017 2018	obs data	~~15~~ 14 23 27 19 21	~~0~~ 0 0 (+5)[~~d~~e] 1 0 0	~~0~~ 0 0 (+5)[~~e~~f] 4.8 (0.89) 0 0	1.0 (+1)[~~f~~g] (CV = 0.89)
Prince William Sound salmon drift gillnet	1990 1991	obs data	4 5	0 2	0 29	15 (CV = 1.0)
Minimum total estimated annual mortality						~~36~~37 (CV = ~~0.44~~0.43)

[a]This animal was discovered during a vessel offload. Because it could not be associated with a haul number, it was not included in the bycatch estimate for the fishery.
[~~a~~b]Total mortality and serious injury observed in 2015: 0 sea lions in sampled hauls + 1 sea lion in an unsampled haul.
[~~b~~c]Total estimate of mortality and serious injury in 2015: 0 sea lions (extrapolated estimate from 0 sea lions observed in sampled hauls) + 1 sea lion (1 sea lion observed in an unsampled haul).
[~~c~~d]Mean annual mortality and serious injury for fishery: 0 sea lions (mean of extrapolated estimates from sampled hauls) + 0.2 sea lions (mean of number observed in unsampled hauls).
[~~d~~e]Total mortality and serious injury observed in 2015: 0 sea lions in sampled hauls + 5 sea lions in unsampled hauls.
[~~e~~f]Total estimate of mortality and serious injury in 2015: 0 sea lions (extrapolated estimate from 0 sea lions observed in sampled hauls) + 5 sea lions (5 sea lions observed in unsampled hauls).
[~~f~~g]Mean annual mortality and serious injury for fishery: 1.0 sea lion (mean of extrapolated estimates from sampled hauls) + 1 sea lion (mean of number observed in unsampled hauls).

Reports ~~from~~to the NMFS Alaska Region marine mammal stranding network of Steller sea lions entangled in fishing gear or with injuries caused by interactions with gear are another source of mortality and serious injury data (Table 4; ~~Delean et al. 2020~~Young et al. in press). From ~~2013~~2014 to ~~2017~~2018, there were ~~two~~three reports of Steller sea lion interactions with troll gear, in which an animal in poor body condition had a flasher lure (troll gear) hanging from its mouth and was believed to have ingested the hook, and one report of an animal that was entangled in unidentified hook and line gear, resulting in a mean annual mortality and serious injury rate of ~~0.6~~0.8 sea lions in these unknown (commercial, recreational, or subsistence) fisheries (Table 4). ~~These~~This mortality and serious injury estimate~~s~~ results from an actual count of verified human-caused deaths and serious injuries and ~~are~~is a minimum~~s~~ because not all entangled animals strand nor are all stranded animals found, reported, or have the cause of death determined. Additionally, since Steller sea lions from parts of the ~~w~~Western stock are known to regularly occur in parts of Southeast Alaska (Jemison et al. 2013, 2018; NMFS 2013), and higher rates of entanglement of Steller sea lions have been observed in this area (e.g., Raum-Suryan et al. 2009), estimates based solely on stranding reports in areas west of 144°W longitude may underestimate the total entanglement of ~~w~~Western stock sea lions in fishery-related gear and marine debris.

Table 4. Summary of Western U.S. Steller sea lion mortality and serious injury, by year and type, reported to the NMFS Alaska Region marine mammal stranding network and Alaska Department of Fish and Game between ~~2013~~2014 and ~~2017~~2018 (~~Delean et al. 2020~~Young et al. in press). N/A indicates that data are not available.

Cause of injury	~~2013~~	2014	2015	2016	2017	2018	Mean annual mortality
Entangled in commercial Kodiak salmon seine net		0	0	0	0	1	0.2
Entangled in commercial longline gear	~~0~~	0	1	0	0	0	0.2
Entangled in unidentified commercial gear	~~0~~	0	0	0	1	0	0.2
Hooked by Southcentral Alaska salmon troll gear*	~~0~~	1	0	0	0	0	0.2
Hooked by salmon troll gear*		0	0	0	1	1	0.4
~~Hooked by troll gear*~~	~~0~~	~~0~~	~~0~~	~~0~~	~~1~~		~~0.2~~
Entangled in ~~unidentified~~ hook and line gear*	~~0~~	1	0	0	0	0	0.2
Entangled in marine debris	~~0~~	3	6	1	~~4~~ 3	3	~~2.8~~3.2
~~Struck by arrow~~	~~1~~	~~0~~	~~0~~	~~0~~	~~0~~		~~0.2~~
~~Entangled in commercial Kodiak salmon hatchery net~~	~~1~~	~~0~~	~~0~~	~~0~~	~~0~~		~~0.2~~
Illegally shot	~~N/A~~	N/A	8	1	0	0	3[a]
Incidental to MMPA-authorized research	~~0~~	0	1	2	0	0	0.6
Total in commercial fisheries							~~0.4~~0.6
*Total in unknown (commercial, recreational, or subsistence) fisheries							~~0.6~~0.8
Total in marine debris							~~2.8~~3.2
Total due to other causes (~~arrow strike, entangled in hatchery net,~~ illegally shot, incidental to MMPA-authorized research)							~~4~~ 3.6

[a]Dedicated effort to survey the Copper River Delta for stranded marine mammals began in 2015 in response to a high number of reported strandings, some of which were later determined to be human-caused (illegally shot). Dedicated surveys were also conducted in 2016, ~~and~~ 2017, and 2018. Because similar data are not available for ~~2013 and~~ 2014 and survey effort was limited in 2018, the data were averaged over ~~the~~ 3 years of survey effort (2015-2017) for a more informed estimate of mean annual mortality.

The minimum ~~average~~mean annual mortality and serious injury rate for all fisheries between 2014 and 2018, based on observer data and stranding data ~~(36 sea lions)~~ for U.S. commercial fisheries (38 sea lions) and on stranding data ~~(0.6 sea lions)~~ for unknown (commercial, recreational, or subsistence) fisheries (0.8 sea lions), is ~~37~~39 ~~w~~Western Steller sea lions.

Alaska Native Subsistence/Harvest Information

NMFS signed agreements with the Tribal Government of St. Paul Island (2000) and the Traditional Council of St. George Island (2001) to co-manage Steller sea lions and northern fur seals. NMFS also signed an agreement with the Aleut Marine Mammal Commission (2006) for the conservation and management of all marine mammal subsistence species, with particular focus on Steller sea lions and harbor seals. These co-management agreements promote full and equal participation by Alaska Natives in decisions affecting the subsistence management of Steller sea lions (to the maximum extent allowed by law) as a tool for conserving Steller sea lion populations in Alaska (https://www.fisheries.noaa.gov/alaska/marine-mammal-protection/co-management-marine-mammals-alaska, accessed August 2020).

Information on the subsistence harvest of Steller sea lions comes via three sources: the Alaska Department of Fish and Game (ADF&G), the Ecosystem Conservation Office of the Aleut Community of St. Paul Island, and the Kayumixtax Eco-Office of the Aleut Community of St. George Island. The ADF&G conducted systematic interviews with hunters and users of marine mammals in approximately 2,100 households in about 60 coastal communities within the geographic range of the Steller sea lion in Alaska (Wolfe et al. 2005, 2006, 2008, 2009a, 2009b). The interviews were conducted once per year in the winter (January to March) and covered hunter activities for the previous calendar year. As of 2009, annual statewide data on community subsistence harvests are no longer being consistently collected. Data are being collected periodically in subareas. Data were collected on the Alaska Native harvest of Western U.S. Steller sea lions for 7 communities on Kodiak Island in 2011 and for 15 communities in Southcentral Alaska in 2014. The Alaska Native Harbor Seal Commission (ANHSC) and ADF&G estimated a total of 20 adult sea lions were harvested on Kodiak Island in 2011, with a 95% confidence range between 15 and 28 animals (Wolfe et al. 2012), and 7.9 sea lions (CI = 6-15.3) were harvested in Southcentral Alaska in 2014, with adults comprising 84% of the harvest (ANHSC 2015). These estimates do not represent a comprehensive statewide estimate; therefore, the best available statewide subsistence harvest estimates for a 5-year period are those from 2004 to 2008. Thus, the most recent 5 years of data available from the ADF&G (2004-2008) will be used for calculating an annual mortality and serious injury estimate for all areas except St. Paul, ~~and~~ St. George, and Atka Islands (Wolfe et al. 2005, 2006, 2008, 2009a, 2009b; NMFS, unpubl. data) (Table 5). Harvest data are collected in near real-time on St. Paul Island (e.g., Melovidov 2013) and St. George Island (e.g., Kashevarof 2015) and recorded within 36 hours of the harvest. The most recent 5 years of data from St. Paul (Melovidov 2013, 2014, 2015, 2016; NMFS, unpubl. data) and St. George (Kashevarof 2015; NMFS, unpubl. data) are for ~~2013~~2014 to ~~2017~~2018 (Table 5).

The mean annual subsistence harvest from this stock for all areas except St. Paul, ~~and~~ St. George, and Atka Island between 2004 and 2008 (172) combined with the mean annual harvest for St. Paul (~~31~~30), ~~and~~ St. George (~~1.2~~1.4), and Atka (6) Islands between ~~2013~~2014 and ~~2017~~2018 is ~~204~~209 ~~w~~Western Steller sea lions (Table 5).

Table 5. Summary of the subsistence harvest data for Western U.S. Steller sea lions. As of 2009, data on community subsistence harvests are no longer being consistently collected. Therefore, the most recent 5 years of data (2004 to 2008) will be used for calculating an annual mortality and serious injury estimate for all areas except St. Paul, ~~and~~ St. George, and Atka Islands. Data from St. Paul, ~~and~~ St. George, and Atka Islands are still being collected and the most recent 5 years of data available (~~2013~~2014 to ~~2017~~2018) will be used. N/A indicates that data are not available.

	All areas except St. Paul Island			**St. Paul Island**	**St. George Island**	**Atka Island**
Year	**Number harvested**	**Number struck and lost**	**Total**	**Number harvested + Number struck and lost**	**Number harvested + Number struck and lost**	**Number harvested + Number struck and lost**
2004	136.8	49.1	185.9[a]			
2005	153.2	27.6	180.8[b]			
2006	114.3	33.1	147.4[c]			
2007	165.7	45.2	210.9[d]			
2008	114.7	21.6	136.3[e]			
~~2013~~	~~N/A~~	~~N/A~~	~~N/A~~	~~34[f]~~	~~0[g]~~	
2014	N/A	N/A	N/A	35[h]	1[g]	N/A
2015	N/A	N/A	N/A	24[i]	3[g]	N/A
2016	N/A	N/A	N/A	31[j]	2[j]	N/A
2017	N/A	N/A	N/A	30[j]	0[j]	N/A
2018	N/A	N/A	N/A	28[j]	1[j]	6
Mean annual harvest	137	35	172	~~31~~30	~~1.2~~1.4	6

[a]Wolfe et al. (2005); [b]Wolfe et al. (2006); [c]Wolfe et al. (2008); [d]Wolfe et al. (2009a); [e]Wolfe et al. (2009b); ~~[f]Melovidov (2014); [g]Kashevarof (2015);~~ [h]Melovidov (2015); [i]Melovidov (2016); [j]NMFS, unpubl. data.

Other Mortality

Reports ~~from~~to the NMFS Alaska Region marine mammal stranding network of Steller sea lions entangled in marine debris or with injuries caused by other types of human interaction are another source of mortality and serious injury data. These mortality and serious injury estimates result from an actual count of verified human-caused deaths and serious injuries and are minimums because not all entangled animals strand nor are all stranded animals found, reported, or have the cause of death determined. Between ~~2013~~2014 and ~~2017~~2018, reports to the ~~NMFS Alaska Region~~ stranding network resulted in mean annual mortality and serious injury rates of ~~3~~three Steller sea lions illegally shot in the Copper River Delta (3-year average)~~,~~ and ~~2.8~~3.2 observed entangled in marine debris~~, 0.2 struck by an arrow, and 0.2 entangled in a commercial Kodiak salmon hatchery net~~ (Table 4; ~~Delean et al. 2020~~Young et al. in press). ~~Two a~~Additional reports of Steller sea lion~~s~~ mortality ~~with~~due to gunshot wounds ~~were reported to the NMFS Alaska Region stranding network between 2013 and 2017 (one each in 2015 and 2016). Although it is likely that illegal shooting does occur in Alaska, these events~~ are not included in the estimate of the ~~average~~mean annual mortality and serious injury rate for 2014 to 2018 because it could not be confirmed that the ~~deaths~~animals were ~~due to~~ illegally ~~shooting~~shot ~~and were not already accounted for in the estimate of animals~~rather than struck and lost in the Alaska Native subsistence harvest.

Mortality and serious injury may occasionally occur incidental to marine mammal research activities authorized under MMPA permits issued to a variety of government, academic, and other research organizations. Between ~~2013~~2014 and ~~2017~~2018, there were three reports (one in 2015 and two in 2016) of mortality incidental to research on the Western U.S. stock of Steller sea lions (Table 4; ~~Delean et al. 2020~~Young et al. in press), resulting in a mean annual mortality and serious injury rate of 0.6 sea lions from this stock.

STATUS OF STOCK

The minimum estimated mean annual U.S. commercial fishery-related mortality and serious injury rate (~~36~~38 sea lions) is more than 10% of the PBR (10% of PBR = 32) and, therefore, cannot be considered insignificant and approaching a zero mortality and serious injury rate. Based on available data, the minimum estimated mean annual level of human-caused mortality and serious injury (~~247~~255 sea lions) is below the PBR level (~~322~~318) for this stock. The Western U.S. stock of Steller sea lions is currently listed as endangered under the ESA and, therefore, designated as depleted under the MMPA. As a result, the stock is classified as a strategic stock. The population previously declined for unknown reasons that are not explained by the documented level of direct human-caused mortality and serious injury.

There are key uncertainties in the assessment of the Western U.S. stock of Steller sea lions. Some genetic studies support the separation of Steller sea lions in western Alaska from those in Russia; population numbers in this assessment are only from the U.S. to be consistent with the geographic range of information on mortality and serious injury. We provide data for the Russian population for context for the entire Western DPS. There is some overlap in range between animals in the ~~w~~Western and ~~e~~Eastern stocks in northern Southeast Alaska. The population abundance is based on counts of visible animals; the calculated N_{MIN} and PBR levels are conservative because there are no data available to correct for animals not visible during the visual surveys. There are multiple nearshore commercial fisheries ~~which~~that are not observed; thus, there is likely to be unreported fishery-related mortality and serious injury of Steller sea lions. Estimates of human-caused mortality and serious injury from stranding data are underestimates because not all animals strand nor are all stranded animals found, reported, or have the cause of death determined. Several factors may have been important drivers of the decline of the stock. However, there is uncertainty about threats currently impeding their recovery, particularly in the Aleutian Islands.

HABITAT CONCERNS

Many factors have been suggested as causes of the steep decline in abundance of ~~w~~Western Steller sea lions observed in the 1980s, including competitive effects of fishing, environmental change, disease, contaminants, killer whale predation, incidental take, and illegal and legal shooting (Atkinson et al. 2008, NMFS 2008). A number of management actions have been implemented since 1990 to promote the recovery of the Western U.S. stock of Steller sea lions, including 3-nmi no-entry zones around rookeries, prohibition of shooting at or near sea lions, and regulation of fisheries for sea lion prey species (e.g., walleye pollock, Pacific cod, and Atka mackerel; see reviews by Fritz et al. 1995, McBeath 2004, Atkinson et al. 2008, NMFS 2008). Additionally, potentially deleterious events, such as harmful algal blooms (Lefebvre et al. 2016) and disease transmission across the Arctic (VanWormer et al. 2019) that have been associated with warming waters, could lead to potentially negative population-level impacts on Steller sea lions. Metal and contaminant exposure remains a focus of ongoing investigation. Total mercury concentrations measured in hair samples collected from pups in the western-central Aleutian Islands are the highest measured for this species and at levels that in other species cause neurological and reproductive effects (Rea et al. 2013), and organochlorine burdens were detected in tissue samples from across the range but were highest in pups sampled from the Aleutian Islands (Beckmen et al. 2016, Keogh et al. 2020).

The area of greatest (continued) decline in the U.S. remains in the western Aleutian Islands (west of Samalga Pass). Pacific cod and Atka mackerel are two of the primary prey species of Steller sea lions in the central and western Aleutian Islands (Sinclair et al. 2013, Tollit et al. 2017). In the increasing eastern Aleutian Islands region, Rand et al. (2019) reported dense and consistent aggregations of Atka mackerel. However, in the western Aleutian Islands region, this important prey species was more spread out over a larger area during the non-breeding (i.e., "winter") season (Fritz et al. 2019, Rand et al. 2019). Prey availability over winter is thought to be a key factor in energy budgets of sea lions, especially for pregnant females and especially those supporting a pup and/or juvenile (NMFS 2010, Boyd 2000, Malavaer 2002, Winship et al. 2002, Williams 2005). This could result in increases in energy expenditures by Steller sea lions associated with finding and capturing prey, as evident by increased frequency and duration of foraging trips observed in juvenile Steller sea lions in this region (Lander et al. 2010). Prey species (e.g., Atka mackerel, Pacific cod, and walleye pollock) are likely to have lower overall abundance, less predictable spatial distributions, and altered demographics in fished versus unfished habitats (Hsieh et al. 2006, Barbeaux et al. 2013, Fritz et al. 2019). In 2011, the Pacific cod and Atka mackerel fisheries were closed and then re-opened in 2014. In the western Aleutian Islands region, ~~where~~ modeled realized counts ~~indicate that there was a period of~~exhibited stability ~~in this region~~ from 2014 to 2016 (and potentially an increase in pup counts), followed by ~~a~~continued declines ~~between~~since 2016 ~~and 2018~~ (Sweeney et al. 2016, 2017, 2018). ~~This coincides with a closure between 2011 and 2014 of the Pacific cod and Atka mackerel fisheries. Pacific cod and Atka mackerel are two of the primary prey species of Steller sea lions in the Aleutian Islands (Sinclair et al. 2013, Tollit et al. 2017).~~ Fritz et al. (2019) suggested that if nutrition is a driver of the decline, then it appears that other factors (than diet diversity, species mix, and energy density) may be acting. The literature does not prove (or disprove) a correlation between fisheries, sea lion population trends, and prey availability in the Aleutian Islands, and this hypothesis is an important area of investigation for Steller sea lions, especially in the Aleutian Islands.

The Pacific marine heatwave that occurred from 2014 to 2016, and subsequent warm waters in the north Pacific, especially the Gulf of Alaska, has been linked to large declines in productivity and impacts on groundfish populations (von Biela et al. 2019, Yang et al. 2019). In fact, the concomitant decline in pup productivity in the eastern and central Gulf of Alaska regions observed from 2015 and 2017 may be related to the reduction of available prey in the area (Sweeney et al. 2017). In 2019, pup production in these regions rebounded to 2015 levels; however, there was a decline in non-pups that spanned all the Gulf of Alaska regions (Sweeney et al. 2019). These declines are concerning given that prior to 2017, these regions were showing relatively consistent and steady increases in counts (Sweeney et al. 2019). As Alaska waters, especially the Gulf of Alaska, continue to warm, it seems evident from NOAA Fisheries sea lion surveys that this could continue to impact the Western stock in the U.S. It is also possible that changes in foraging ability could affect sea lion movements between and within the stocks (Jemison et al. 2018).

CITATIONS

AFSC/MML/Alaska Ecosystems Program. 2016. Steller sea lion haulout and rookery locations in the United States for 2016-05-14 (NCEI Accession 0129877). NOAA National Centers for Environmental Information. Dataset. DOI: dx.doi.org/10.7289/V58C9T7V .

Alaska Native Harbor Seal Commission (ANHSC). 2015. 2014 estimate of the subsistence harvest of harbor seals and sea lions by Alaska Natives in southcentral Alaska: summary of study findings. Alaska Native Harbor Seal Commission and Alaska Department of Fish & Game, Division of Subsistence. 15 p.

Atkinson, S., D. P. DeMaster, and D. G. Calkins. 2008. Anthropogenic causes of the western Steller sea lion *Eumetopias jubatus* population decline and their threat to recovery. Mammal Rev. 38(1):1-18.

Baker, A. R., T. R. Loughlin, V. Burkanov, C. W. Matson, T. G. Trujillo, D. G. Calkins, J. K. Wickliffe, and J. W. Bickham. 2005. Variation of mitochondrial control region sequences of Steller sea lions: the three-stock hypothesis. J. Mammal. 86:1075-1084.

Barbeaux, S. J., J. K. Horne, and M. W. Dorn. 2013. Characterizing walleye pollock (*Theragra chalcogramma*) winter distribution from opportunistic data. ICES J. Mar. Sci. 70(6):1162-1173. DOI: dx.doi.org/10.1093/icesjms/fst052 .

Beckmen, K. B., M. J. Keogh, K. A. Burek-Huntington, G. M. Ylitalo, B. S. Fadely, and K. W Pitcher. 2016. Organochlorine contaminant concentrations in multiple tissues of free-ranging Steller sea lions (*Eumetopias jubatus*) in Alaska. Science of the Total Environment 542:441-452. DOI: dx.doi.org/10.1016/j.scitotenv.2015.10.119 .

Berta, A., and M. Churchill. 2012. Pinniped taxonomy: review of currently recognized species and subspecies, and evidence used for their description. Mammal Rev. 42(2):207-234.

Bickham, J. W., J. C. Patton, and T. R. Loughlin. 1996. High variability for control-region sequences in a marine mammal: implications for conservation and biogeography of Steller sea lions (*Eumetopias jubatus*). J. Mammal. 77:95-108.

Bond, N. A., M. F. Cronin, H. Freeland, and N. Mantua. 2015. Causes and impacts of the 2014 warm anomaly in the NE Pacific. Geophys. Res. Lett. 42(9):3414-3420. DOI: dx.doi.org/10.1002/2015GL063306 .

Boyd, I. L. 2000. State-dependent fertility in pinnipeds: contrasting capital and income breeders. Functional Ecology 14(5):623-630.

Braham, H. W., R. D. Everitt, and D. J. Rugh. 1980. Northern sea lion decline in the eastern Aleutian Islands. J. Wildl. Manage. 44:25-33.

Breiwick, J. M. 2013. North Pacific marine mammal bycatch estimation methodology and results, 2007-2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-260, 40 p.

Burkanov, V. 2017. Results of breeding season Steller sea lion pup surveys in Russia, 2011-2016. Memorandum to T. Gelatt and J. Bengtson, April 6, 2017. Available from Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Burkanov, V. 2018a. Brief results on the most recent and complete Steller sea lion counts in Russia. Memorandum to T. Gelatt and J. Bengtson. Available from Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115. 35 p.

Burkanov, V. 2018b. Current Steller sea lion pup production along Asian coast, 2016-2017. Memorandum to T. Gelatt and J. Bengtson. Available from Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115. 3 p.

Burkanov, V., and T. R. Loughlin. 2005. Distribution and abundance of Steller sea lions on the Asian coast, 1720's–2005. Mar. Fish. Rev. 67(2):1-62.

Byrd, G. V. 1989. Observations of northern sea lions at Ugamak, Buldir, and Agattu Islands, Alaska in 1989. Unpubl. report, U.S. Fish and Wildlife Service, Alaska Maritime National Wildlife Refuge, P.O. Box 5251, NSA Adak, FPO Seattle, WA 98791.

Calkins, D. G., and K. W. Pitcher. 1982. Population assessment, ecology and trophic relationships of Steller sea lions in the Gulf of Alaska. Environmental Assessment of the Alaskan Continental Shelf. Final Reports 19:455-546.

~~Delean, B. J., V. T. Helker, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, J. Jannot, and N. C. Young. 2020. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2013-2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-401, 86 p.~~

DeMaster, D. P. 2014. Results of Steller sea lion surveys in Alaska, June-July 2013. Memorandum to J. Balsiger, J. Kurland, B. Gerke, and L. Rotterman, NMFS Alaska Regional Office, Juneau, AK, January 30, 2014. Available from Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Dizon, A. E., C. Lockyer, W. F. Perrin, D. P. DeMaster, and J. Sisson. 1992. Rethinking the stock concept: a phylogeographic approach. Conserv. Biol. 6:24-36.

Fritz, L. W., R. C. Ferrero, and R. J. Berg. 1995. The threatened status of Steller sea lions, *Eumetopias jubatus*, under the Endangered Species Act: effects on Alaska groundfish fisheries management. Mar. Fish. Rev. 57(2):14-27.

Fritz, L., K. Sweeney, D. Johnson, M. Lynn, and J. Gilpatrick. 2013. Aerial and ship-based surveys of Steller sea lions (*Eumetopias jubatus*) conducted in Alaska in June-July 2008 through 2012, and an update on the status and trend of the western stock in Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-251, 91 p.

Fritz, L., K. Sweeney, R. Towell, and T. Gelatt. 2016. Aerial and ship-based surveys of Steller sea lions (*Eumetopias jubatus*) conducted in Alaska in June-July 2013 through 2015, and an update on the status and trend of the western distinct population segment in Alaska. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-321, 72 p.

Fritz, L., B. Brost, E. Laman, K. Luxa, K. Sweeney, J. Thomason, D. Tollit, W. Walker, and T. Zeppelin. 2019. A re-examination of the relationship between Steller sea lion (*Eumetopias jubatus*) diet and population trend using data from the Aleutian Islands. Can. J. Zool. 97:1137-1155. DOI: dx.doi.org/10.1139/cjz-2018-0329 .

Gelatt, T. S., A. W. Trites, K. Hastings, L. Jemison, K. Pitcher, and G. O'Corry-Crowe. 2007. Population trends, diet, genetics, and observations of Steller sea lions in Glacier Bay National Park, p. 145-149. *In* J. F. Piatt, and S. M. Gende (eds.), Proceedings of the Fourth Glacier Bay Science Symposium, October 26–28, 2004: U.S. Geological Survey Scientific Investigations Report 2007-5047.

Harlin-Cognato, A., J. W. Bickham, T. R. Loughlin, and R. L. Honeycutt. 2006. Glacial refugia and the phylogeography of Steller's sea lion (*Eumetopias jubatus*) in the North Pacific. J. Evol. Biol. 19:955-969. DOI: dx.doi.org/10.1111/j.1420-9101.2005.01052.x .

Hastings, K. K., L. A. Jemison, G. W. Pendleton, K. L. Raum-Suryan, and K. W. Pitcher. 2017. Natal and breeding philopatry of female Steller sea lions in southeastern Alaska. PLoS ONE 13(4):e0196412. DOI: dx.doi.org/10.1371/journal.pone.0176840 .

Hastings, K. K., M. J Rehberg, G. M. O'Corry-Crowe, G. W. Pendleton, L. A Jemison, and T. S. Gelatt. 2019. Demographic consequences and characteristics of recent population mixing and colonization in Steller sea lions, *Eumetopias jubatus*. J. Mammal. DOI: dx.doi.org/10.1093/jmammal/gyz192 .

Higgins, L. V., D. P. Costa, A. C. Huntley, and B. J. Le Boeuf. 1988. Behavioral and physiological measurements of maternal investment in the Steller sea lion, *Eumetopias jubatus*. Mar. Mammal Sci. 4:44-58.

Hoffman, J. I., C. W. Matson, W. Amos, T. R. Loughlin, and J. W. Bickham. 2006. Deep genetic subdivision within a continuously distributed and highly vagile marine mammal, the Steller's sea lion (*Eumetopias jubatus*). Mol. Ecol. 15:2821-2832.

Hoffman, J. I., K. K. Dasmahapatra, W. Amos, C. D. Phillips, T. S. Gelatt, and J. W Bickham. 2009. Contrasting patterns of genetic diversity at three different genetic markers in a marine mammal metapopulation. Mol. Ecol. 18(14):2961-2978.

Holmes, E. E., L. W. Fritz, A. E. York, and K. Sweeney. 2007. Age-structured modeling provides evidence for a 28-year decline in the birth rate of western Steller sea lions. Ecol. Appl. 17(8):2214-2232.

Hsieh, C. H., C. S. Reiss, J. R. Hunter, J. R. Beddington, R. M. May, and G. Sugihara. 2006. Fishing elevates variability in the abundance of exploited species. Nature 443:859-862. DOI: dx.doi.org/10.1038/nature05232 .

Jemison, L. A., G. W. Pendleton, L. W. Fritz, K. K. Hastings, J. M. Maniscalco, A. W. Trites, and T. S. Gelatt. 2013. Inter-population movements of Steller sea lions in Alaska, with implications for population separation. PLoS ONE 8(8):e70167.

Jemison, L. A., G. W. Pendleton, K. K. Hastings, J. M. Maniscalco, and L. W. Fritz. 2018. Spatial distribution, movements, and geographic range of Steller sea lions (*Eumetopias jubatus*) in Alaska. PLoS ONE 13(12):e0208093. DOI: dx.doi.org/10.1371/journal.pone.0208093 .

Johnson, D. 2018. Trends of nonpup survey counts of Russian Steller sea lions. Memorandum for T. Gelatt and J. Bengtson, June 6, 2018. Available from NMFS Alaska Region, Office of Protected Resources, 709 West 9th Street, Juneau, AK 99802-1668.

Johnson, D. S., and L. W. Fritz. 2014. agTrend: a Bayesian approach for estimating trends of aggregated abundance. Methods Ecol. Evol. 5:1110-1115. DOI: dx.doi.org/10.1111/2041-210X.12231 .

Kashevarof, H. 2015. St. George co-management comprehensive report. St. George Island Traditional Council Kayumixtax Eco-Office, St. George Island, AK 99591.

Keogh, M. J., B. Taras, K. B. Beckmen, K. A. Burek-Huntington, G. M. Ylitalo, B. S. Fadely, L. D. Rea, and K. W. Pitcher. 2020. Organochlorine contaminant concentrations in blubber of young Steller sea lion (*Eumetopias jubatus*) are influenced by region, age, sex and lipid stores. Science of the Total Environment 698:134183. DOI: dx.doi.org/10.1016/j.scitotenv.2019.134183 .

Kuhn, C. E., K. Chumbley, D. Johnson, and L. Fritz. 2017. A re-examination of the timing of pupping for Steller sea lions *Eumetopias jubatus* breeding on two islands in Alaska. Endang. Species Res. 32:213-222. DOI: dx.doi.org/10.3354/esr00796 .

Lander, M. E., T. R. Loughlin, M. G. Logsdon, G. R. VanBlaricom, and B. S. Fadely. 2010. Foraging effort of juvenile Steller sea lions *Eumetopias jubatus* with respect to heterogeneity of sea surface temperature. Endang. Species Res. 10:145-158. DOI: dx.doi.org/ 10.3354/esr00260 .

Lefebvre, K. A., L. Quakenbush, E. Frame, K. Burek Huntington, G. Sheffield, R. Stimmelmayr, A. Bryan, P. Kendrick, H. Ziel, T. Goldstein, J. A. Snyder, T. Gelatt, F. Gulland, B. Dickerson, and V. Gil. 2016. Prevalence of algal toxins in Alaskan marine mammals foraging in a changing arctic and subarctic environment. Harmful Algae 55:13-24. DOI: dx.doi.org/10.1016/j.hal.2016.01.007 .

Loughlin, T. R. 1997. Using the phylogeographic method to identify Steller sea lion stocks, p. 329-341. *In* A. Dizon, S. J. Chivers, and W. Perrin (eds.), Molecular genetics of marine mammals, incorporating the proceedings of a workshop on the analysis of genetic data to address problems of stock identity as related to management of marine mammals. Soc. Mar. Mammal., Spec. Rep. No. 3.

Loughlin, T. R., and A. E. York. 2000. An accounting of the sources of Steller sea lion mortality. Mar. Fish. Rev. 62(4):40-45.

Loughlin, T. R., D. J. Rugh, and C. H. Fiscus. 1984. Northern sea lion distribution and abundance: 1956-1980. J. Wildl. Manage. 48:729-740.

Malavaer, M. Y. G. 2002. Modeling the energetics of Steller sea lions (*Eumetopias jubatus*) along the Oregon Coast. M.S. Thesis, Oregon State University, Corvallis, Oregon.

Maniscalco, J. M., P. Parker, and S. Atkinson. 2006. Interseasonal and interannual measures of maternal care among individual Steller sea lions (*Eumetopias jubatus*). J. Mammal. 87:304-311.

Manly, B. F. J. 2015. Incidental takes and interactions of marine mammals and birds in districts 6, 7, and 8 of the Southeast Alaska salmon drift gillnet fishery, 2012 and 2013. Final Report to NMFS Alaska Region. 52 p.

McBeath, J. 2004. Greenpeace v. National Marine Fisheries Service: Steller sea lions and commercial fisheries in the North Pacific. Alaska Law Rev. 21:1-42.

Melovidov, P. I. 2013. 2012 subsistence hunting of Steller sea lions on St. Paul Island. Memorandum for the Record, February 25, 2013, Aleut Community of St. Paul, Tribal Government, Ecosystem Conservation Office, St. Paul Island, Pribilof Islands, AK.

Melovidov, P. I. 2014. 2013 subsistence hunting of Steller sea lions on St. Paul Island. Memorandum for the Record, February 28, 2014, Aleut Community of St. Paul, Tribal Government, Ecosystem Conservation Office, St. Paul Island, Pribilof Islands, AK.

Melovidov, P. I. 2015. 2014 subsistence hunting of Steller sea lions on St. Paul Island. Memorandum for the Record, February 20, 2015, Aleut Community of St. Paul, Tribal Government, Ecosystem Conservation Office, St. Paul Island, Pribilof Islands, AK.

Melovidov, P. I. 2016. 2015 subsistence hunting of Steller sea lions on St. Paul Island. Memorandum for the Record, February 23, 2016, Aleut Community of St. Paul, Tribal Government, Ecosystem Conservation Office, St. Paul Island, Pribilof Islands, AK.

Merrick, R. L., T. R. Loughlin, and D. G. Calkins. 1987. Decline in abundance of the northern sea lion, *Eumetopias jubatus*, in 1956-86. Fish. Bull., U.S. 85:351-365.

Merrick, R. L., R. Brown, D. G. Calkins, and T. R. Loughlin. 1995. A comparison of Steller sea lion, *Eumetopias jubatus*, pup masses between rookeries with increasing and decreasing populations. Fish. Bull., U.S. 93:753-758.

Milette, L. L., and A. W. Trites. 2003. Maternal attendance patterns of Steller sea lions (*Eumetopias jubatus*) from stable and declining populations in Alaska. Can. J. Zool. 81:340-348.

National Marine Fisheries Service (NMFS). 1990. Final rule. Listing of Steller Sea Lions as Threatened Under the Endangered Species Act. 55 FR 24345, 26 November 1990.

National Marine Fisheries Service (NMFS). 1997. Final rule. Change in Listing Status of Steller Sea Lions Under the Endangered Species Act. 62 FR 24345, 5 May 1997.

National Marine Fisheries Service (NMFS). 2008. Recovery Plan for the Steller sea lion (*Eumetopias jubatus*). Revision. National Marine Fisheries Service, Silver Spring, MD. 325 p.

National Marine Fisheries Service (NMFS). 2010. Endangered Species Act - Section 7 Consultation Biological Opinion: Authorization of groundfish fisheries under the Fishery Management Plan for Groundfish of the Bering Sea and Aleutian Islands Management Area; Authorization of groundfish fisheries under the Fishery Management Plan for Groundfish of the Gulf of Alaska, State of Alaska parallel groundfish fisheries. Available online: https://www.fisheries.noaa.gov/resource/document/biological-opinion-authorization-alaska-groundfish-fisheries . Accessed August 2020.

National Marine Fisheries Service (NMFS). 2013. Occurrence of ~~w~~Western Distinct Population Segment Steller sea lions east of 144° W longitude. December 18, 2013. NMFS Alaska Region, Protected Resources Division, Juneau, AK. 3 p.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed ~~December 2019~~August 2020.

O'Corry-Crowe, G., B. L. Taylor, and T. Gelatt. 2006. Demographic independence along ecosystem boundaries in Steller sea lions revealed by mtDNA analysis: implications for management of an endangered species. Can. J. Zool. 84(12):1796-1809.

O'Corry-Crowe, G., T. Gelatt, L. Rea, C. Bonin, and M. Rehberg. 2014. Crossing to safety: dispersal, colonization and mate choice in evolutionarily distinct populations of Steller sea lions, *Eumetopias jubatus*. Mol. Ecol. 23(22):5415-5434.

Olesiuk, P. F. 2008. Abundance of Steller sea lions (*Eumetopias jubatus*) in British Columbia. Department of Fisheries and Oceans Canada, Canadian Science Advisory Secretariat Research Document 2008/063. 29 p. Available online: http://www.dfo-mpo.gc.ca/csas/ . Accessed ~~December 2019~~August 2020.

Peterson, W., N. Bond, and M. Robert. 2016. The blob (part three): going, going, gone? PICES Press 24(1):46-48. Available online: https://search.proquest.com/docview/1785278412?accountid=28257 . Accessed ~~December 2019~~August 2020.

Phillips, C. D., J. W. Bickham, J. C. Patton, and T. S. Gelatt. 2009. Systematics of Steller sea lions (*Eumetopias jubatus*): subspecies recognition based on concordance of genetics and morphometrics. Museum of Texas Tech University Occasional Papers 283:1-15.

Phillips, C. D., T. S. Gelatt, J. C. Patton, and J. W. Bickham. 2011. Phylogeography of Steller sea lions: relationships among climate change, effective population size, and genetic diversity. J. Mammal. 92(5):1091-1104.

Pitcher, K. W., V. N. Burkanov, D. G. Calkins, B. J. Le Boeuf, E. G. Mamaev, R. L. Merrick, and G. W. Pendleton. 2001. Spatial and temporal variation in the timing of births of Steller sea lions. J. Mammal. 82(4):1047-1053.

Pitcher, K. W., P. F. Olesiuk, R. F. Brown, M. S. Lowry, S. J. Jeffries, J. L. Sease, W. L. Perryman, C. E. Stinchcomb, and L. F. Lowry. 2007. Abundance and distribution of the eastern North Pacific Steller sea lion (*Eumetopias jubatus*) population. Fish. Bull., U.S. 105(1):102-115.

Rand, K., S. McDermott, E. Logerwell, M. E. Matta, M. Levine, D. R. Bryan, I. B. Spies, and T. Loomis. 2019. Higher aggregation of key prey species associated with diet and abundance of the Steller sea lion *Eumetopias jubatus* across the Aleutian Islands. Marine and Coastal Fisheries 11(6):472-486. DOI: dx.doi.org/10.1002/mcf2.10096 .

Raum-Suryan, K. L, K. W. Pitcher, D. G. Calkins, J. L. Sease, and T. R. Loughlin. 2002. Dispersal, rookery fidelity, and metapopulation structure of Steller sea lions (*Eumetopias jubatus*) in an increasing and a decreasing population in Alaska. Mar. Mammal Sci. 18(3):746-764. DOI: dx.doi.org/10.1111/j.1748-7692.2002.tb01071.x .

Raum-Suryan, K. L., L. A. Jemison, and K. W. Pitcher. 2009. Entanglement of Steller sea lions (*Eumetopias jubatus*) in marine debris: identifying causes and finding solutions. Mar. Pollut. Bull. 58:1487-1495.

Rea, L. D., J. M. Castellini, L. Correa, B. S. Fadely, and T. M. O'Hara. 2013. Maternal Steller sea lion diets elevate fetal mercury concentrations in an area of population decline. Science of the Total Environment 454-455:277-282. DOI: dx.doi.org/10.1016/j.scitotenv.2013.02.095 .

Rehberg, M., L. Jemison, J. N. Womble, and G. O'Corry-Crowe. 2018. Winter movements and long-term dispersal of Steller sea lions in the Glacier Bay region of Southeast Alaska. Endang. Species Res. 37:11-24. DOI: dx.doi.org/10.3354/esr00909 .

Sease, J. L., and C. J. Gudmundson. 2002. Aerial and land-based surveys of Steller sea lions (*Eumetopias jubatus*) from the western stock in Alaska, June and July 2001 and 2002. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-131, 54 p.

Sease, J. L., and A. E. York. 2003. Seasonal distribution of Steller's sea lions at rookeries and haul-out sites in Alaska. Mar. Mammal Sci. 19(4):745-763.

Sease, J. L., W. P. Taylor, T. R. Loughlin, and K. W. Pitcher. 2001. Aerial and land-based surveys of Steller sea lions (*Eumetopias jubatus*) in Alaska, June and July 1999 and 2000. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-122, 52 p.

Sinclair, E. H., D. S. Johnson, T. K. Zeppelin, and T. S. Gelatt. 2013. Decadal variation in the diet of ~~w~~Western stock Steller sea lions (*Eumetopias jubatus*). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-248, 67 p.

Sweeney, K., L. Fritz, R. Towell, and T. Gelatt. 2016. Results of Steller sea lion surveys in Alaska, June-July 2016. Memorandum to D. DeMaster, J. Bengtson, J. Balsiger, J. Kurland, and L. Rotterman, December 5, 2016. Available from Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Sweeney, K., L. Fritz, R. Towell, and T. Gelatt. 2017. Results of Steller sea lion surveys in Alaska, June-July 2017. Memorandum to the Record, December 5, 2017. Available from Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Sweeney, K., R. Towell, and T. Gelatt. 2018. Results of Steller sea lion surveys in Alaska, June-July 2018. Memorandum to the Record, December 5, 2018. Available from Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Sweeney, K., K. Luxa, B. Birkemeier, and T. Gelatt. 2019. Results of Steller sea lion surveys in Alaska, June-July 2019. Memorandum to the Record, December 6, 2019. Available from Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Tollit, D., L. Fritz, R. Joy, K. Miller, A. Schulze, J. Thomason, W. Walker, T. Zeppelin, and T. Gelatt. 2017. Diet of endangered Steller sea lions (*Eumetopias jubatus*) in the Aleutian Islands: new insights from DNA detections and bioenergetics reconstructions. Can. J. Zool. 95:853-868. DOI: dx.doi.org/10.1139/cjz-2016-0253 .

VanWormer, E., J. A. K. Mazet, A. Hall, V. A. Gill, P. L. Boveng, J. M. London, T. Gelatt, B. S. Fadely, M. E. Lander, J. Sterling, V. N. Burkanov, R. R. Ream, P. M. Brock, L. D. Rea, B. R. Smith, A. Jeffers, M. Henstock, M. J. Rehberg, K. A. Burek-Huntington, S. L. Cosby, J. A. Hammond, and T. Goldstein. 2019. Viral emergence in marine mammals in the North Pacific may be linked to Arctic sea ice reduction. Scientific Reports 9, 15569. DOI: dx.doi.org/10.1038/s41598-019-51699-4 .

von Biela, V. R., M. L. Arimitsu, J. F. Piatt, B. Heflin, S. K. Schoen, J. L. Trowbridge, and C. M. Clawson. 2019. Extreme reduction in nutritional value of a key forage fish during the Pacific marine heatwave of 2014-2016. Mar. Ecol. Prog. Series 613:171-182. DOI: dx.doi.org/10.3354/meps12891 .

Wade, P. R. 1994. Managing populations under the Marine Mammal Protection Act of 1994: a strategy for selecting values for N_{MIN}, the minimum abundance estimate, and F_R, the recovery factor. Southwest Fisheries Science Center Administrative Report LJ-94-19, 26 p. Available from SWFSC, NMFS, 8901 La Jolla Shores Drive, La Jolla, CA 92037.

Williams, T. 2005. Reproductive energetics of sea lions: implications for the size of protected areas around Steller sea lion rookeries, p. 83-89. *In* T. R. Loughlin, D. G. Calkins, and S. Atkinson (eds.), Synopsis of research on Steller sea lions, 2001–2005. Alaska SeaLife Center, Seward, Alaska.

Winship, A. J., A. W. Trites, and D. A. S. Rosen. 2002. A bioenergetic model for estimating the food requirements of Steller sea lions *Eumetopias jubatus* in Alaska, USA. Mar. Ecol. Prog. Ser. 229:291-312.

Wolfe, R. J., J. A. Fall, and R. T. Stanek. 2005. The subsistence harvest of harbor seals and sea lions by Alaska Natives in 2004. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 303, Juneau, AK.

Wolfe, R. J., J. A. Fall, and R. T. Stanek. 2006. The subsistence harvest of harbor seals and sea lions by Alaska Natives in 2005. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 319, Juneau, AK.

Wolfe, R. J., J. A. Fall, and M. Riedel. 2008. The subsistence harvest of harbor seals and sea lions by Alaska Natives in 2006. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 339, Juneau, AK.

Wolfe, R. J., J. A. Fall, and M. Riedel. 2009a. The subsistence harvest of harbor seals and sea lions by Alaska Natives in 2007. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 345, Juneau, AK.

Wolfe, R. J., J. A. Fall, and M. Riedel. 2009b. The subsistence harvest of harbor seals and sea lions by Alaska Natives in 2008. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 347, Juneau, AK.

Wolfe, R. J., L. Hutchinson-Scarbrough, and M. Riedel. 2012. The subsistence harvest of harbor seals and sea lions on Kodiak Island in 2011. Alaska Department of Fish and Game, Division of Subsistence, Technical Paper No. 374, Anchorage, AK.

Wynne, K. M., D. Hicks, and N. Munro. 1991. 1990 salmon gillnet fisheries observer programs in Prince William Sound and South Unimak Alaska. Annual Report NMFS/NOAA Contract 50ABNF000036. 65 p. Available from NMFS Alaska Region, Office of Marine Mammals, P.O. Box 21668, Juneau, AK 99802.

Wynne, K. M., D. Hicks, and N. Munro. 1992. 1991 marine mammal observer program for the salmon driftnet fishery of Prince William Sound Alaska. Annual Report NMFS/NOAA Contract 50ABNF000036. 53 p. Available from NMFS Alaska Region, Office of Marine Mammals, P.O. Box 21668, Juneau, AK 99802.

Yang, Q., E. D. Cokelet, P. J. Stabeno, L. Li, A. B. Hollowed, W. A. Palsson, N. A. Bond, and S. Barbeaux. 2019. How "The Blob" affected groundfish distributions in the Gulf of Alaska. Fish. Oceanography 28(4):434-453. DOI: dx.doi.org/10.1111/fog.12422 .

York, A. E., R. L. Merrick, and T. R. Loughlin. 1996. An analysis of the Steller sea lion metapopulation in Alaska, Chapter 12, p. 259-292. *In* D. R. McCullough (ed.), Metapopulations and Wildlife Conservation. Island Press, Covelo, CA.

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX.

NORTHERN FUR SEAL (*Callorhinus ursinus*): Eastern Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Northern fur seals occur from southern California north to the Bering Sea (Fig. 1) and west to the Sea of Okhotsk and Honshu Island, Japan. During the summer breeding season, most of the worldwide population is found on the Pribilof Islands (St. Paul Island and St. George Island) in the southern Bering Sea, with the remaining animals on rookeries in Russia, on Bogoslof Island in the southern Bering Sea, on San Miguel Island off southern California (Lander and Kajimura 1982, NMFS 1993), and on the Farallon Islands off central California. Non-breeding northern fur seals may occasionally haul out on land at other sites in Alaska, British Columbia, and on islets along the west coast of the United States (Fiscus 1983).

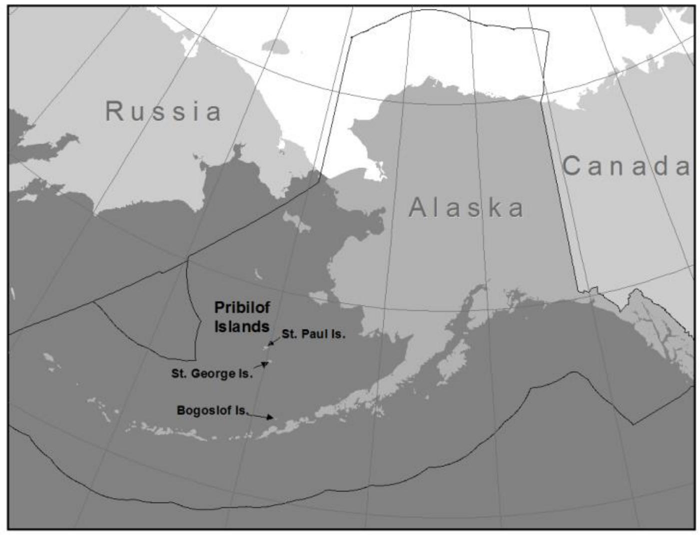

Figure 1. Approximate distribution of northern fur seals in the eastern North Pacific (dark shaded area). Eastern Pacific northern fur seal breeding colonies in U.S. waters are located on the three named islands. The U.S. Exclusive Economic Zone is delineated by a black line.

During the reproductive season, adult males usually are on shore during the 4-month period from May to August, although some may be present until November (well after giving up their territories). Adult females are ashore during a 6-month period (June-November). Following their respective times ashore, Alaska northern fur seals of both genders then move south and remain at sea until the next breeding season (Roppel 1984). Adult females and pups from the Pribilof Islands move through the Aleutian Islands into the North Pacific Ocean, often to the waters offshore of Oregon and California (Ream et al. 2005). Adult males generally move only as far south as the Gulf of Alaska in the eastern North Pacific (Kajimura 1984) and the Kuril Islands in the western North Pacific (Loughlin et al. 1999). In Alaska, pups are born during summer months and leave the rookeries in the fall, on average around mid-November but ranging from late October to early December. Alaska northern fur seal pups generally remain at sea for 22 months (Kenyon and Wilke 1953) before returning to land, usually at their rookery of birth but with considerable interchange of individuals between rookeries.

Two separate stocks of northern fur seals, an Eastern Pacific stock and a California stock, are recognized within U.S. waters based on the distribution and population response factors of the Dizon et al. (1992) phylogeographic approach: 1) Distribution: continuous during non-breeding season and discontinuous during the breeding season, high natal site fidelity (DeLong 1982, Baker et al. 1995); 2) Population response: substantial differences in population dynamics between the Pribilof Islands and San Miguel Island (DeLong 1982, DeLong and Antonelis 1991, NMFS 1993); 3) Phenotypic differentiation: unknown; and 4) Genotypic differentiation: little evidence of genetic differentiation among breeding islands (Ream 2002, Dickerson et al. 2010). The California stock is reported in the Stock Assessment Reports for the U.S. Pacific Region.

POPULATION SIZE

The population estimate for the Eastern Pacific stock of northern fur seals is calculated as the estimated number of pups born at rookeries in the eastern Bering Sea multiplied by a series of expansion factors determined from a life table analysis to estimate the number of yearlings, 2-year-olds, 3-year-olds, and animals 4 or more years old (Lander 1981). The resulting population estimate is equal to the pup production estimate multiplied by 4.47. The expansion factor is based on a sex and age distribution estimated after the harvest of juvenile males was terminated. There is no coefficient of variation (CV) for the expansion factor. Pup production is estimated at all islands using a mark-recapture method, or “shear-sampling” (Chapman and Johnson 1968, York and Kozloff 1987, Towell et al. 2006), with the exception of estimates conducted at Bogoslof Island through 1995, where the smaller population size in those years allowed direct counting of pups. As the majority of pups are born on St. Paul and St. George Islands, pup surveys are conducted biennially on these islands. Pup production estimates are available less frequently on Sea Lion Rock (adjacent to St. Paul Island) and Bogoslof Island (Table 1). Annual variation in female reproductive rates is reflected in the respective pup production estimates~~;~~. ~~b~~Because the estimation of stock population size relies on these estimates of pup production, means of recent pup production estimates are used to account for variability in the reproductive rates over time. The most recent estimate for the number of northern fur seals in the Eastern Pacific stock, based on pup production estimates on Sea Lion Rock (2014), on St. Paul and St. George Islands (mean of ~~2012,~~ 2014, ~~and~~ 2016, and 2018), and on Bogoslof Island (~~mean of 2011 and~~ 2015), is ~~620,660~~608,143 northern fur seals (4.47 × ~~138,850~~136,050).

Table 1. Estimates and/or counts of northern fur seal pups born on the Pribilof Islands and Bogoslof Island. Standard errors for pup estimates at rookery locations and the CV for total pup production estimates are provided in parentheses (direct counts do not have standard errors). The " symbol indicates that no new data are available for that year and, thus, the most recent prior estimate/count was used in determining total annual estimates.

	Rookery location				
Year	**St. Paul**	**Sea Lion Rock**	**St. George**	**Bogoslof**	**Total**
1994	192,104 (8,180)	12,891 (989)	22,244 (410)	1,472 (N/A)	228,711 (0.036)
1995	"	"	"	1,272 (N/A)	228,511 (0.036)
1996	170,125 (21,244)	"	27,385 (294)		211,673 (0.10)
1997	"	"	"	5,096 (33)	215,497 (0.099)
1998	179,149 (6,193)	"	22,090 (222)		219,226 (0.029)
2000	158,736 (17,284)	"	20,176 (271)	"	196,899 (0.089)
2002	145,716 (1,629)	8,262 (191)	17,593 (527)	"	176,667 (0.01)
2004	122,825 (1,290)	"	16,876 (239)	"	153,059 (0.01)
2005	"	"	"	12,631 (335)	160,594 (0.01)
2006	109, 961 (1,520)	"	17,072 (144)	"	147,900 (0.011)
2007	"	"	"	17,574 (843)	152,867 (0.011)
2008	102,674 (1,084)	6,741 (80)	18,160 (288)	"	145,149 (0.009)
2010	94,502 (1,259)	"	17,973 (323)	"	136,790 (0.011)
2011	"	"	"	22,905 (921.5)	142,121 (0.011)
2012	96,828 (1,260)	"	16,184 (155)	"	142,658 (0.011)
2014	91,737 (769)	5,250 (293)	18,937 (308)	"	138,829 (0.009)
2015	"	"	"	27,750 (228)	143,674 (0.006)
2016	80,641 (717)	"	20,490 (460)	"	134,131 (0.007)
2018	75,719 (1,008)	"	21,625 (345)	"	130,344 (0.009)

Minimum Population Estimate

A CV(N) that incorporates the variance of the correction factor is not available. Consistent with a recommendation of the Alaska Scientific Review Group (SRG) in October 1997 (DeMaster 1998) and recommendations contained in Wade and Angliss (1997), a default CV(N) of 0.2 is used in the calculation of the minimum population estimate (N_{MIN}) for this stock. N_{MIN} is calculated using Equation 1 from the potential biological removal (PBR) guidelines (NMFS 2016): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the population estimate (N) of ~~620,660~~608,143 and the default CV (0.2), N_{MIN} for the Eastern Pacific stock is ~~525,333~~514,738 northern fur seals.

Current Population Trend

Estimates of the size of the Alaska population of northern fur seals increased to approximately 1.25 million in 1974. The population began to decrease in the mid-1970s, with pup production declining at a rate of 6.5-7.8% per year into the 1980s (York 1987). By 1983, the total stock estimate was 877,000 northern fur seals (Briggs and Fowler 1984). Annual pup production on St. Paul Island remained stable between 1981 and 1996 (Fig. 2; York and Fowler 1992). There has been a decline in pup production on St. Paul Island since the mid-1990s. Pup production at St. George Island had a less pronounced period of stabilization, beginning in the late-1980s, that was similarly followed by a decline. However, pup production ~~appeared to~~ stabilized again on St. George Island beginning around 2002 (Fig. 3). From 1998 to ~~2016~~2018, pup production declined ~~4.12~~4.09% per year (SE = ~~0.40~~0.34%; P < 0.01) on St. Paul Island and showed no significant trend (SE = ~~0.57~~0.58%; P = ~~0.13~~0.59) on St. George Island. The estimated pup production in ~~2016~~2018 was below the 1919 level (Bower 1920) on both St. Paul and St. George Islands. Northern fur seal pup production at Bogoslof Island has grown at an exponential rate since the 1990s (Towell and Ream 2012) (Fig. 4). Despite continued growth at Bogoslof Island, recent estimates of pup production indicate that the rate of increase may be slowing. Between 1997 and 2015, pup production at Bogoslof Island increased 10.1% per year. Temporary increases in the overall stock size are observed when opportunistic estimates are conducted at Bogoslof, but declines at the larger Pribilof colony (specifically St. Paul) continue to drive the overall stock estimate down over time. The current trend in pup production was fit using agTrend (Johnson and Fritz~~,~~ 2014). Estimated pup production for the Eastern Pacific stock has been declining ~~2.21~~1.93% (95% CI: ~~-2.82 to -1.54~~ -2.67 to -1.24) per year from 1998 to ~~2016~~2018 (Fig. 5).

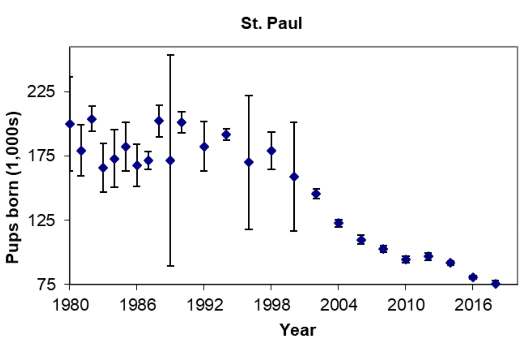

Figure 2. Estimated number of northern fur seal pups born on St. Paul Island, 1980-~~2016~~2018.

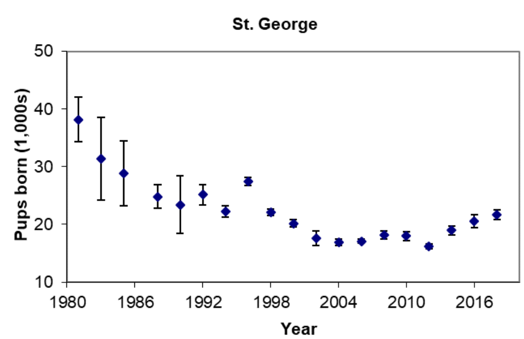

Figure 3. Estimated number of northern fur seal pups born on St. George Island, 1980-~~2016~~2018.

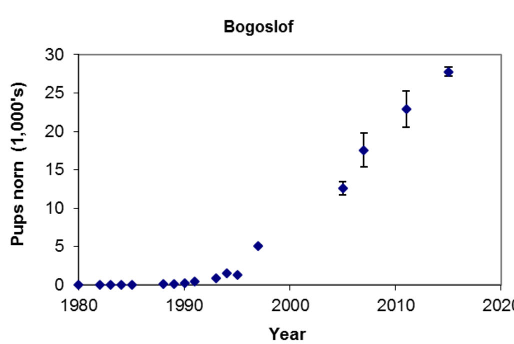

Figure 4. Estimated number of northern fur seal pups born on Bogoslof Island, 1980-~~2016~~2015.

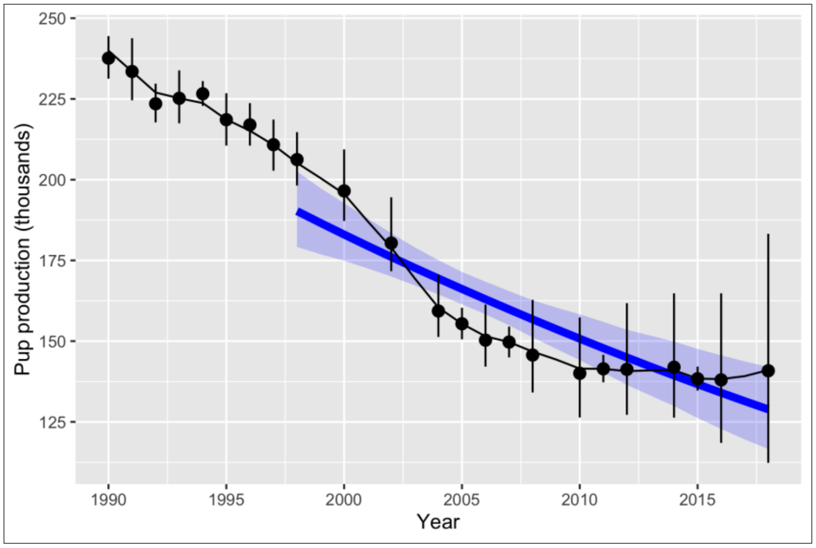

Figure 5. Estimated pup production for the Eastern Pacific stock, 1990-~~2016~~2018, from agTrend (dots), 95% credible interval (bars), agTrend temporal interpolation fit (black line), 1998-~~2016~~2018 average decline (blue line), and 95% credible interval for the fitted average decline in each year (light blue shading).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Pelagic sealing led to a decrease in the fur seal population; however, a moratorium on fur seal harvesting and termination of pelagic sealing resulted in a steady increase in the northern fur seal population from 1912 to 1924. During this period, the rate of population growth was approximately 8.6% (SE = 1.47) per year (A. York, NMFS-AFSC-MML (retired), unpubl. data), the maximum recorded for this species. This growth rate is similar and slightly higher than the 8.1% rate of increase (approximate SE = 1.29) estimated by Gerrodette et al. (1985). Though not as high as growth rates estimated for other fur seal species, the 8.6% rate of increase is considered a reliable estimate of the maximum net productivity rate (R_{MAX}) given the extremely low density of the population in the early 1900s.

POTENTIAL BIOLOGICAL REMOVAL

PBR is defined as the product of the minimum population estimate, one-half the maximum estimated net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for depleted stocks under the Marine Mammal Protection Act (MMPA) (NMFS 2016). Thus, for the Eastern Pacific stock, PBR ~~=~~is ~~11,295~~11,067 northern fur seals (~~525,333~~514,738 × 0.043 × 0.5).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals between ~~2013~~2014 and ~~2017~~2018 is listed, by marine mammal stock, in ~~Delean et al. (2020)~~Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. The minimum estimated mean annual level of human-caused mortality and serious injury for the Eastern Pacific stock between ~~2013~~2014 and ~~2017~~2018 is ~~399~~387 northern fur seals: ~~2.2~~2.6 in U.S. commercial fisheries, 2.6 in unknown (commercial, recreational, or subsistence) fisheries, ~~6.8~~7.8 in marine debris, 0.6 due to other causes (car strike, dog attack, oil/tar), and ~~387~~373 in the Alaska Native subsistence harvest. These mortality and serious injury data do not reflect the total potential threat of entanglement, since additional northern fur seals initially considered seriously injured due to entanglement in fishing gear or marine debris were disentangled and released with non-serious injuries between ~~2013~~2014 and ~~2017~~2018 (see details in the text and in ~~Delean et al. 2020~~Young et al. in press). Assignment of mortality and serious injury to both the Eastern Pacific and California stocks of northern fur seals, when events occur in the area and time of year where the two stocks overlap (off the U.S. west coast in December through May), may result in overestimating stock specific mortality and serious injury. Additional potential threats most likely to result in direct human-caused mortality or serious injury of this stock include the increased potential for oil spills due to an increase in vessel traffic in Alaska waters (with changes in sea-ice coverage).

Fisheries Information

Information ~~on~~for federally-managed and state-managed U.S. commercial fisheries in Alaska waters ~~(including observer programs, observer coverage, and observed incidental takes of marine mammals)~~ is ~~presented~~available in Appendi~~ces~~x 3~~-6~~ of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

Between ~~2013~~2014 and ~~2017~~2018, incidental mortality and serious injury of northern fur seals was observed in one of the federally-managed U.S. commercial fisheries in Alaska monitored for incidental mortality and serious injury by fisheries observers: the Bering Sea/Aleutian Islands flatfish trawl fishery (Table 2; Breiwick 2013; MML, unpubl. data). The minimum estimated mean annual mortality and serious injury rate in this fishery between ~~2013~~2014 and ~~2017~~2018 is ~~0.4~~0.8 northern fur seals.

Observer programs for Alaska State-managed commercial fisheries have not documented any mortality or serious injury of northern fur seals ~~(Wynne et al. 1991, Manly 2007)~~.

Table 2. Summary of incidental mortality and serious injury of Eastern Pacific northern fur seals due to U.S. commercial fisheries between ~~2013~~2014 and ~~2017~~2018 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix ~~6~~3 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality (CV)	Mean estimated annual mortality
Bering Sea/Aleutian Is. flatfish trawl	~~2013~~ 2014 2015 2016 2017 2018	obs data	~~100~~ 100 100 99 100 100	~~0~~ 1 0 0 1 2	~~0~~ 1 (0.04) 0 0 1 (0.03) 2 (0.03)	~~0.4~~0.8 (CV = ~~0.03~~0.02)
Minimum total estimated annual mortality						~~0.4~~0.8 (CV = ~~0.03~~0.02)

Entanglements of northern fur seals have been observed on St. Paul, St. George, and Bogoslof Islands. Since 2011, there has been an increased effort to include entanglement reports in the NMFS Alaska Region stranding database. A summary of entanglements in fishing gear reported between ~~2013~~2014 and ~~2017~~2018 is provided in Table 3 (~~Delean et al. 2020~~Young et al. in press). These mortality and serious injury estimates result from an actual count of verified human-caused deaths and serious injuries and are minimums because not all entangled animals strand nor are all stranded animals found, reported, or have the cause of death determined. Three northern fur seals entangled in commercial Bering Sea/Aleutian Islands halibut longline gear and six northern fur seals entangled in commercial Bering Sea/Aleutian Islands trawl gear were reported to the NMFS Alaska Region marine mammal stranding network between ~~2013~~2014 and ~~2017~~2018, resulting in minimum mean annual mortality and serious injury rates of 0.6 and 1.2 northern fur seals, respectively, in these fisheries (Table 3; ~~Delean et al. 2020~~Young et al. in press).

A~~n~~ ~~additional~~total of seven northern fur seals ~~were~~ initially considered to be seriously injured due to entanglement in commercial Bering Sea/Aleutian Islands trawl gear (one in 2014), Bering Sea/Aleutian Islands trawl gear (one in 2015), unidentified trawl gear (three in 2016), and unidentified net (one each in 2016 and 2017)~~; however, because these animals~~ were disentangled and released with non-serious injuries (~~Delean et al. 2020~~Young et al. in press), therefore, they were not included in the mean annual mortality and serious injury rate for ~~2013~~2014 to ~~2017~~2018.

The total mean annual mortality and serious injury rate incidental to U.S. commercial fisheries between ~~2013~~2014 and ~~2017~~2018 is ~~2.2~~2.6 northern fur seals (~~0.4~~0.8 from observer data + 1.8 from stranding data).

The minimum mean annual mortality and serious injury rate due to entanglements in gillnet (0.4), unidentified fishing gear (0.2), unidentified fishing net (0.2), and trawl gear (~~0.6~~0.8) in Alaska waters between ~~2013~~2014 and ~~2017~~2018 totaled ~~1.4~~1.6 northern fur seals (Table 3; ~~Delean et al. 2020~~Young et al. in press). These entanglements cannot be assigned to a specific fishery, and it is unknown whether commercial, recreational, or subsistence fisheries are the source of the fishing debris.

The Eastern Pacific northern fur seal stock can occur off the west coast of the continental U.S. in winter/spring; therefore, any mortality or serious injury of northern fur seals reported off the coasts of Washington, Oregon, or California during December through May is assigned to both the Eastern Pacific and California stocks of northern fur seals (~~see~~as noted in Table 3). Reports to the NMFS West Coast Region marine mammal stranding network between ~~2013~~2014 and ~~2017~~2018 resulted in ~~a~~ minimum mean annual mortality and serious injury rates of ~~1.2~~one northern fur seal~~s~~ ~~from~~ entangle~~ments~~d in trawl gear ~~(1)~~ and 0.2 entangled in unidentified fishing net ~~(0.2)~~ from unknown (commercial, recreational, or subsistence) fisheries off the U.S. west coast in December through May (Table 3; ~~Delean et al. 2020~~Young et al. in press). ~~This~~These mortality and serious injury estimates result~~s~~ from an actual count of verified human-caused deaths and serious injuries and ~~is a~~are minimums because not all entangled animals strand nor are all stranded animals found, reported, or have the cause of death determined

Table 3. Summary of mortality and serious injury of Eastern Pacific northern fur seals, by year and type, reported to the NMFS Alaska Region and NMFS West Coast Region marine mammal stranding networks between ~~2013~~2014 and ~~2017~~2018 (~~Delean et al. 2020~~Young et al. in press). Animals that were disentangled and released with non-serious injuries have been excluded from this table.

Cause of injury	~~2013~~	2014	2015	2016	2017	2018	Mean annual mortality
Entangled in commercial Bering Sea/Aleutian Is. halibut longline gear	~~0~~	3	0	0	0	0	0.6
Entangled in commercial Bering Sea/Aleutian Is. trawl gear	~~0~~	6	0	0	0	0	1.2
Entangled in Bering Sea/Aleutian Is. trawl gear*	~~0~~	0	1	0	0	0	0.2
Entangled in Bering Sea/Aleutian Is. gillnet gear*	~~0~~	0	1	0	0	0	0.2
Entangled in Bering Sea/Aleutian Is. unidentified fishing gear*	~~0~~	0	1	0	0	0	0.2
Entangled in gillnet*	~~0~~	1	0	0	0	0	0.2
Entangled in unidentified net*	~~0~~	1 + 1[a]	0	0	0	0	0.2 + 0.2[a]
Entangled in trawl gear*	~~0~~	2[a]	0	1	1 + 3[a]	1	~~0.4 + 1[a]~~ 0.6 + 1[a]
Entangled in marine debris	~~1~~	11	0	9	13	6	~~6.8~~7.8
Struck by car	~~0~~	0	1	0	0	0	0.2
Dog attack	~~0~~	0	0	1[a]	0	0	0.2[a]
Oil/tar	~~0~~	1[a]	0	0	0	0	0.2[a]
Total in commercial fisheries							1.8
*Total in unknown (commercial, recreational, or subsistence) fisheries							~~2.6~~2.8
Total in marine debris							~~6.8~~7.8
Total due to other ~~sources~~causes (car strike, dog attack, oil/tar)							0.6

[a]The mortality or serious injury occurred off the coast of Washington, Oregon, or California in December through May and was assigned to both the Eastern Pacific and California stocks of northern fur seals.

Alaska Native Subsistence/Harvest Information

NMFS signed agreements with the Tribal Government of St. Paul Island (2000) and the Traditional Council of St. George Island (2001) to co-manage Steller sea lions and northern fur seals. These co-management agreements promote full and equal participation by Alaska Natives in decisions affecting the subsistence management of northern fur seals (to the maximum extent allowed by law) as a tool for conserving northern fur seal populations in

Alaska (https://www.fisheries.noaa.gov/alaska/marine-mammal-protection/co-management-marine-mammals-alaska, accessed August 2020). Alaska Natives residing on the Pribilof Islands are allowed an annual subsistence harvest of northern fur seals, with a 3-year take range based on historical local needs. Typically, only juvenile males are taken in the subsistence harvest, which results in a much smaller impact on population growth than a harvest that includes females. However, accidental harvesting of females ~~and adult males~~ does occur. The accidental harvest of female northern fur seals between ~~2013~~2014 and ~~2017~~2018 included ~~three females on St. Paul Island in 2013 (Lestenkof et al. 2014),~~ four females on St. Paul Island (Melovidov et al. 2014) and one on St. George Island (Kashevarof 2014~~b~~) in 2014, two on St. Paul in 2015 (Lestenkof et al. 2015), and one on St. Paul in 2016 (Melovidov et al. 2017). The harvest of northern fur seal pups on St. George Island between ~~2013~~2014 and ~~2017~~2018, beginning with the inaugural pup harvest in 2014, included 54 pups in 2014 (Testa 2016), 57 in 2015 (Meyer 2016), 46 in 2016 (Meyer 2017), ~~and~~ 51 in 2017 (Meyer 2018), and 26 in 2018 (Meyer 2019). Between ~~2013~~2014 and ~~2017~~2018, the average annual subsistence harvest of northern fur seals on the Pribilof Islands was ~~387~~373 fur seals (Table 4).

Table 4. Summary of the Alaska Native subsistence harvest of northern fur seals on St. Paul and St. George Islands between ~~2013~~2014 and ~~2017~~2018.

Year	St. Paul	St. George	Total harvested
~~2013~~	~~301[a]~~	~~80[b]~~	~~381~~
2014	266[~~c~~a]	158[~~d, e~~b, c]	424
2015	314[~~f~~d]	118[~~g, h~~e, f]	432
2016	309[~~i~~g]	83[~~j, k~~h, i]	392
2017	217[~~l~~j]	89[~~m, n~~k, l]	306
2018	225[m]	88[n,o]	313
Mean annual harvest			~~387~~373

~~[a]Lestenkof et al. (2014); [b]Kashevarof (2014a);~~ [~~c~~a]Melovidov et al. (2014); [~~d~~b]Kashevarof (2014~~b~~); [~~e~~c]Testa (2016); [~~f~~d]Lestenkof et al. (2015); [~~g~~e]Kashevarof (2016), [~~h~~f]Meyer (2016); [~~i~~g]Melovidov et al. (2017); [~~j~~h]Testa (2018); [~~k~~i]Meyer (2017); [~~l~~j]NMFS, unpubl. data; [~~m~~k]Lekanof (2017); [~~n~~l]Meyer (2018); [m]Lestenkof et al. (2019), [n]Malavansky (2019); [o]Meyer (2019).

Other Mortality

Intentional killing of northern fur seals by commercial fishermen, sport fishermen, and others may occur, but the magnitude of that mortality is unknown.

Because the Eastern Pacific and California stocks of northern fur seals overlap off the west coast of the continental U.S. during December through May, non-fishery mortality and serious injury reported off the coast of Washington, Oregon, or California during that time is assigned to both stocks (see details in Table 3). Reports to the NMFS Alaska Region and West Coast Region stranding networks between ~~2013~~2014 and ~~2017~~2018 resulted in mean annual mortality and serious injury rates of ~~6.8~~7.8 northern fur seals due to entanglement in marine debris in Alaska waters, 0.2 due to a car strike on St. Paul Island, and 0.2 each due to a dog attack and oil/tar in California (Table 3; ~~Delean et al. 2020~~Young et al. in press). These mortality and serious injury estimates result from an actual count of verified human-caused deaths and serious injuries and are minimums because not all entangled animals strand nor are all stranded animals found, reported, or have the cause of death determined

An additional ~~20~~29 northern fur seals that were initially considered seriously injured due to entanglement in marine debris (four in 2014, six in 2015, six in 2016, ~~and~~ four in 2017, and 9 in 2018) were disentangled and released with non-serious injuries (~~Delean et al. 2020~~Young et al. in press); therefore, these animals were not included in the mean annual mortality and serious injury rate for ~~2013~~2014 to ~~2017~~2018.

STATUS OF STOCK

Based on currently available data, the minimum estimate of the mean annual U.S. commercial fishery-related mortality and serious injury rate for this stock (~~2.2~~2.6 northern fur seals) is less than 10% of the calculated PBR (10% of PBR = ~~1,130~~1,107 northern fur seals) and, therefore, can be considered insignificant and approaching a zero mortality and serious injury rate. The minimum estimated mean annual level of human-caused mortality and serious injury (~~399~~387 northern fur seals) does not exceed the PBR (~~11,295~~11,067) for this stock. The PBR calculation assumes mortality is evenly distributed across males, females, and each age class; but that is not the case with the subsistence harvest, which accounts for most of the known direct human-caused mortality. The subsistence harvest is almost entirely sub-adult males and male pups and, therefore, has a relatively low impact on the population due to the disproportionate importance of females to the population. Thus, non-breeding male-biased mortality up to the maximum levels authorized for subsistence use does not represent a significant risk to the Eastern

Pacific northern fur seal stock.~~ Human-caused mortality and serious injury are well below PBR and the population is still declining; thus, it is unlikely that human-caused mortality and serious injury are causing the decline.~~ The northern fur seal was designated as depleted under the MMPA in 1988 because population levels had declined to less than 50% of levels observed in the late 1950s (1.8 million animals; 53 FR 17888, 18 May 1988). The Eastern Pacific stock of northern fur seals is classified as a strategic stock because it is designated as depleted under the MMPA.

There are key uncertainties in the assessment of the Eastern Pacific stock of northern fur seals. The abundance estimate is based on pup counts multiplied by a constant; this constant was based on northern fur seal demographic information which is now quite dated and it is unknown whether the constant is still optimum for this population. Because an estimate of variance cannot be determined, the N_{MIN} calculation uses a default CV of 0.2. At this time, the cause of the decline of this stock is unknown. Estimates of human-caused mortality and serious injury from stranding data are underestimates because not all animals strand nor are all stranded animals found, reported, or have the cause of death determined.

HABITAT CONCERNS

A number of natural and human-related factors have been suggested as contributing to the continued decline in abundance of the Eastern Pacific stock of northern fur seals, including environmental perturbation, disease, predation, contaminants, indirect effects of commercial fishing, incidental take, poaching, and the effects of human presence and development at or near fur seal rookeries (NMFS 2007). The concentration of fur seals on the breeding islands and in the surrounding waters of the Bering Sea during summer, and their broad pelagic distribution across the North Pacific Ocean over the winter, complicates the understanding of these factors and the ability to implement effective management strategies. However, the population trends at the Pribilof Islands are of significant concern, with declines in stock abundance continuing to be driven by the declines on St. Paul Island rookeries; pup production at St. George Island has stabilized (Figs. 2 and 3). The Pribilof Island communities, particularly St. Paul, have developed a fishery-based economy since the cessation of the commercial fur harvest in 1985. Harbor development and expansion from 1985 to present, and the economic growth resulting from the now well-established fisheries, has increased the potential exposure of fur seals to construction activities, vessel and vehicle traffic, seafood and municipal waste discharge, and human presence. Management measures are in place to help ameliorate some of these threats around the fur seal breeding and resting sites (e.g., regulatory closures that prohibit unauthorized human access beyond posted fur seal breeding and resting sites from 1 June to 15 October each year, establishment of Aircraft Advisory Zones and Requested Aircraft Flight Paths, and new subsistence use regulations).

Northern fur seals from each island, and even from central breeding areas within each island, may also experience dissimilar exposure to varying environmental and foraging conditions across the Bering Sea; northern fur seals from different central breeding areas consistently use different foraging habitat (Robson et al. 2004, Sterling and Ream 2004, Call et al. 2008, Kuhn et al. 2014). Climate change could alter the abundance, distribution, and makeup of available prey for northern fur seals in the Bering Sea as a result of reduced sea ice and warming temperatures. These changes could differentially impact the survival and reproduction of individuals and breeding aggregations on the three islands; however, the exact mechanisms are unknown and there are no clear management actions that could be taken to address the impacts on northern fur seals.

Commercial fisheries target fur seal prey and prey that compete with fur seals in both the Bering Sea and the North Pacific Ocean.~~Northern fur seals are described as generalist or opportunistic foragers consuming a wide variety of midwater shelf and mesopelagic fish and squid species.~~ Northern fur seals predominantly prey on ~~W~~walleye pollock ~~is the predominant prey of northern fur seals foraging~~ over the Bering Sea shelf, and progressively greater proportions of oceanic fish and squid are consumed when they forage over the slope and in off-shelf waters (Zeppelin and Ream 2006).~~ Analyses of scats collected from Pribilof Island rookeries from 1987 to 2000 found that pollock (46-75% by frequency of occurrence, FO) and gonatid squids dominated in the diet and that other primary prey (FO >5%) included Pacific sand lance, Pacific herring, northern smoothtongue, Atka mackerel, and Pacific salmon (Zeppelin and Ream 2006, Zeppelin and Orr 2010). These analyses also found that diets associated with rookery complexes reflected patterns associated with foraging in the specific hydrographic domains identified by Robson et al. (2004).~~ Comparison of ingested prey sizes based on scat and spew analysis indicates an ~~much larger~~ overlap between sizes of pollock consumed by Pribilof Island northern fur seals and those caught by the commercial trawl fishery~~ than was previously known~~, suggesting possible competition between fur seals and commercial fisheries for pollock (Gudmundson et al. 2006). In contrast to northern fur seals from the Pribilof Islands, Bogoslof Island northern fur seals forage in the deeper water of the Bering Sea Basin and their diet is ~~Analysis of Bogoslof Island northern fur seal diet found that it~~ comprised primarily of off-shelf species (northern smoothtongue, squid, myctophids) as well as juvenile walleye pollock (Zeppelin and Orr 2010, Kuhn et al. 2014).

Our understanding of the consequences of commercial fisheries removals on northern fur seal survival and productivity is highly uncertain. Current research is looking at the bioenergetics of female fur seals at two different sites.

Environmental conditions and exposure to human activities vary across the range of habitats used by northern fur seals. Robson et al. (2004) and Kuhn et al. (2014) found that lactating female northern fur seals from different groups of breeding rookeries on St. Paul and St. George Islands consistently use different foraging habitats. Sterling and Ream (2004) found that juvenile male northern fur seals from different haulouts also exhibit foraging habitat segregation and found evidence of separation between the sexes. Call et al. (2008) also found lactating female northern fur seals had three types of individual foraging route tactics as they depart from the rookery, which is important to consider in the context of adaptation to changes in environmental conditions and prey distributions. From 1982 to 2016, pup production declined on St. Paul and St. George Islands (Figs. 2 and 3). However, it remains unclear whether the pattern of declines in northern fur seal pup production on the two Pribilof Islands is related to natural or anthropogenic changes in the northern fur seals' summer foraging habitat. In contrast, Bogoslof Island northern fur seals that forage in the deeper water of the Bering Sea Basin have shown dramatic increases in pup production (Fig. 4). Bogoslof Island experienced substantial volcanic activity beginning in December 2016 and continuing through the summer northern fur seal breeding season until September 2017. Volcanic activity involved explosive eruptions and ash emissions and dramatically changed the size and shape of the island. Live northern fur seals, including pups, were observed on land in photographs taken during both July and August 2017, but population level impacts on northern fur seals at Bogoslof Island are unknown. Adult female northern fur seals from Bogoslof Island and the Pribilof Islands spend approximately 8 months in varied regions of the North Pacific Ocean during winter and forage in areas associated with eddies and the subarctic-subtropical transition region (Ream et al. 2005). Thus, environmental changes in the North Pacific Ocean could potentially be affecting abundance and productivity of northern fur seals breeding in Alaska.

A variety of human activities other than commercial fishing, including vessel traffic and possible oil spills, may impact northern fur seals. A Conservation Plan for the Eastern Pacific stock was released in December 2007 (NMFS 2007). This plan reviews known and potential threats to the recovery of northern fur seals in Alaska.

CITATIONS

Baker, J. D., G. A. Antonelis, C. W. Fowler, and A. E. York. 1995. Natal site fidelity in northern fur seals, *Callorhinus ursinus*. Anim. Behav. 50(1):237-247.

Bower, W. T. 1920. Alaska fisheries and fur industries in 1919. U.S. Dep. Commer., Appendix IX to Report of U.S. Commissioner of Fisheries for 1919. Bureau of Fisheries Document No. 891. Washington Government Printing Office. 160 p.

Breiwick, J. M. 2013. North Pacific marine mammal bycatch estimation methodology and results, 2007-2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-260, 40 p.

Briggs, L., and C. W. Fowler. 1984. Table and figures of the basic population data for northern fur seals of the Pribilof Islands. *In* Background papers submitted by the United States to the 27th annual meeting of the Standing Scientific Committee of the North Pacific Fur Seal Commission, March 29-April 9, 1984, Moscow, U.S.S.R. Available from Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Call, K. A., R. R. Ream, D. Johnson, J. T. Sterling, and R. G. Towell. 2008. Foraging route tactics and site fidelity of adult female northern fur seal (*Callorhinus ursinus*) around the Pribilof Islands. Deep-Sea Res. II 55:1883-1896.

Chapman, D. G., and A. M. Johnson. 1968. Estimation of fur seal pup populations by randomized sampling. Trans. Am. Fish. Soc. 97:264-270.

Delean, B. J., V. T. Helker, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, J. Jannot, and N. C. Young. 2020. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2013-2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-401, 86 p.

DeLong, R. L. 1982. Population biology of northern fur seals at San Miguel Island, California. Ph.D. Dissertation, University of California, Berkeley, CA. 185 p.

DeLong, R. L., and G. A. Antonelis. 1991. Impacts of the 1982-1983 El Niño on the northern fur seal population at San Miguel Island, California, p. 75-83. *In* F. Trillmich and K. Ono (eds.), Pinnipeds and El Niño: Responses to Environmental Stress. University of California Press, Berkeley, CA.

DeMaster, D. P. 1998. Minutes from the sixth meeting of the Alaska Scientific Review Group, 21-23 October 1997, Seattle, Washington. 40 p. Available from Alaska Fisheries Science Center, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Dickerson B. R., R. R. Ream, S. N. Vignieri, and P. Bentzen. 2010. Population structure as revealed by mtDNA and microsatellites in northern fur seals, *Callorhinus ursinus*, throughout their range. PLoS ONE 5(5):e10671. DOI: dx.doi.org/10.1371/journal.pone.0010671 .

Dizon, A. E., C. Lockyer, W. F. Perrin, D. P. DeMaster, and J. Sisson. 1992. Rethinking the stock concept: a phylogeographic approach. Conserv. Biol. 6:24-36.

Fiscus, C. F. 1983. Fur seals. *In* Background papers submitted by the United States to the 26th annual meeting of the Standing Scientific Committee of the North Pacific Fur Seal Commission, Washington, DC, 28 March-5 April, 1983. Available from Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Gerrodette, T., D. Goodman, and J. Barlow. 1985. Confidence limits for population projections when vital rates vary randomly. Fish. Bull., U.S. 83:207-217.

Gudmundson, C. J., T. K. Zeppelin, and R. R. Ream. 2006. Application of two methods for determining diet of northern fur seals (*Callorhinus ursinus*). Fish. Bull., U.S. 104:445-455.

Johnson, D. S., and L. Fritz. 2014. agTrend: a Bayesian approach for estimating trends of aggregated abundance. Methods Ecol. Evol. 5:1110-1115. DOI: dx.doi.org/10.1111/2041-210X.12231 .

Kajimura, H. 1984. Opportunistic feeding of the northern fur seal, *Callorhinus ursinus*, in the eastern North Pacific Ocean and eastern Bering Sea. U.S. Dep. Commer., NOAA Tech. Rep. NMFS SSRF-779, 49 p.

~~Kashevarof, H. 2014a. Northern fur seal harvests, St. George Island, AK: harvest report for the 2013 season 7.8.2013-8.7.2013. Aleut Community of St. George Island, St. George Traditional Council, Kayumixtax Eco-Office, St. George Island, Pribilof Islands, AK. 4 p.~~

Kashevarof, H. 2014~~b~~. Northern fur seal harvests, St. George Island, AK: harvest report for the 2014 season 7.7.2014-8.8.2014. Aleut Community of St. George Island, St. George Traditional Council, Kayumixtax Eco-Office, St. George Island, Pribilof Islands, AK. 3 p.

Kashevarof, H. 2016. Northern fur seal harvests, St. George Island, AK: harvest report for the 2015 season 7.7.2015-8.7.2015. Aleut Community of St. George Island, St. George Traditional Council, Kayumixtax Eco-Office, St. George Island, Pribilof Islands, AK.

Kenyon K. W., and F. Wilke. 1953. Migration of the northern fur seal, *Callorhinus ursinus*. J. Mammal. 34(1):86-98.

Kuhn, C. E., R. R. Ream, J. T. Sterling, J. R. Thomason, and R. G. Towell. 2014. Spatial segregation and the influence of habitat on the foraging behavior of northern fur seals (*Callorhinus ursinus*). Can. J. Zool. 92:861-873.

Lander, R. H. 1981. A life table and biomass estimate for Alaskan fur seals. Fish. Res. (Amst.) 1:55-70.

Lander, R. H., and H. Kajimura. 1982. Status of northern fur seals. FAO Fisheries Series 5:319-345.

Lekanof, D. 2017. Northern fur seal harvests, St. George Island, AK: harvest report for the 2017 season 07/10/2017-08/08/2017. Aleut Community of St. George Island, St. George Traditional Council, Kayumixtax Eco-Office, St. George Island, Pribilof Islands, AK.

~~Lestenkof, P. M., P. I. Melovidov, and M. Rukovishnikoff. 2014. The subsistence harvest of subadult northern fur seals on St. Paul Island, Alaska in 2013. Aleut Community of St. Paul Island, Tribal Government, Ecosystem Conservation Office, St. Paul Island, Pribilof Islands, AK. 17 p.~~

Lestenkof, P. M., P. I. Melovidov, and A. P. Lestenkof. 2015. The subsistence harvest of subadult northern fur seals on St. Paul Island, Alaska in 2015. Aleut Community of St. Paul Island, Tribal Government, Ecosystem Conservation Office, St. Paul Island, Pribilof Islands, AK. 16 p.

Lestenkof, P. M., L. M. Divine, P. I. Melovidov, A. P. Lestenkof, V. M. Padula, and K. M. Melovidov. 2019. The subsistence harvest of subadult laaqudan (northern fur seals) on St. Paul Island, Alaska in 2018. Aleut Community of St. Paul Island, Tribal Government, Ecosystem Conservation Office, St. Paul Island, Pribilof Islands, AK. 16 p.

Loughlin, T. R., W. J. Ingraham, Jr., N. Baba, and B. W. Robson. 1999. Use of a surface-current model and satellite telemetry to assess marine mammal movements in the Bering Sea. University of Alaska Sea Grant Press, AK-SG-99-03, Fairbanks, AK.

Malavansky, A. 2019. Northern fur seal harvests, St. George Island, AK: harvest report for the 2018 season 06/21/2018-08/08/2018. Aleut Community of St. George Island, St. George Traditional Council, Kayumixtax Eco-Office, St. George Island, Pribilof Islands, AK.

~~Manly, B. F. J. 2007. Incidental take and interactions of marine mammals and birds in the Kodiak Island salmon set gillnet fishery, 2002 and 2005. Final Report to Alaska Marine Mammal Observer Program, NMFS Alaska Region. 221 p.~~

Melovidov, P. I., P. M. Lestenkof, M. Rukovishnikoff, Sr., and D. V. V. Roberts. 2014. The subsistence harvest of subadult northern fur seals on St. Paul Island, Alaska in 2014. Aleut Community of St. Paul Island, Tribal Government, Ecosystem Conservation Office, St. Paul Island, Pribilof Islands, AK. 16 p.

Melovidov, P. I., P. M. Lestenkof, A. P. Lestenkof, L. M. Divine, and R. M. Rukovishnikoff. 2017. The subsistence harvest of subadult northern fur seals on St. Paul Island, Alaska in 2016. Aleut Community of St. Paul Island, Tribal Government, Ecosystem Conservation Office, St. Paul Island, Pribilof Islands, AK. 14 p. + appendices.

Meyer, B. 2016. Harvest monitoring services, subsistence harvest of northern fur seals on St. George Island, AK: harvest report for the 2015 season September 15 to November 30, 2015. Aleut Community of St. George Island, St. George Traditional Council, Kayumixtax Eco-Office, St. George Island, Pribilof Islands, AK.

Meyer, B. 2017. Harvest monitoring services, subsistence harvest of northern fur seals on St. George Island, AK: harvest report for the 2016 season September 16 to November 30, 2016. Aleut Community of St. George Island, St. George Traditional Council, Kayumixtax Eco-Office, St. George Island, Pribilof Islands, AK.

Meyer, B. 2018. Harvest monitoring services, subsistence harvest of northern fur seals on St. George Island, AK: harvest report for the 2017 season September 15 to November 30, 2017. Aleut Community of St. George Island, St. George Traditional Council, Kayumixtax Eco-Office, St. George Island, Pribilof Islands, AK. 5 p.

Meyer, B. 2019. Young of the year subsistence harvest of northern fur seals on St. George Island, AK: harvest report for the 2018 season September 15 to November 30. Aleut Community of St. George Island, St. George Traditional Council, Kayumixtax Eco-Office, St. George Island, Pribilof Islands, AK. 8 p.

National Marine Fisheries Service (NMFS). 1993. Final conservation plan for the northern fur seal (*Callorhinus ursinus*). Prepared by the National Marine Mammal Laboratory, Alaska Fisheries Science Center, Seattle, WA, and the Office of Protected Resources, National Marine Fisheries Service, Silver Spring, MD. 80 p.

National Marine Fisheries Service (NMFS). 2007. Conservation plan for the Eastern Pacific stock of northern fur seal (*Callorhinus ursinus*). National Marine Fisheries Service, Alaska Regional Office, Juneau, AK.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed ~~December 2019~~August 2020.

Ream, R. R. 2002. Molecular ecology of northern otariids: genetic assessment of northern fur seal and Steller sea lion distributions. Ph.D. Dissertation, University of Washington, Seattle, WA. 134 p.

Ream, R. R., J. T. Sterling, and T. R. Loughlin. 2005. Oceanographic features related to northern fur seal migratory movements. Deep-Sea Res. II 52:823-843.

Robson, B. R., M. E. Goebel, J. D. Baker, R. R. Ream, T. R. Loughlin, R. C. Francis, G. A. Antonelis, and D. P. Costa. 2004. Separation of foraging habitat among breeding sites of a colonial marine predator, the northern fur seal (*Callorhinus ursinus*). Can. J. Zool. 82:20-29.

Roppel, A. Y. 1984. Management of northern fur seals on the Pribilof Islands, Alaska, 1786-1981. U.S. Dep. Commer., NOAA Tech. Rep. NMFS-4, 32 p.

Sterling, J. T., and R. R. Ream. 2004. At-sea behavior of juvenile male northern fur seals (*Callorhinus ursinus*). Can. J. Zool. 82:1621-1637.

Testa, J. W. (ed.). 2016. Fur seal investigations, 2013-2014. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-316, 124 p.

Testa, J. W. (ed.). 2018. Fur seal investigations, 2015-2016. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-375, 107 p.

Towell, R., and R. Ream. 2012. 2011 northern fur seal pup production estimate on Bogoslof Island, Alaska. Available from Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Towell, R. G., R. R. Ream, and A. E. York. 2006. Decline in northern fur seal (*Callorhinus ursinus*) pup production on the Pribilof Islands. Mar. Mammal Sci. 22(2):486-491.

Wade, P. R., and R. Angliss. 1997. Guidelines for assessing marine mammal stocks: report of the GAMMS Workshop April 3-5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12, 93 p.

~~Wynne, K. M., D. Hicks, and N. Munro. 1991. 1990 salmon gillnet fisheries observer programs in Prince William Sound and South Unimak Alaska. Annual Report NMFS/NOAA Contract 50ABNF000036. 65 p. Available from NMFS, Alaska Region, Office of Marine Mammals, P.O. Box 21668, Juneau, AK 99802.~~

York, A. E. 1987. Northern fur seal, *Callorhinus ursinus*, eastern Pacific population (Pribilof Islands, Alaska, and San Miguel Island, California), p. 9-21. *In* J. P. Croxall and R. L. Gentry (eds.), Status, biology, and ecology of fur seals. Proceedings of an international symposium and workshop, Cambridge, England, 23-27 April 1984. U.S. Dep. Commer., NOAA Tech. Rep. NMFS-51.

York, A. E., and C. W. Fowler. 1992. Population assessment, Pribilof Islands, Alaska, p. 9-26. *In* H. Kajimura and E. Sinclair (eds.), Fur seal investigations, 1990. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-2.

York, A. E., and P. Kozloff. 1987. On estimating the number of fur seal pups born on St. Paul Island, 1980-86. Fish. Bull., U.S. 85:367-375.

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX.

Zeppelin, T. K., and A. J. Orr. 2010. Stable isotope and scat analyses indicate diet and habitat partitioning in northern fur seals, *Callorhinus ursinus*, across the eastern Pacific. Mar. Ecol. Prog. Ser. 409:241-253.

Zeppelin, T. K., and R. R. Ream. 2006. Foraging habitats based on the diet of female northern fur seals (*Callorhinus ursinus*) on the Pribilof Islands, Alaska. J. Zool. 270:565-576.

SPOTTED SEAL (*Phoca largha*): ~~Alaska~~Bering Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Spotted seals are distributed along the continental shelf of the Bering, Chukchi, and Beaufort seas, and the Sea of Okhotsk south to the western Sea of Japan and northern Yellow Sea (Fig. 1). Eight main areas of spotted seal breeding have been reported (Shaughnessy and Fay 1977). On the basis of small samples and preliminary analyses of genetic composition, potential geographic barriers, and significance of breeding groups, Boveng et al. (2009) grouped those breeding areas into three Distinct Population Segments (DPSs): the Bering DPS, which includes breeding areas in the Bering Sea and portions of the East Siberian, Chukchi, and Beaufort seas that may be occupied outside the breeding period; the Okhotsk DPS; and the Southern DPS, which includes spotted seals breeding in the Yellow Sea and Peter the Great Bay in the Sea of Japan. ~~For the purposes of this stock assessment, we define t~~The ~~Alaska~~Bering stock of spotted seals ~~to be that portion of~~is defined as the Bering DPS. This stock assessment considers only the portion of the stock found within U.S. waters bounded by the U.S. Exclusive Economic Zone (EEZ; Fig. 1), because the relevant stock assessment data on abundance and human-caused mortality and serious injury are generally not available for the broader range of the stock or even for waters adjacent to the U.S. EEZ.

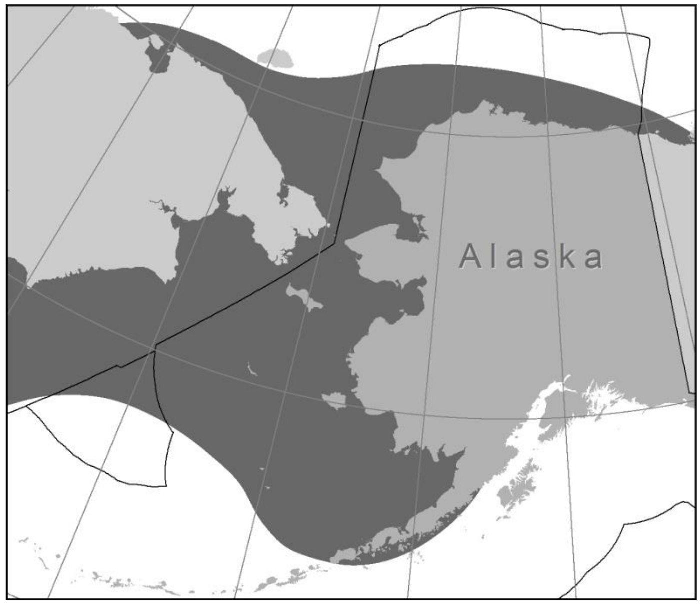

Figure 1. Approximate distribution of spotted seals in the Bering ~~DPS~~stock (dark shaded area), which is defined as the Bering DPS. ~~The Alaska~~This stock ~~is defined as the portion of the Bering DPS~~assessment considers only the portion of the stock occurring within U.S. waters (i.e., the U.S. Exclusive Economic Zone delineated by a black line).

The distribution of spotted seals is seasonally related to specific life-history events that can be broadly divided into two periods: late-fall through spring, when whelping, nursing, breeding, and molting occur in association with the presence of sea ice on which the seals haul out, and summer through fall when seasonal sea ice has melted and most spotted seals use land for hauling out (Boveng et al. 2009, Citta et al. 2018). Satellite-tagging studies showed that seals tagged in the northeastern Chukchi Sea moved south in October and passed through the Bering Strait in November. Seals overwintered in the Bering Sea along the ice edge and made east-west movements along the edge (Lowry et al. 1998). During spring they tend to prefer small floes (i.e., <20 m in diameter), and inhabit mainly the southern margin of the ice in areas where water depth does not exceed 200 m, and move to coastal habitats after molting and the retreat of the sea ice (Fay 1974, Shaughnessy and Fay 1977, Lowry et al. 2000, Simpkins et al. 2003). In summer and fall, spotted seals use coastal haul-out sites regularly (Frost et al. 1993, Lowry et al. 1998) and may be found as far north as 69-72°N in the Chukchi and Beaufort seas (Porsild 1945, Shaughnessy and Fay 1977). To the south, along the west coast of Alaska, spotted seals are known to occur around the Pribilof Islands, Bristol Bay, and the eastern Aleutian Islands. Spotted seals are closely related to, and often mistaken for, Pacific harbor seals (*Phoca vitulina richardii*). The two species are often seen together and are partially sympatric, as their ranges overlap in the southern part of the Bering Sea (Quakenbush 1988). Yet, spotted seals breed earlier and are less social during the breeding season, and only spotted seals are strongly associated with pack ice (Shaughnessy and Fay 1977). These and other ecological, behavioral, genetic, and morphological differences support their recognition as two separate species (Quakenbush 1988, O'Corry-Crowe and Westlake 1997, Berta and Churchill 2012).

~~The following information was considered in classifying stock structure based on the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: geographic distribution continuous; 2) Population response data:~~

~~unknown; 3) Phenotypic data: unknown; 4) Genotypic data: unknown. Based on this limited information, and the absence of any significant fishery interactions, there is currently no strong evidence to suggest splitting Alaska spotted seals into more than one stock. Therefore, only one Alaska stock is recognized in U.S. waters.~~

POPULATION SIZE

In the spring of 2012 and 2013, U.S. and Russian researchers conducted aerial abundance and distribution surveys over the entire ice-covered portions of the Bering Sea ~~(defined as south of 65°45'N) and Sea of Okhotsk~~ (Moreland et al. 2013). Conn et al. (2014), using a ~~very limited~~ sub-sample of the data collected ~~only~~ from the U.S. portion of the Bering Sea in 2012, calculated an abundance estimate of ~~approximately~~ 461,625 spotted seals (95% CI: 388,732-560,348) in those waters. ~~Although the entire Alaska stock of spotted seals is believed to be in the Bering Sea in the spring (Boveng et al. 2009), the proportion of the Alaska stock that occupies U.S. (vs. Russian) waters at that time is not known. As the Conn et al. (2014) estimate is only for the U.S. Bering Sea it is possible that it is a biased estimate of the Alaska stock, but the direction of any bias cannot be determined at this time.~~Although this is a preliminary abundance estimate it is also the best available and it is a reasonable estimate for the entire portion of the Bering spotted seal stock in U.S. waters because relatively few spotted seals are expected north of the Bering Strait during the surveys.

Minimum Population Estimate

The minimum population estimate (N_{MIN}) for a stock is usually calculated using Equation 1 from the potential biological removal (PBR) guidelines (~~Wade and Angliss 1997~~NMFS 2016): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$, which approximates the 20th percentile of a distribution that is assumed to be log-normal. However, ~~T~~the ~~2012 Bering Sea~~ abundance estimate ~~by~~based on Conn et al. (2014)~~, however,~~ was calculated using a Bayesian hierarchical framework, ~~and~~ so we used the 20th percentile of the posterior distribution of abundance estimates ~~in place of the CV in~~as a more direct estimator of N_{MIN} than Equation 1 to provide an N_{MIN} of 423,237 spotted seals in the U.S. ~~portion of the~~ Bering Sea in the spring.

Current Population Trend

Reliable data on trends in population abundance for the ~~Alaska~~Bering stock of spotted seals or the portion of the stock within U.S. waters are not ~~un~~available.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is not ~~un~~available for the ~~Alaska~~Bering stock of spotted seals or for any portion of the stock within U.S. waters. ~~Hence, u~~Until additional data become available, the default pinniped maximum theoretical net productivity rate ~~(R_{MAX})~~ of 12% will be used for this stock (~~Wade and Angliss 1997~~NMFS 2016).

POTENTIAL BIOLOGICAL REMOVAL

PBR is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is ~~0.5~~1.0, ~~the~~a value that may be used for ~~pinniped~~ stocks ~~with unknown population status~~that are not known to be decreasing and are taken primarily by aboriginal subsistence hunters, provided there have not been recent increases in the levels of takes (~~Wade and Angliss 1997~~NMFS 2016). Using the N_{MIN} ~~calculated from~~based on Conn et al. (2014) for spotted seals in the U.S. portion of the stock, the PBR ~~for the Alaska stock of spotted seals~~ is ~~12,697~~25,394 seals (423,237 × 0.06 × ~~0.5~~1.0).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

~~Detailed i~~Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals ~~in 2011-2015~~between 2014 and 2018 is listed, by marine mammal stock, in ~~Helker et al. (2017)~~Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. The ~~total~~minimum estimated mean annual level of human-caused mortality and serious injury for the portion of the ~~Alaska~~Bering spotted seal~~s~~ stock ~~in 2011-2015~~in U.S. waters between 2014 and 2018 is ~~329~~5,254 seals: ~~0.9~~1 in U.S. commercial fisheries, ~~and 0.2~~0.4 ~~due to mortality~~ incidental to Marine Mammal Protection Act (MMPA)-authorized research ~~(from 2011-2015 data)~~, and ~~328~~5,253 in the Alaska Native subsistence harvest (~~from 2010-2014 data~~average statewide harvest, including struck and lost animals, in 2015, based on a recently published analysis (Nelson et al. 2019) that is higher and likely more accurate than previous estimates; see below). However, the total mortality and serious injury due to commercial fisheries is unknown because some of the reported harbor seal takes in U.S. commercial fisheries may actually have been spotted seals (since it is virtually impossible to distinguish between these two species without genetic analysis), and there have been no observer programs in nearshore Bristol Bay fisheries that are known to interact with spotted seals. Additional potential threats most likely to result in direct human-caused mortality or serious injury of this stock include the increased potential for oil spills due to an increase in vessel traffic in Alaska waters (with changes in sea-ice coverage).

Fisheries Information

~~Detailed i~~Information ~~(including observer programs, observer coverage, and observed incidental takes of marine mammals)~~ for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is ~~presented~~available in Appendi~~ces~~x 3~~-6~~ of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

~~In 2011-2015~~Between 2014 and 2018, incidental mortality and serious injury of spotted seals in U.S. waters occurred in ~~2~~one of the ~~22~~ federally~~-regulated~~managed U.S. commercial fisheries in Alaska monitored for incidental mortality and serious injury by fisheries observers: the Bering Sea/Aleutian Islands flatfish trawl ~~and Bering Sea/Aleutian Islands Pacific cod longline~~ fisheri~~es~~y (Table 1; Breiwick 2013; MML, unpubl. data). This~~.~~ ~~The~~resulted in a minimum estimated ~~minimum~~ mean annual mortality and serious injury rate of one spotted seal incidental to U.S. commercial fisheries between 2014 and 2018, ~~in 2011-2015 is 0.9 spotted seals,~~ based exclusively on observer data.

Mortality and serious injury of harbor seals incidental to U.S. commercial fisheries occurred ~~in 2011-2015~~between 2014 and 2018 and, because it is virtually impossible to distinguish between ~~these two species~~harbor seals and spotted seals without genetic analysis, some of the reported harbor seal takes may actually have been spotted seals. Further, there have been no observer programs on nearshore Bristol Bay fisheries that are known to interact with spotted seals, making the total mortality and serious injury due to fisheries unknown.

Table 1. Summary of incidental mortality and serious injury of ~~Alaska~~Bering spotted seals in U.S. waters due to U.S. commercial fisheries ~~in 2011-2015~~between 2014 and 2018 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix ~~6~~3 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality (CV)	Mean estimated annual mortality
Bering Sea/Aleutian Is. flatfish trawl	~~2011~~ ~~2012~~ ~~2013~~ 2014 2015 2016 2017 2018	obs data	~~99~~ ~~99~~ ~~99~~ ~~99~~100 ~~99~~100 99 100 100	~~0~~ ~~2~~ ~~0~~ 0 ~~1~~2 1 2 0	~~0~~ ~~2~~ ~~0~~ 0 ~~1~~2 (0.03) 1 (0.05) 2 (0.03) 0	~~0.6~~1 (CV = ~~0.03~~0.02)
~~Bering Sea/Aleutian Is. Pacific cod longline~~	~~2011~~ ~~2012~~ ~~2013~~ ~~2014~~ ~~2015~~	~~obs data~~	~~57~~ ~~51~~ ~~66~~ ~~64~~ ~~62~~	~~1~~ ~~0~~ ~~0~~ ~~0~~ ~~0~~	~~1.6~~ ~~0~~ ~~0~~ ~~0~~ ~~0~~	~~0.3~~ ~~(CV = 0.61)~~
Minimum total estimated annual mortality						~~0.9~~1 (CV = ~~0.21~~0.02)

Alaska Native Subsistence/Harvest Information

NMFS signed an agreement with the Ice Seal Committee (ISC; 2006) to co-manage Alaska ice seal populations. This co-management agreement promotes full and equal participation by Alaska Natives in decisions affecting the subsistence management of ice seals (to the maximum extent allowed by law) as a tool for conserving ice seal populations in Alaska (https://www.fisheries.noaa.gov/alaska/marine-mammal-protection/co-management-marine-mammals-alaska, accessed August 2020).

Spotted seals are an important resource for Alaska Native subsistence hunters. Approximately 64 coastal communities in Alaska~~ Native communities in western and northern Alaska~~, from Bristol Bay to the Beaufort Sea, ~~regularly~~ harvest ice seals (~~Ice Seal Committee~~ISC ~~2016~~2019). The ~~Ice Seal Committee~~ISC, as co-managers with NMFS, recognizes the importance of harvest information and has collected it since 2008~~, when funding and personnel have allowed~~. Annual household survey results compiled in a statewide harvest report include historical ice seal harvest information ~~back to~~from 1960 to 2017 (Quakenbush et al. 2009, ISC 2019).~~ This report is used to determine where and how often harvest information has been collected and where to focus in the future (Ice Seal Committee 2016). Information for 2010-2014 is available for 12 communities (Point Lay, Kivalina, Noatak, Buckland, Deering, Emmonak, Scammon Bay, Hooper Bay, Tununak, Quinhagak, Togiak, and Twin Hills) (Table 2), but more than 50 other communities harvest spotted seals and have not been surveyed in this time period or have never been surveyed. Harvest surveys are designed to estimate harvest within the surveyed community, but because of differences in seal availability, cultural hunting practices, and environmental conditions, extrapolating harvest numbers beyond that community is not appropriate. For example, during 2010-2014, only 12 of 64 coastal communities were surveyed for spotted seals and, of those communities, only 5 were surveyed for two or more consecutive years (Ice Seal Committee 2016). Thus, annual community-level harvest estimates totaled across communities provide a partial (i.e., minimum) estimate of annual statewide harvest. The geographic distribution of communities with annual harvest estimates also varies among years, so total annual estimates across communities may be geographically or otherwise biased. During 2010-2014, the minimum annual spotted seal harvest estimates totaled across surveyed communities ranged from 83 (in 2 communities) to 518 spotted seals (in 10 communities) (Table 2). Based on the harvest data from these 12 communities (Table 2), a minimum estimate of the average annual harvest of spotted seals in 2010-2014 is 328 seals. The Ice Seal Committee is working toward a better understanding of ice seal harvest by conducting more consecutive surveys in more communities with a goal to report a statewide ice seal harvest estimate.~~ To estimate the recent subsistence harvest of ice seals, Nelson et al. (2019) used ice seal harvest survey data collected from 1992 to 2014 for 41 of 55 communities that regularly hunt ice seals, as well as the per capita removal estimates (based on the 2015 human population) from the surveyed communities, to estimate the average regional and statewide subsistence harvest (Table 2). The best statewide estimate of the average number of spotted seals harvested in 2015, including struck and lost animals, is 5,253 seals (Nelson et al. 2019). The authors also found stable or decreasing trends in the annual numbers of ice seals harvested (Nelson et al. 2019).

Table 2. Average regional and statewide subsistence harvest (including struck and lost animals) of Bering spotted seals in 2015 (Nelson et al. 2019). See Figure 1 in Nelson et al. (2019) for a list of the communities in each region.

Region	**Average harvest (including struck and lost animals)**
North Slope Borough	89
Maniilaq	507
Kawerak	3,175
Association of Village Council Presidents	1,205
Bristol Bay Native Association	277
Statewide total	5,253

~~**Table 2**. Alaska spotted seal minimum harvest estimates in 2010-2014 (Ice Seal Committee 2016).~~

~~**Community**~~	~~**Estimated spotted seal harvest**~~				
	~~**2010**~~	~~**2011**~~	~~**2012**~~	~~**2013**~~	~~**2014**~~
~~Point Lay~~			~~8~~		
~~Kivalina~~		~~21~~			
~~Noatak~~		~~25~~			
~~Buckland~~		~~84~~			
~~Deering~~		~~3~~			
~~Emmonak~~		~~28~~			
~~Scammon Bay~~		~~56~~	~~53~~		
~~Hooper Bay~~	~~71~~	~~57~~	~~46~~	~~61~~	~~27~~
~~Tununak~~	~~96~~	~~100~~	~~51~~		
~~Quinhagak~~	~~179~~	~~78~~	~~128~~	~~195~~	~~56~~
~~Togiak[1]~~	~~132~~	~~66~~			
~~Twin Hills[1]~~	~~18~~				
~~Minimum total~~	~~496~~	~~518~~	~~286~~	~~256~~	~~83~~

~~[1]Spotted seals or harbor seals.~~

Other Mortality

~~Beginning in mid-July 2011, elevated numbers of sick or dead pinnipeds, primarily ringed seals, with skin lesions were discovered in the Arctic and Bering Strait regions. By December 2011, there were more than 100 cases of affected pinnipeds, including spotted seals, ringed seals, bearded seals, and walruses in northern and western Alaska. Due to the unusual number of marine mammals discovered with similar symptoms across a wide geographic area, NMFS and the USFWS declared a Northern Pinniped Unusual Mortality Event (UME) on 20 December 2011 (https://alaskafisheries.noaa.gov/pr/ice-seals, accessed December 2017). Since 2014, few new cases similar to those observed in 2011 have been seen, but the UME investigation remains open for spotted seals based on continuing reports of ice seals with patchy hair loss (alopecia). Some of these seals may be survivors of the 2011 mortality event. No specific cause for the disease has been identified.~~

Mortality and serious injury may occasionally occur incidental to marine mammal research activities authorized under MMPA permits issued to a variety of government, academic, and other research organizations. ~~In~~Between 2014 and 2018, there ~~was~~were ~~one~~two reports of ~~a~~ mortality incidental to research on the ~~Alaska~~Bering stock of spotted seals (one each in 2014 and 2016), resulting in a mean annual mortality and serious injury rate of ~~0.2~~0.4 spotted seals from this stock ~~in 2011-2015~~ (Table 3~~) (Helker et al. 2017~~; Young et al. in press).

In 2011, NMFS and the U.S. Fish and Wildlife Service declared an Unusual Mortality Event (UME) for pinnipeds in the Bering and Chukchi seas, due to the unusual number of sick or dead seals and walruses discovered with skin lesions, bald patches, and other symptoms. The UME occurred from 1 May 2011 to 31 December 2016 and primarily affected ice seals, including ringed seals, bearded seals, ribbon seals, and spotted seals. The investigation concluded that the skin and hair symptoms were signs of a molt abnormality; however, no infectious disease agent or environmental cause for the UME symptoms and mortality was identified (https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events, accessed August 2020). Patchy baldness and delayed molt, however, continue to be observed in limited numbers (<20 per year) of harvested and beachcast ringed seals, bearded seals, ribbon seals, and spotted seals in Alaska.

Since 1 June 2018, elevated numbers of ice seal strandings have occurred in the Bering and Chukchi seas in Alaska and NMFS declared a UME for bearded seals, ringed seals, and spotted seals from 1 June 2018 to present in the Bering and Chukchi seas (https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events, accessed August 2020). As of 31 July 2020, 298 ice seal strandings of all age classes have been reported, including 88 bearded seals, 72 ringed seals, 49 spotted seals, and 89 unidentified seals. A subset of seals has been sampled for genetics and harmful algal bloom exposure and a few have had histopathology samples collected.

Table 3. Summary of mortality and serious injury of ~~Alaska~~Bering spotted seals in U.S. waters, by year and type, reported to the NMFS Office of Protected Resources ~~in 2011-2015~~between 2014 and 2018 (~~Helker et al. 2017~~Young et al. in press).

Cause of injury	~~2011~~	~~2012~~	~~2013~~	2014	2015	2016	2017	2018	Mean annual mortality
Incidental to MMPA-authorized research~~-related~~	~~0~~	~~0~~	~~0~~	1	0	1	0	0	~~0.2~~0.4
Total incidental to MMPA-authorized research									~~0.2~~0.4

STATUS OF STOCK

The Bering ~~S~~spotted seal~~s~~ stock ~~in Alaska are~~is not designated as depleted under the MMPA or listed as threatened or endangered under the Endangered Species Act (ESA). NMFS completed a comprehensive status review of the spotted seal under the ESA in 2009 (Boveng et al. 2009) and concluded that listing the Bering DPS of spotted seals, which corresponds to the Bering stock of spotted seals, was not warranted at that time (73 FR 51615, 20 October 2009). The Bering stock of spotted seals is not considered a strategic stock. The best estimate of the mean annual level of human-caused mortality and serious injury in the portion of the stock in U.S. waters is 5,254 spotted seals, which is less than the PBR (25,394 seals). ~~Based on available data, t~~The minimum estimated mean annual rate of U.S. commercial fishery-related mortality and serious injury ~~rate for this stock~~ (~~0.9~~one seal) is less than 10% of the ~~calculated~~ PBR (10% of PBR = ~~1,270~~2,539) and, therefore, can be considered ~~to be~~ insignificant and approaching a zero mortality and serious injury rate. ~~The PBR of the Alaska stock (i.e., portion of the Bering DPS that occurs in U.S. waters) is 12,697 spotted seals. The total estimated annual level of human-caused mortality and serious injury is 329 spotted seals. The Alaska stock of spotted seals is not considered a strategic stock.~~ Population trends and status of this stock relative to its Optimum Sustainable Population are unknown.

There are key uncertainties in the assessment of the ~~Alaska~~Bering stock of spotted seals. ~~Though the entire Alaska stock is believed to be in the Bering Sea in the spring, the proportion that occupies U.S. (vs. Russian) waters at that time is not known.~~ The 2012 Bering Sea abundance estimate by Conn et al. (2014) was calculated using only a sub-sample of the survey data and may be biased. ~~As such, it is possible that using the Conn et al (2014) abundance estimates to describe the entire Alaska stock may be biased.~~ Further, the sample size available for genetics analysis was small so there could be additional stock structure within the ~~Alaska~~Bering stock. Nearshore commercial fisheries are not observed, and fishery-related mortality and serious injury in these fisheries could occur undetected. ~~Similarly, the estimates of harvest by Alaska Natives are taken from surveys of only a fraction of the communities known to harvest marine mammals and so are considered minimum estimates.~~ Based on the best available information, spotted seals are likely to be moderately sensitive to climate change.

HABITAT CONCERNS

The main concern about the conservation status of spotted seals ~~stems from the likelihood that their preferred sea ice habitats are being modified by the warming climate~~is long-term habitat loss and modification resulting from climate change (Boveng et al. 2009). Laidre et al. (2008) concluded that on a worldwide basis spotted seals were likely to be moderately sensitive to climate change, based on an analysis of various life-history features that could be affected by climate. ~~Scientific projections are for continued and perhaps accelerated warming (Boveng et al. 2009). Despite the recent dramatic reductions in Arctic Ocean ice extent during summer~~Climate models consistently project substantial reductions in both the extent and timing of sea ice within the range of spotted seals in Alaska waters; however, the sea ice in the Bering Sea is expected to continue forming annually in winter for the foreseeable future. Spotted seals are associated with sea ice during the periods of reproduction and molting. The presence of sea ice is considered a requirement for whelping and nursing young, providing a platform out of the water to facilitate these life-history events. Similarly, the molt is believed to be promoted by elevated skin temperatures that, in polar regions, can only be achieved when seals haul out of the water. There will likely be more frequent years in which ice coverage is reduced, resulting in a decline in the long-term average ice extent, but Bering Sea spotted seals will likely continue to encounter sufficient ice to support adequate vital rates. Even if sea ice were to vanish completely from the Bering Sea, there may be prospects for spotted seals to adjust their breeding grounds to follow the northward shift of the annual ice front into the Chukchi Sea. ~~Laidre et al. (2008) concluded that on a~~

~~worldwide basis spotted seals were likely to be moderately sensitive to climate change, based on an analysis of various life history features that could be affected by climate.~~

A second major concern, driven primarily by the production of carbon dioxide (CO_2) emissions, is the modification of habitat by ocean acidification, which may alter prey populations and other important aspects of the marine ecosystem. Ocean acidification, a result of increased CO_2 in the atmosphere, may affect spotted seal survival and recruitment through disruption of trophic regimes that are dependent on calcifying organisms. The nature and timing of such impacts are extremely uncertain. As described in Boveng et al. (2009), changes in spotted seal prey, anticipated in response to ocean warming and loss of sea ice, have the potential for negative impacts, but the possibilities are complex. Ecosystem responses may have very long lags as they propagate through trophic webs. Because of spotted seals' apparent dietary flexibility, this threat should be of less immediate concern than the direct effects of sea-ice degradation ~~(Boveng et al. 2009)~~.

Additional habitat concerns include the potential effects from increased shipping (particularly in the Bering Strait), such as disturbance from vessel traffic ~~or~~and the potential for oil spills.

CITATIONS

Berta, A., and M. Churchill. 2012. Pinniped taxonomy: review of currently recognized species and subspecies, and evidence used for their description. Mammal Rev. 42(3):207-234.

Boveng, P. L., J. L. Bengtson, T. W. Buckley, M. F. Cameron, S. P. Dahle, B. P. Kelly, B. A. Megrey, J. E. Overland, and N. J. Williamson. 2009. Status review of the spotted seal (*Phoca largha*). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-200, 153 p.

Breiwick, J. M. 2013. North Pacific marine mammal bycatch estimation methodology and results, 2007-2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-260, 40 p.

Citta, J. J., L. F. Lowry, L. T. Quakenbush, B. P. Kelly, A. S. Fischbach, J. M. London, C. V. Jay, K. J. Frost, G. O'Corry-Crowe, J. A. Crawford, P. L. Boveng, M. Cameron, A. L. Von Duyke, M. Nelson, L. A. Harwood, P. Richard, R. Suydam, M. P. Heide-Jørgensen, R. C. Hobbs, D. I. Litovka, M. Marcoux, A. Whiting, A. S. Kennedy, J. C. George, J. Orr, and T. Gray. 2018. A multi-species synthesis of satellite telemetry data in the Pacific Arctic (1987–2015): overlap of marine mammal distributions and core use areas. Deep-Sea Res. II 152:132-153 . DOI: dx.doi.org/10.1016/j.dsr2.2018.02.006 .

Conn, P. B., J. M. Ver Hoef, B. T. McClintock, E. E. Moreland, J. M. London, M. F. Cameron, S. P. Dahle, and P. L. Boveng. 2014. Estimating multispecies abundance using automated detection systems: ice-associated seals in the Bering Sea. Methods Ecol. Evol. 5:1280-1293. DOI: dx.doi.org/10.1111/2041-210X.12127 .

~~Dizon, A. E., C. Lockyer, W. F. Perrin, D. P. DeMaster, and J. Sisson. 1992. Rethinking the stock concept: a phylogeographic approach. Conserv. Biol. 6:24-36.~~

Fay, F. H. 1974. The role of ice in the ecology of marine mammals of the Bering Sea, p. 383-399. *In* D. W. Hood and E. J. Kelley (eds.), Oceanography of the Bering Sea. University of Alaska Fairbanks, Institute of Marine Science, Occasional Publication 2.

Frost, K. J., L. F. Lowry, and G. Carroll. 1993. Beluga whale and spotted seal use of a coastal lagoon system in the northeastern Chukchi Sea. Arctic 46:8-16.

~~Helker, V. T., M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. 2017. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2011-2015. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-354, 112 p.~~

Ice Seal Committee (ISC). ~~2016~~2019. The subsistence harvest of ice seals in Alaska – a compilation of existing information, 1960-~~2014~~2017. ~~76~~86 p. Available online: http://www.north-slope.org/departments/wildlife-management/co-management-organizations/ice-seal-committee . Accessed August 2020.

Laidre, K. L., I. Stirling, L. Lowry, Ø. Wiig, M. P. Heide-Jørgensen, and S. Ferguson. 2008. Quantifying the sensitivity of arctic marine mammals to climate-induced habitat change. Ecol. Appl. 18(2):S97-S125.

Lowry, L. F., K. J. Frost, R. Davis, D. P. DeMaster, and R. S. Suydam. 1998. Movements and behavior of satellite-tagged spotted seals (*Phoca largha*) in the Bering and Chukchi Seas. Polar Biol. 19:221-230.

Lowry, L. F., V. N. Burkanov, K. J. Frost, M. A. Simpkins, A. Springer, D. P. DeMaster, and R. Suydam. 2000. Habitat use and habitat selection by spotted seals (*Phoca largha*) in the Bering Sea. Can. J. Zool. 78:1959-1971.

Moreland, E., M. Cameron, and P. Boveng. 2013. Bering Okhotsk Seal Surveys (BOSS), joint U.S.-Russian aerial surveys for ice-associated seals, 2012-13. Alaska Fisheries Science Center Quarterly Report (July-August-September 2013):1-6.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed August 2020.

Nelson, M. A., L. T. Quakenbush, B. D. Taras, and Ice Seal Committee. 2019. Subsistence harvest of ringed, bearded, spotted, and ribbon seals in Alaska is sustainable. Endang. Species Res. 40:1-16. DOI: dx.doi.org/10.3354/esr00973 .

O'Corry-Crowe, G. M., and R. L. Westlake. 1997. Molecular investigations of spotted seals (*Phoca larhga*) and harbor seals (*P. vitulina*), and their relationships in areas of sympatry, p. 291-304. *In* A. E. Dizon, S. J. Chivers, and W. F. Perrin (eds.), Molecular Genetics of Marine Mammals. The Society for Marine Mammalogy, Spec. Publ. 3.

Porsild, A. E. 1945. Mammals of the Mackenzie Delta. Can. Field-Nat. 59:4-22.

Quakenbush, L. T. 1988. Spotted seal, *Phoca largha*, p. 107-124. *In* J. W. Lentfer (ed.), Selected Marine Mammals of Alaska: Species Accounts with Research and Management Recommendations. Marine Mammal Commission, Washington, DC.

Quakenbush, L., J. Citta, and J. Crawford. 2009. Biology of the spotted seal (*Phoca largha*) in Alaska from 1962 to 2008. Report to NMFS. Arctic Marine Mammal Program, Alaska Department of Fish and Game, Fairbanks, AK. 66 p.

Shaughnessy, P. D., and F. H. Fay. 1977. A review of the taxonomy and nomenclature of North Pacific harbour seals. J. Zool. (Lond.) 182:385-419.

Simpkins, M. A., L. M. Hiruki-Raring, G. Sheffield, J. M. Grebmeier, and J. L. Bengtson. 2003. Habitat selection by ice-associated pinnipeds near St. Lawrence Island, Alaska in March 2001. Polar Biol. 26:577-586.

~~Wade, P. R., and R. Angliss. 1997. Guidelines for assessing marine mammal stocks: report of the GAMMS Workshop April 3-5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12, 93 p.~~

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC.

BEARDED SEAL (*Erignathus barbatus nauticus*): ~~Alaska~~Beringia Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Bearded seals are a boreoarctic species with a circumpolar distribution (Fedoseev 1965; Johnson et al. 1966; Burns 1967, 1981; Burns and Frost 1979; Smith 1981; Kelly 1988). Their normal range extends from the Arctic Ocean (85°N) south to Sakhalin Island (45°N) in the Pacific Ocean and south to Hudson Bay (55°N) in the Atlantic Ocean (Allen 1880, Ognev 1935, King 1983). Bearded seals inhabit the seasonally ice-covered seas of the Northern Hemisphere, where they whelp and rear their pups and molt their coats on the ice in the spring and early summer. Bearded seals feed primarily on benthic organisms, including epifaunal and infaunal invertebrates, and demersal fishes and are closely linked to areas where the seafloor is shallow (less than 200 m).

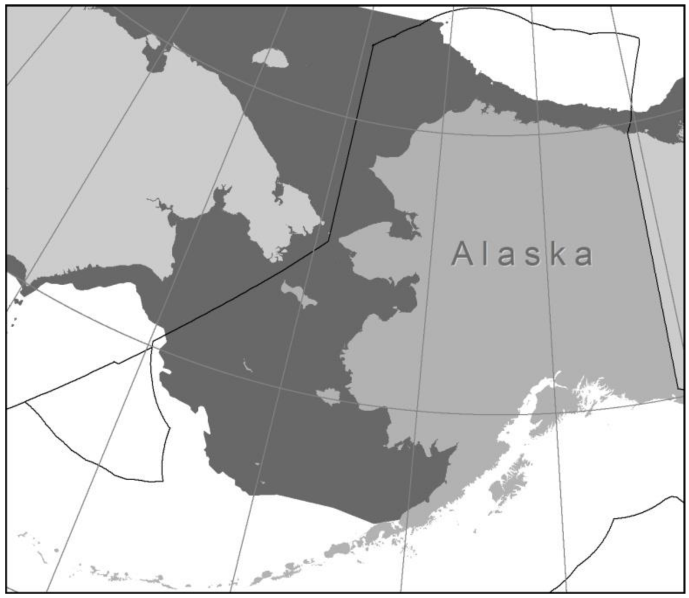

Figure 1. The ~~Alaska~~Beringia ~~stock of~~ bearded seal stock is defined as the ~~portion of the~~ Beringia DPS of the *E. B. nauticus* subspecies (dark shaded area~~s~~). This stock assessment considers only the portion of the stock occurring in U.S. waters (i.e., ~~T~~the U.S. Exclusive Economic Zone ~~is~~ delineated by a black line).

Two subspecies have been described: *Erignathus barbatus barbatus* from the Laptev Sea, Barents Sea, North Atlantic Ocean, and Hudson Bay (Rice 1998); and *E. b. nauticus* from the remaining portions of the Arctic Ocean, the Bering Sea, and the Sea of Okhotsk (Ognev 1935, Scheffer 1958, Manning 1974, Heptner et al. 1976). The geographic distributions of these subspecies are not separated by conspicuous gaps, and there are regions of intergrading generally described as somewhere along the northern Russian and central Canadian coasts. NMFS defined longitude 145°E as the Eurasian delineation between the two subspecies and 130°W in western Canada as the North American delineation between the two subspecies (Cameron et al. 2010; 77 FR 76740, 28 December 2012). Based on evidence for discreteness and ecological uniqueness of bearded seals in the Sea of Okhotsk, under the Endangered Species Act (ESA) the *E. b. nauticus* subspecies was further divided into an Okhotsk Distinct Population Segment (DPS) and a Beringia DPS (77 FR 76740), so named because the continental shelf waters of the Bering, Chukchi, Beaufort, and East Siberian seas that are the bearded seals' range in this region overlie much of the land bridge that was exposed during the last glaciation, which has been referred to as Beringia. This stock is defined as the Beringia DPS; however, ~~For the purposes of~~ this stock assessment~~, we define the Alaska stock of bearded seals to be that~~ considers only the portion of the Beringia ~~DPS~~stock found with~~in~~ U.S. waters bounded by the U.S. Exclusive Economic Zone (EEZ; Fig. 1), because the relevant stock assessment data on abundance and human-caused mortality and serious injury are generally not available for the broader range of the stock or even for waters adjacent to the U.S. EEZ.

Spring surveys conducted in 1999 and 2000 along the Alaska coast indicate that bearded seals are typically more abundant 20-100 nautical miles (nmi) from shore than within 20 nmi from shore, except for high concentrations nearshore to the south of Kivalina (Bengtson et al. 2000, 2005; Simpkins et al. 2003). Many seals that winter in the Bering Sea move north through the Bering Strait from late April through June and spend the summer in the Chukchi Sea (Burns 1967, 1981). Bearded seal sounds (produced by adult males) have been recorded nearly year-round (peak occurrence in December-June, when sea-~~-~~ice concentrations were >50%) at multiple locations in the Bering, Chukchi, and Beaufort seas, and calling behavior is closely related to the presence of sea ice (MacIntyre et al. 2013, 2015; Jimbo et al. 2019). The overall summer distribution is quite broad, with seals rarely hauled out on land, and some seals, mostly juveniles, may not follow the ice northward but remain near the coasts of the Bering and Chukchi seas (Burns 1967, 1981; Heptner et al. 1976; Nelson 1981; Cameron et al. 2018). As the ice forms again in the fall and winter, most seals move south with the advancing ice edge through the Bering Strait into the Bering Sea where they spend the winter (Burns and Frost 1979; Frost et al. 2005, 2008; Cameron and Boveng 2007, 2009; Breed et al. 2018;

Cameron et al. 2018). This southward migration is less noticeable and predictable than the northward movements in late spring and early summer (Burns and Frost 1979, Burns 1981, Kelly 1988). During winter, the central and northern parts of the Bering Sea shelf have the highest densities of bearded seals (Fay 1974, Heptner et al. 1976, Burns and Frost 1979, Braham et al. 1981, Burns 1981, Nelson et al. 1984, Citta et al. 2018). In late winter and early spring, bearded seals are widely, but not uniformly, distributed in the broken, drifting pack ice ranging from the Chukchi Sea to the ice front in the Bering Sea. In these areas, they tend to avoid the coasts and areas of fast ice (Burns 1967, Burns and Frost 1979).

POPULATION SIZE

Although a reliable population estimate for the entire stock is not available, ~~but research programs have developed~~ survey methods ~~that~~ have been ~~used to determine abundance estimates for part of the range~~developed and applied to substantial portions of the stock's range in U.S. waters. In the spring of 2012 and 2013, U.S. and Russian researchers conducted aerial abundance and distribution surveys over the entire ice-covered portions of the Bering Sea ~~and Sea of Okhotsk~~ (Moreland et al. 2013). Conn et al. (2014), using a ~~very limited~~ sub-sample of the data collected from the U.S. portion of the Bering Sea in 2012, calculated an abundance estimate of 301,836 bearded seals (95% CI: 238,195-371,147) in those waters. Researchers expect to provide a population estimate for the entire ~~Alaska stock~~U.S. portion of the bearded seal stock once the final Bering Sea results are combined with the results from spring surveys of the Chukchi Sea (conducted in 2016) and Beaufort Sea (planned for ~~2020~~2021).

Minimum Population Estimate

~~The~~A minimum population estimate (N_{MIN}) for the entire U.S. portion of the stock cannot be determined because reliable abundance estimates are not yet available for the Chukchi and Beaufort seas. Using the 2012 Bering Sea ~~abundance~~density estimate by Conn et al. (2014), however, we are able to calculate an N_{MIN} of 273,676 bearded seals in the U.S. Bering Sea. The N_{MIN} for a stock is usually calculated using Equation 1 from the potential biological removal (PBR) guidelines (NMFS 2016): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{1/2})$, which approximates the 20th percentile of a distribution that is assumed to be log-normal. However, ~~T~~the abundance estimate ~~by~~based on Conn et al. (2014) was calculated using a Bayesian hierarchical framework~~, however~~, so we used the 20th percentile of the posterior distribution of abundance estimates ~~in place of the CV in~~as a more direct estimator of N_{MIN} than Equation 1. This N_{MIN} is negatively biased as an estimator of the Beringia bearded seal stock, and even the U.S. portion of the stock, because the estimate is based solely on the Bering Sea and, therefore, doesn't include the many bearded seals that inhabit the Chukchi and Beaufort seas (e.g., Bengtson et al. 2005, Laidre et al. 2015).

Current Population Trend

Reliable data on trends in population abundance for the ~~Alaska~~Beringia stock of bearded seals or the portion of the stock within U.S. waters are not ~~un~~available.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is not ~~un~~available for the ~~Alaska~~Beringia stock of bearded seals or any portion of the stock within U.S. waters. Until additional data become available, the default pinniped maximum theoretical net productivity rate of 12% will be used for this stock (NMFS 2016).

POTENTIAL BIOLOGICAL REMOVAL

PBR is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for pinniped stocks listed as threatened under the ESA (NMFS 2016). Using the negatively biased N_{MIN} ~~calculated~~ for bearded seals in the ~~Bering Sea~~U.S. portion of the Beringia stock, ~~a~~ PBR ~~for bearded seals that overwinter and breed in the U.S. Bering Sea =~~is 8,210 seals (273,676 × 0.06 × 0.5). ~~However, this is not an estimate of~~This PBR ~~for the entire stock because a reliable estimate of~~is negatively biased because of its dependence on the negatively biased N_{MIN} estimate~~is not available for the entire stock; i.e., N_{MIN} is not available for the Chukchi and Beaufort seas~~.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals between ~~2013~~2014 and ~~2017~~2018 is listed, by marine mammal stock, in ~~Delean et al. (2020)~~Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. The minimum estimated mean annual level of human-caused mortality and serious injury for the portion of the ~~Alaska~~Beringia bearded seal stock in U.S. waters between ~~2013~~2014 and ~~2017~~2018 is ~~551~~6,709 seals: ~~1.6~~1.8 in U.S. commercial fisheries, ~~549~~6,707 in the Alaska Native subsistence harvest (average statewide harvest, including struck and lost animals, in 2015, based on a recently published analysis (Nelson et al. 2019) that is higher and likely more accurate than previous estimates; see below), and 0.4 due to Marine Mammal Protection Act (MMPA)-authorized research-related permanent removals from the population.~~ This is a minimum estimate of the Alaska Native subsistence harvest because only a small proportion of the communities that harvest ice seals are surveyed each year.~~ Additional potential threats most likely to result in direct human-caused mortality or serious injury of this stock include the increased potential for oil spills due to an increase in vessel traffic in Alaska waters (with changes in sea-ice coverage).

Fisheries Information

Information ~~(including observer programs, observer coverage, and observed incidental takes of marine mammals)~~ for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is ~~presented~~available in Appendi~~ces~~x 3~~-6~~ of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

Between ~~2013~~2014 and ~~2017~~2018, incidental mortality and serious injury of bearded seals in U.S. waters occurred in ~~three~~two of the federally-managed U.S. commercial fisheries in Alaska monitored for incidental mortality and serious injury by fisheries observers: the Bering Sea/Aleutian Islands pollock trawl~~,~~ and Bering Sea/Aleutian Islands flatfish trawl~~, and Bering Sea/Aleutian Islands Pacific cod trawl~~ fisheries (Table 1; Breiwick 2013; MML, unpubl. data). The minimum estimated mean annual mortality and serious injury rate incidental to U.S. commercial fisheries between ~~2013~~2014 and ~~2017~~2018 is ~~1.6~~1.8 bearded seals, based exclusively on observer data.

Table 1. Summary of incidental mortality and serious injury of ~~Alaska~~Beringia bearded seals in U.S. waters due to U.S. commercial fisheries between ~~2013~~2014 and ~~2017~~2018 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix ~~6~~3 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality (CV)	Mean estimated annual mortality
Bering Sea/Aleutian Is. pollock trawl	~~2013~~ 2014 2015 2016 2017 2018	obs data	~~98~~ 98 99 99 99 99	~~0~~ 1 0 0 1 0	~~0~~ 1.0 (0.14) 0 0 1.0 (0.1) 0	0.4 (CV = 0.09)
Bering Sea/Aleutian Is. pollock trawl	2016	obs data	99	1*	N/A	0.2 (CV = N/A)
Bering Sea/Aleutian Is. flatfish trawl	~~2013~~ 2014 2015 2016 2017 2018	obs data	~~100~~ 100 100 99 100 100	~~0~~ 1 2 1 1 1	~~0~~ 1 (0.05) 2 (0.03) 1 (0.05) 1 (0.04) 1 (0.05)	1.2 (CV = 0.02)
~~Bering Sea/Aleutian Is. Pacific cod trawl~~	~~2013~~ ~~2014~~ ~~2015~~ ~~2016~~ ~~2017~~	~~obs data~~	~~80~~ ~~80~~ ~~72~~ ~~68~~ ~~68~~	~~1~~ ~~0~~ ~~0~~ ~~0~~ ~~0~~	~~1~~ ~~0~~ ~~0~~ ~~0~~ ~~0~~	~~0.2~~ ~~(CV = 0.03)~~
Minimum total estimated annual mortality						~~1.6~~1.8 (CV = 0.03)

*This seal was discovered during a vessel offload. Because it could not be associated with a haul number, it was not included in the bycatch estimate for the fishery.

Alaska Native Subsistence/Harvest Information

NMFS signed an agreement with the Ice Seal Committee (ISC; 2006) to co-manage Alaska ice seal populations. This co-management agreement promotes full and equal participation by Alaska Natives in decisions affecting the subsistence management of ice seals (to the maximum extent allowed by law) as a tool for conserving ice seal populations in Alaska (https://www.fisheries.noaa.gov/alaska/marine-mammal-protection/co-management-marine-mammals-alaska, accessed August 2020).

Bearded seals are an important resource for Alaska Native subsistence hunters. Approximately 64 coastal communities in Alaska, from Bristol Bay to the Beaufort Sea, ~~regularly~~ harvest ice seals (~~Ice Seal Committee~~ISC 2019). The ~~Ice Seal Committee~~ISC, as co-managers with NMFS, recognizes the importance of harvest information and has collected it since 2008. Annual household survey results compiled in a statewide harvest report include historical ice seal harvest information from 1960 to 2017 (Quakenbush et al. 2011, ~~Ice Seal Committee~~ISC 2019). ~~Bearded seal harvest information for 2013 to 2017 is available for 12 communities (see Table 2). However, a number of other communities harvest ice seals and were not surveyed between 2013 and 2017, including a few communities that have never been surveyed.~~

~~Household harvest surveys are designed to estimate the harvest within each surveyed community, but because of differences in bearded seal availability, cultural hunting practices, and environmental conditions, it is not appropriate to extrapolate harvest numbers beyond that community. The number of communities surveyed and successive annual surveys in the same communities have also been limited. For example, between 2013 and 2017, only 12 of a possible 64 coastal communities were surveyed for ice seal harvest; and, of the 12 communities, only 2 were surveyed for two or more consecutive years (Ice Seal Committee 2019). Thus, annual community-level harvest estimates totaled across communities provide a partial (i.e., minimum) estimate of annual statewide harvest. The geographic distribution of communities with annual harvest estimates also varies among years, so total annual estimates across communities may be geographically or otherwise biased. Between 2013 and 2017, the minimum annual bearded seal harvest estimates totaled across surveyed communities ranged from 114 (in a year that only one community was surveyed) to 1,906 bearded seals (in a year that seven communities were surveyed) (Table 2). Based on the available harvest data from these 12 communities (Table 2), a minimum estimate of the average annual bearded seal harvest between 2013 and 2017 is 549 seals. The Ice Seal Committee is working for a better understanding of ice seal harvest by conducting more consecutive surveys in more communities and one of their goals is to report a statewide ice seal harvest estimate.~~To estimate the recent subsistence harvest of ice seals, Nelson et al. (2019) used ice seal harvest survey data collected from 1992 to 2014 for 41 of 55 communities that regularly hunt ice seals, as well as the per capita removal estimates (based on the 2015 human population) from the surveyed communities, to estimate the average regional and statewide subsistence harvest (Table 2). The best statewide estimate of the average number of bearded seals harvested in 2015, including struck and lost animals, is 6,707 seals (Nelson et al. 2019). The authors also found stable or decreasing trends in the annual numbers of ice seals harvested (Nelson et al. 2019).

Table 2. Average regional and statewide subsistence harvest (including struck and lost animals) of Beringia bearded seals in 2015 (Nelson et al. 2019). See Figure 1 in Nelson et al. (2019) for a list of the communities in each region.

Region	**Average harvest (including struck and lost animals)**
North Slope Borough	1,031
Maniilaq	1,038
Kawerak	3,248
Association of Village Council Presidents	1,360
Bristol Bay Native Association	30
Statewide total	6,707

~~**Table 2.** Alaska bearded seal minimum harvest estimates between 2013 and 2017 (Ice Seal Committee 2019). Empty cells represent the years in which the communities were not surveyed for harvest information.~~

~~**Community**~~	~~**Bearded seal minimum harvest estimates**~~				
	~~**2013**~~	~~**2014**~~	~~**2015**~~	~~**2016**~~	~~**2017**~~
~~Nuiqsut~~		~~26~~			
~~Utqiaġvik (formerly Barrow)~~		~~1,070~~			
~~Point Hope~~		~~183~~			
~~Kotzebue~~		~~228~~			
~~Deering~~	~~29~~				
~~Shishmaref~~		~~319~~			
~~Scammon Bay~~	~~82~~				
~~Hooper Bay~~	~~171~~	~~64~~	~~148~~	~~118~~	~~114~~
~~Tununak~~				~~19~~	
~~Tuntutuliak~~	~~53~~				
~~Eek~~	~~17~~				
~~Quinhagak~~	~~49~~	~~16~~		~~38~~	
~~Minimum total~~	~~401~~	~~1,906~~	~~148~~	~~175~~	~~114~~

Other Mortality

Permanent removals from the population may occasionally occur during marine mammal research activities authorized under MMPA permits issued to a variety of government, academic, and other research organizations. Between ~~2013~~2014 and ~~2017~~2018, two research-related permanent removals (one seal each in 2014 and 2015) were reported for the ~~Alaska~~Beringia stock of bearded seals (~~Delean et al. 2020~~Young et al. in press; Table 3), resulting in a mean annual rate of 0.4 bearded seals.

In 2011, NMFS and the U.S. Fish and Wildlife Service declared an Unusual Mortality Event (UME) for pinnipeds in the Bering and Chukchi seas, due to the unusual number of sick or dead seals and walruses discovered with skin lesions, bald patches, and other symptoms. The UME occurred from 1 May 2011 to 31 December 2016 and primarily affected ice seals, including ringed seals, bearded seals, ribbon seals, and spotted seals. The investigation concluded that the skin and hair symptoms were signs of a molt abnormality; however, no infectious disease agent or environmental cause for the UME symptoms and mortality was identified (~~https://www.fisheries.noaa.gov/alaska/marine-life-distress/diseased-ice-seals~~https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events, accessed ~~December 2019~~August 2020). Patchy baldness and delayed molt, however, continue to be observed in limited numbers (<20 per year) of harvested and beachcast ringed seals, bearded seals, ribbon seals, and spotted seals in Alaska.

Since 1 June 2018, elevated numbers of ice seal strandings have occurred in the Bering and Chukchi seas in Alaska and NMFS declared a UME for bearded seals, ringed seals, and spotted seals from 1 June 2018 to present in the Bering and Chukchi seas (https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events, accessed August 2020). As of 31 July 2020, 298 ice seal strandings of all age classes have been reported, including 88 bearded seals, 72 ringed seals, 49 spotted seals, and 89 unidentified seals. A subset of seals has been sampled for genetics and harmful algal bloom exposure and a few have had histopathology samples collected.

Table 3. Summary of mortality and serious injury of ~~Alaska~~Beringia bearded seals, by year and type, reported to the NMFS Alaska Region marine mammal stranding network and NMFS Office of Protected Resources between ~~2013~~2014 and ~~2017~~2018 (~~Delean et al. 2020~~Young et al. in press).

Cause of Injury	~~2013~~	2014	2015	2016	2017	2018	Mean annual mortality
MMPA-authorized research-related permanent removals	~~0~~	1	1	0	0	0	0.4
Total MMPA-authorized research-related permanent removals							0.4

STATUS OF STOCK

On 28 December 2012, NMFS listed the Beringia DPS bearded seal (*E. b. nauticus*)~~ and, thus,~~ which corresponds to the ~~Alaska~~Beringia stock of bearded seals, as threatened under the ESA (77 FR 76740). The primary concern for this population is the ongoing and projected loss of sea-ice cover ~~stemming~~resulting from climate change, which is expected to pose a significant threat to the persistence of these seals in the foreseeable future (based on projections through the end of the 21st century: Cameron et al. 2010). Because of its threatened status under the ESA, this stock is designated as depleted under the MMPA and is classified as a strategic stock. ~~A minimum~~The best estimate of the mean annual level of human-caused mortality and serious injury in the portion of the stock in U.S. waters is ~~551~~6,709 bearded seals, which is less than the negatively biased PBR of 8,210 seals~~ calculated for only those bearded seals that overwinter and breed in the U.S. portion of the Bering Sea~~. The minimum estimated mean annual rate of U.S. commercial fishery-related mortality and serious injury (~~1.6~~1.8 seals) is less than 10% of the PBR (10% of PBR = 821)~~ calculated for U.S. waters~~ and, therefore, can be considered insignificant and approaching a zero mortality and serious injury rate. Population trends and status of this stock relative to its Optimum Sustainable Population are unknown.

There are key uncertainties in the assessment of the ~~Alaska~~Beringia stock of bearded seals. Abundance and mortality and serious injury estimates are not available for the vast majority of the stock's range. Within U.S. waters, where abundance estimates are being developed and data are currently available on mortality and serious injury in commercial fisheries and the Alaska Native subsistence harvest, key abundance estimates for the Beaufort and Chukchi seas are not yet available. ~~and t~~The negatively biased N_{MIN} used here, based on a 2012 Bering Sea ~~abundance~~density estimate ~~by~~from Conn et al. (2014), was calculated using only a ~~limited~~ sub-sample of the data and may be biased as an estimate for the U.S. waters of the Bering Sea. Also, it represents just a portion of the population of bearded seals in U.S. waters and is, therefore, not very reliable for comparison with mortality and serious injury numbers for the entire U.S. portion of the stock.~~ Similarly, counts of harvest by Alaska Natives are taken from surveys conducted in a few recent years for a fraction of the communities known to harvest marine mammals and so are considered minimum estimates.~~ Based on the best available information, bearded seals are likely to be highly sensitive to climate change.

HABITAT CONCERNS

The main concern about the conservation status of bearded seals ~~stems from the likelihood that a warming climate is reducing their preferred sea-ice habitats~~is long-term habitat loss and modification resulting from climate change (77 FR 76740, 28 December 2012).~~ Scientific projections are for continued and perhaps accelerated warming (Cameron et al. 2010).~~ Laidre et al. (2008) concluded that on a worldwide basis bearded seals were likely to be highly sensitive to climate change, based on an analysis of various life-history features that could be affected by climate. Climate models consistently project substantial reductions in both the extent and timing of sea ice within the range of bearded seals in Alaska waters (Cameron et al. 2010). ~~For b~~Bearded seals are closely associated with sea ice, particularly during the periods of reproduction and molting. ~~t~~The presence of sea ice is considered a requirement for whelping and nursing young. Similarly, the molt is believed to be promoted by elevated skin temperatures that, in polar regions, can only be achieved when seals haul out of the water. ~~Thus, i~~If suitable ice cover is absent from shallow feeding areas during times of peak whelping and nursing (April/May)~~,~~ or molting (May/June and sometimes through August), bearded seals would be forced to seek either sea-ice habitat over deeper waters (perhaps with poor access to food) or onshore haul-out sites (perhaps with increased risks of disturbance, predation, and competition). Both scenarios would require bearded seals to adapt to novel (i.e., potentially suboptimal) conditions~~,~~ and to exploit habitats to which they may not be well adapted, likely compromising their reproduction and survival rates.~~ A reliable assessment for the future conservation status of each bearded seal DPS requires a focus on projections of specific regional conditions, especially sea ice. End of century projections for the Bering Sea in April-May suggest that there~~

~~will be sufficient ice only in small zones in the Gulf of Anadyr and in the area between St. Lawrence Island and the Bering Strait. Suitable ice in June in the Bering Sea is predicted to disappear as early as mid-century. To adapt to this regime, bearded seals would likely have to shift their nursing, rearing, and molting areas to the ice-covered seas north of the Bering Strait (Cameron et al. 2010). Laidre et al. (2008) also concluded that on a worldwide basis bearded seals were likely to be highly sensitive to climate change, based on an analysis of various life history features that could be affected by climate.~~

A second major concern, driven primarily by the production of carbon dioxide (CO_2) emissions, is the modification of habitat by ocean acidification, which may alter prey populations and other important aspects of the marine ecosystem. Ocean acidification, a result of increased CO_2 in the atmosphere, may affect bearded seal survival and recruitment through disruption of trophic regimes that are dependent on calcifying organisms. The nature and timing of such impacts are extremely uncertain. As discussed in Cameron et al. (2010), ~~C~~changes in bearded seal prey, anticipated in response to ocean warming and loss of sea ice, have the potential for negative impacts, but the possibilities are complex. Ecosystem responses may have very long lags as they propagate through trophic webs. Because of bearded seals' apparent dietary flexibility, this threat may be of less immediate concern than the threats from sea-ice degradation.

Additional habitat concerns include the potential effects from increased shipping (particularly in the Bering Strait)~~ and oil and gas exploration and development activities~~, such as disturbance from vessel traffic~~, seismic exploration noise,~~ and the potential for oil spills.

CITATIONS

Allen, J. A. 1880. History of North American Pinnipeds: A Monograph of the Walruses, Sea-lions, Sea-bears and Seals of North America. U.S. Department of the Interior, U.S. Government Printing Office, Washington, D.C. 785 p.

Bengtson, J. L., P. L. Boveng, L. M. Hiruki-Raring, K. L. Laidre, C. Pungowiyi, and M. A. Simpkins. 2000. Abundance and distribution of ringed seals (*Phoca hispida*) in the coastal Chukchi Sea, p. 149-160. *In* A. L. Lopez and D. P. DeMaster (eds.), Marine Mammal Protection Act and Endangered Species Act Implementation Program 1999. AFSC Processed Rep. 2000-11, Alaska Fisheries Science Center, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Bengtson, J. L., L. M. Hiruki-Raring, M. A. Simpkins, and P. L. Boveng. 2005. Ringed and bearded seal densities in the eastern Chukchi Sea, 1999-2000. Polar Biol. 28:833-845.

Braham, H. W., J. J. Burns, G. A. Fedoseev, and B. D. Krogman. 1981. Distribution and density of ice-associated pinnipeds in the Bering Sea. Available from Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115. 27 p.

Breed, G. A., M. F. Cameron, J. M. Ver Hoef, P. L. Boveng, A. Whiting, and K. J. Frost. 2018. Seasonal sea ice dynamics drive movement and migration of juvenile bearded seals *Erignathus barbatus*. Mar. Ecol. Progr. Ser. 600:223-237. DOI: dx.doi.org/10.3354/meps12659 .

Breiwick, J. M. 2013. North Pacific marine mammal bycatch estimation methodology and results, 2007-2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-260, 40 p.

Burns, J. J. 1967. The Pacific bearded seal. Alaska Department of Fish and Game, Pittman-Robertson Project Report W-6-R and W-14-R. 66 p.

Burns, J. J. 1981. Bearded seal-*Erignathus barbatus* Erxleben, 1777, p. 145-170. *In* S. H. Ridgway and R. J. Harrison (eds.), Handbook of Marine Mammals. Vol. 2. Seals. Academic Press, New York.

Burns, J. J., and K. J. Frost. 1979. The natural history and ecology of the bearded seal, *Erignathus barbatus*. Alaska Department of Fish and Game. 77 p.

Cameron, M., and P. Boveng. 2007. Abundance and distribution surveys for ice seals aboard the USCG *Healy* and the *Oscar Dyson*, 10 April - 18 June 2007. Alaska Fisheries Science Center Quarterly Report (April-May-June 2007):12-14.

Cameron, M., and P. Boveng. 2009. Habitat use and seasonal movements of adult and sub-adult bearded seals. Alaska Fisheries Science Center Quarterly Report (October-November-December 2009):1-4.

Cameron, M. F., J. L. Bengtson, P. L. Boveng, J. K. Jansen, B. P. Kelly, S. P. Dahle, E. A. Logerwell, J. E. Overland, C. L. Sabine, G. T. Waring, and J. M. Wilder. 2010. Status review of the bearded seal (*Erignathus barbatus*). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-211, 246 p.

Cameron, M. F., K. J. Frost, J. M. Ver Hoef, G. A. Breed, A. V. Whiting, J. Goodwin, and P. L. Boveng. 2018. Habitat selection and seasonal movements of young bearded seals (*Erignathus barbatus*) in the Bering Sea. PLoS ONE 13(2):e0192743. DOI: dx.doi.org/10.1371/journal.pone.0192743 .

Citta, J. J., L. F. Lowry, L. T. Quakenbush, B. P. Kelly, A. S. Fischbach, J. M. London, C. V. Jay, K. J. Frost, G. O'Corry-Crowe, J. A. Crawford, P. L. Boveng, M. Cameron, A. L. Von Duyke, M. Nelson, L. A. Harwood, P. Richard, R. Suydam, M. P. Heide-Jørgensen, R. C. Hobbs, D. I. Litovka, M. Marcoux, A. Whiting, A. S. Kennedy, J. C. George, J. Orr, and T. Gray. 2018. A multi-species synthesis of satellite telemetry data in the Pacific Arctic (1987–2015): overlap of marine mammal distributions and core use areas. Deep-Sea Res. II 152:132-153 . DOI: dx.doi.org/10.1016/j.dsr2.2018.02.006 .

Conn, P. B., J. M. Ver Hoef, B. T. McClintock, E. E. Moreland, J. M. London, M. F. Cameron, S. P. Dahle, and P. L. Boveng. 2014. Estimating multispecies abundance using automated detection systems: ice-associated seals in the Bering Sea. Methods Ecol. Evol. 5:1280-1293. DOI: dx.doi.org/10.1111/2041-210X.12127 .

~~Delean, B. J., V. T. Helker, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, J. Jannot, and N. C. Young. 2020. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2013-2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-401, 86 p.~~

Fay, F. H. 1974. The role of ice in the ecology of marine mammals of the Bering Sea, p. 383-399. *In* D. W. Hood and E. J. Kelley (eds.), Oceanography of the Bering Sea. University of Alaska, Fairbanks, Institute of Marine Science, Occasional Publication 2.

Fedoseev, G. A. 1965. The ecology of the reproduction of seals on the northern part of the Sea of Okhotsk. Izvestiya TINRO 65:212-216. (Translated from Russian by the Fisheries and Marine Service, Quebec, Canada, Translation Series No. 3369. 8 p.)

Frost, K. J., M. F. Cameron, M. Simpkins, C. Schaeffer, and A. Whiting. 2005. Diving behavior, habitat use, and movements of bearded seal (*Erignathus barbatus*) pups in Kotzebue Sound and Chukchi Sea, p. 98-99. *In* Proceedings of the Sixteenth Biennial Conference on the Biology of Marine Mammals, San Diego, CA.

Frost, K. J., A. Whiting, M. F. Cameron, and M. A. Simpkins. 2008. Habitat use, seasonal movements and stock structure of bearded seals in Kotzebue Sound, Alaska. Tribal Wildlife Grants Program, Fish and Wildlife Service, Tribal Wildlife Grants Study U-4-IT. Final Report from the Native Village of Kotzebue, Kotzebue, AK, for U.S. Fish and Wildlife Service, Anchorage, AK. 16 p.

Heptner, L. V. G., K. K. Chapskii, V. A. Arsen'ev, and V. T. Sokolov. 1976. Bearded seal. *Erignathus barbatus* (Erxleben, 1777), p. 166-217. *In* L. V. G. Heptner, N. P. Naumov, and J. Mead (eds.), Mammals of the Soviet Union. Volume II, Part 3--Pinnipeds and Toothed Whales, Pinnipedia and Odontoceti. Vysshaya Shkola Publishers, Moscow, Russia. (Translated from Russian by P. M. Rao, 1996, Science Publishers, Inc., Lebanon, NH.)

Ice Seal Committee (ISC). 2019. The subsistence harvest of ice seals in Alaska – a compilation of existing information, 1960-2017. 86 p. Available online: http://www.north-slope.org/departments/wildlife-management/co-management-organizations/ice-seal-committee . Accessed ~~December 2019~~August 2020.

Jimbo, M., D. Mizuguchi, H. Shirakawa, K. Tsujii, A. Fujiwara, K. Miyashita, and Y. Mitani. 2019. Seasonal variations in the call presence of bearded seals in relation to sea ice in the southern Chukchi Sea. Polar Biol. 42:1953. DOI: dx.doi.org/10.1007/s00300-019-02569-2 .

Johnson, M. L., C. H. Fiscus, B. T. Stenson, and M. L. Barbour. 1966. Marine mammals, p. 877-924. *In* N. J. Wilimovsky and J. N. Wolfe (eds.), Environment of the Cape Thompson Region, Alaska. U.S. Atomic Energy Commission, Oak Ridge, TN.

Kelly, B. P. 1988. Bearded seal, *Erignathus barbatus*, p. 77-94. *In* J. W. Lentfer (ed.), Selected Marine Mammals of Alaska: Species Accounts with Research and Management Recommendations. Marine Mammal Commission, Washington, DC.

King, J. E. 1983. Seals of the World. 2nd edition. British Museum (Natural History) and Oxford University Press, London, UK. 240 p.

Laidre, K. L., I. Stirling, L. Lowry, Ø. Wiig, M. P. Heide-Jørgensen, and S. Ferguson. 2008. Quantifying the sensitivity of arctic marine mammals to climate-induced habitat change. Ecol. Appl. 18(2):S97-S125.

Laidre, K., H. Stern, K. M. Kovacs, L. Lowry, S. E. Moore, E. V. Regehr, S. H. Ferguson, Ø. Wiig, P. Boveng, R. P. Angliss, E. W. Born, D. Litovka, L. Quakenbush, C. Lydersen, D. Vongraven, and F. Ugarte. 2015. Arctic marine mammal population status, sea ice habitat loss, and conservation recommendations for the 21st century. Conservation Biology 29:724-737.

MacIntyre, K. Q., K. M. Stafford, C. L. Berchok, and P. L. Boveng. 2013. Year-round acoustic detection of bearded seals (*Erignathus barbatus*) in the Beaufort Sea relative to changing environmental conditions, 2008-2010. Polar Biol. 36(8):1161-1173.

MacIntyre, K. Q., K. M. Stafford, P. B. Conn, K. L. Laidre, and P. L. Boveng. 2015. The relationship between sea ice concentration and the spatio-temporal distribution of vocalizing bearded seals (*Erignathus barbatus*) in the Bering, Chukchi, and Beaufort seas from 2008 to 2011. Prog. Oceanogr. 136:241-249. DOI: dx.doi.org/10.1016/j.pocean.2015.05.008 .

Manning, T. H. 1974. Variation in the skull of the bearded seal, *Erignathus barbatus* (Erxleben). Biological Papers of the University of Alaska 16:1-21.

Moreland, E., M. Cameron, and P. Boveng. 2013. Bering Okhotsk Seal Surveys (BOSS), joint U.S.-Russian aerial surveys for ice-associated seals, 2012-13. Alaska Fisheries Science Center Quarterly Report (July-August-September 2013):1-6.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed ~~December 2019~~August 2020.

Nelson, R. K. 1981. Harvest of the sea: coastal subsistence in modern Wainwright. North Slope Borough, Barrow, AK. 125 p.

Nelson, R. R., J. J. Burns, and K. J. Frost. 1984. The bearded seal (*Erignathus barbatus*), p. 1-6. *In* J. J. Burns (ed.), Marine Mammal Species Accounts. Wildlife Technical Bulletin No. 7. Alaska Department of Fish and Game, Juneau, AK.

Nelson, M. A., L. T. Quakenbush, B. D. Taras, and Ice Seal Committee. 2019. Subsistence harvest of ringed, bearded, spotted, and ribbon seals in Alaska is sustainable. Endang. Species Res. 40:1-16. DOI: dx.doi.org/10.3354/esr00973 .

Ognev, S. I. 1935. Mammals of the U.S.S.R. and Adjacent Countries. Vol. 3. Carnivora (Fissipedia and Pinnipedia). Gosudarst. Izdat. Biol. Med. Lit., Moscow. (Translated from Russian by Israel Program for Scientific Translations, 1962. 741 p.)

Quakenbush, L., J. Citta, and J. Crawford. 2011. Biology of the bearded seal (*Erignathus barbatus*) in Alaska, 1961–2009. Final Report to NMFS. Arctic Marine Mammal Program, Alaska Department of Fish and Game, Fairbanks, AK. 71 p.

Rice, D. W. 1998. Marine Mammals of the World: Systematics and Distribution. Soc. Mar. Mammal. Spec. Publ. No. 4.

Scheffer, V. B. 1958. Seals, Sea Lions and Walruses: A Review of the Pinnipedia. Stanford University Press, Palo Alto, CA. 179 p.

Simpkins, M. A., L. M. Hiruki-Raring, G. Sheffield, J. M. Grebmeier, and J. L. Bengtson. 2003. Habitat selection by ice-associated pinnipeds near St. Lawrence Island, Alaska in March 2001. Polar Biol. 26:577-586.

Smith, T. G. 1981. Notes on the bearded seal, *Erignathus barbatus*, in the Canadian Arctic. Department of Fisheries and Oceans, Arctic Biological Station, Can. Tech. Rep. Fish. Aquat. Sci. No. 1042. 49 p.

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC.

RINGED SEAL (*Pusa hispida hispida*): ~~Alaska~~Arctic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Ringed seals (*Pusa hispida*) have a circumpolar distribution and are found in all seasonally ice-covered seas of the Northern Hemisphere as well as in certain freshwater lakes (King 1983). Most taxonomists currently recognize five subspecies of ringed seals: *P. h. hispida* in the Arctic Ocean and Bering Sea; *P. h. ochotensis* in the Sea of Okhotsk and northern Sea of Japan; *P. h. botnica* in the northern Baltic Sea; *P. h. lagodensis* in Lake Ladoga, Russia; and *P. h. saimensis* in Lake Saimaa, Finland. Morphologically, the Baltic and Okhotsk subspecies are fairly well differentiated from the Arctic subspecies (Ognev 1935, Müller-Wille 1969, Rice 1998) and the Ladoga and Saimaa subspecies differ significantly from each other and from the Baltic subspecies (Müller-Wille 1969, Hyvärinen and Nieminen 1990, Amano et al. 2002). Genetic analyses support isolation of the lake-inhabiting populations (Palo 2003, Palo et al. 2003, Valtonen et al. 2012). Lack of differentiation between the Baltic and the Arctic subspecies may reflect recurrent gene flow (Martinez-Bakker et al. 2013) but is more likely due to retention of high diversity within the relatively large effective population size of the Baltic subspecies since separation from the Arctic subspecies (Nyman et al. 2014). Widespread mixing within the Arctic subspecies is the likely explanation for its high diversity and apparent lack of population structure (Palo et al. 2001, Davis et al. 2008, Kelly et al. 2009, Martinez-Bakker et al. 2013). Differences in body size, morphology, growth rates, and/or diet between Arctic ringed seals in shorefast versus pack ice have been taken as evidence of separate breeding populations in some locations (McLaren 1958, Fedoseev 1975, Finley et al. 1983). This has not been thoroughly examined, however, and the taxonomic status and population structure of the Arctic subspecies remain~~s~~ unresolved (Berta and Churchill 2012). The stock, therefore, may be as large as the entire *P. h. hispida* subspecies range. ~~For the purposes of t~~This stock assessment~~, the Alaska stock of ringed seals is considered the portion of the Arctic subspecies (*P. h. hispida*) in U.S. waters (Fig. 1)~~ considers only the portion of the stock found within U.S. waters bounded by the U.S. Exclusive Economic Zone (EEZ; Fig. 1), because the relevant stock assessment data on abundance and human-caused mortality and serious injury are generally not available for the broader range of the stock or even for waters adjacent to the U.S. EEZ.

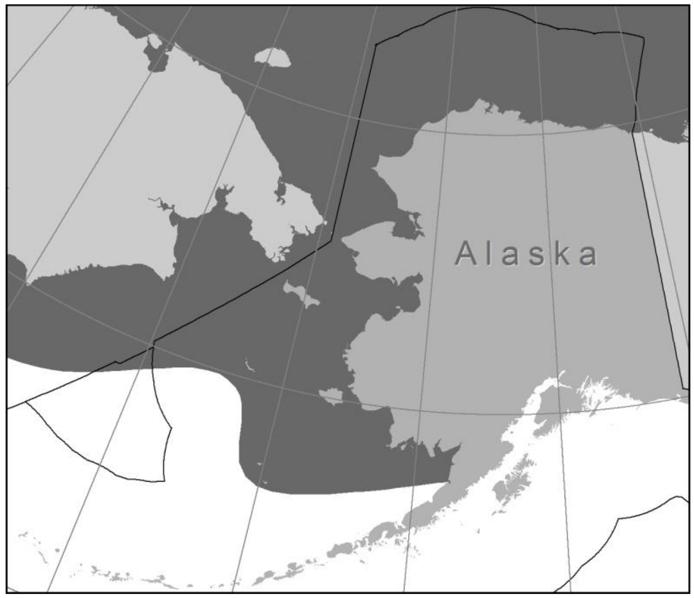

Figure 1. The ~~Alaska~~Arctic ~~stock of~~ ringed seal~~s~~ stock is defined as the ~~portion~~population of the Arctic subspecies (*P. h. hispida*). This stock assessment considers only the portion of the stock occurring in U.S. waters (i.e., the U.S. Exclusive Economic Zone delineated by a black line). The dark shaded area shows ~~their~~the approximate winter distribution of the Arctic ringed seal stock around Alaska.~~ The U.S. Exclusive Economic Zone is delineated by a black line.~~

Throughout their range, ringed seals have an affinity for ice-covered waters and are well adapted to occupying both shorefast and pack ice (Kelly 1988~~a~~). They remain with the ice most of the year and use it as a platform for pupping and nursing in late winter to early spring, for molting in late spring to early summer, and for resting at other times of the year. ~~This species~~Arctic ringed seals rarely come~~s~~ ashore in the Arctic~~; however, in more southerly portions of its range where sea or lake ice is absent during summer and fall, ringed seals are known to use isolated sites on land for molting and resting~~, although they have been observed during summer months resting on land in the White Sea (Lukin et al. 2006) and, recently, in a fjord system in Svalbard (~~Härkönen et al. 1998, Trukhin 2000, Kunnasranta 2001, Lukin et al. 2006~~Lydersen et al. 2017). In Alaska waters, during winter and early spring when sea ice is at its maximal extent, ringed seals are abundant in the northern Bering Sea, Norton and Kotzebue Sounds, and throughout the Chukchi and Beaufort seas. They occur as far south as Bristol Bay in years of extensive ice coverage but generally are not abundant south of Norton Sound except in nearshore areas (Frost 1985).

However, surveys conducted in the Bering Sea in the spring of 2012 and 2013 documented numerous ringed seals in both nearshore and offshore habitat extending south of Norton Sound (79 FR 73010, 9 December 2014). Although details of their seasonal movements have not been adequately documented, most ringed seals that winter in the Bering, ~~and~~ Chukchi, and Beaufort seas are thought to migrate north in the spring as the seasonal ice melts and retreats (Burns 1970, Kelly et al. 2010b) and spend summers in the pack ice of the northern Chukchi and Beaufort seas, as well as on nearshore ice remnants in the Beaufort Sea (Frost 1985, Kelly et al. 2010b). During summer, ringed seals range hundreds to thousands of kilometers to forage along ice edges or in highly productive open-water areas (Harwood and Stirling 1992, Freitas et al. 2008, Kelly et al. 2010b, Harwood et al. 2015). With the onset of freeze-up in the fall, ringed seal movements become increasingly restricted. Seals that have summered in the Beaufort Sea are thought to move west and south with the advancing ice pack, with many seals dispersing throughout the Chukchi and Bering seas while some remain in the Beaufort Sea (Frost and Lowry 1984, Crawford et al. 2012, Harwood et al. 2012). Some adult ringed seals return to the same small home ranges they occupied during the previous winter (Kelly et al. 2010b).

POPULATION SIZE

Although a reliable population estimate for the entire stock is not available, ~~research programs have developed~~ survey methods ~~that~~ have been ~~used to determine abundance estimates for part of the range~~developed and applied to substantial portions of the stock's range in U.S. waters. In the spring of 2012 and 2013, U.S. and Russian researchers conducted aerial abundance and distribution surveys over the entire ice-covered portions of the Bering Sea ~~and Sea of Okhotsk~~ (Moreland et al. 2013). Conn et al. (2014), using a ~~very limited~~ sub-sample of the data collected from the U.S. portion of the Bering Sea in 2012, calculated an abundance estimate of 171,418 ringed seals (95% CI: 141,588-201,090). This estimate did not account for availability bias due to seals in the water at the time of the surveys and did not include ringed seals in the shorefast ice zone, which were surveyed using a different track-line design that will require a separate analysis. Thus, the actual number of ringed seals in the U.S. portion of the Bering Sea is likely much higher, perhaps by a factor of two or more. Researchers expect to provide a population estimate, corrected for availability bias, for the entire ~~Alaska stock~~U.S. portion of the ringed seal~~s~~ stock once the final Bering Sea results are combined with the results from spring surveys of the Chukchi Sea (conducted in 2016) and Beaufort Sea (planned for 2020).

Minimum Population Estimate

A minimum population estimate (N_{MIN}) for the entire U.S. portion of the stock cannot be determined because reliable abundance estimates are not yet available for the Chukchi and Beaufort seas. Using the 2012 Bering Sea ~~abundance~~density estimate by Conn et al. (2014), however, we are able to calculate an N_{MIN} of 158,507 ringed seals in the U.S. Bering Sea. The N_{MIN} for a stock is usually calculated using Equation 1 from the potential biological removal (PBR) guidelines (NMFS 2016): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$, which approximates the 20th percentile of a distribution that is assumed to be log-normal. However, ~~T~~the ~~(minimal population)~~ abundance estimate ~~by~~based on Conn et al. (2014) was calculated using a Bayesian hierarchical framework~~, however~~, so we used the 20th percentile of the posterior distribution of abundance estimates ~~in place of the CV in~~as a more direct estimator of N_{MIN} than Equation 1. This N_{MIN} is negatively biased as an estimator of the Arctic ringed seal stock, and even the U.S. portion of the stock, because the estimate is based solely on the Bering Sea and, therefore, doesn't include the many ringed seals that inhabit the Chukchi and Beaufort seas (e.g., Kelly et al. 2010a, Laidre et al. 2015) and because the Conn et al. (2014) study did not adjust densities for seals in the water (not detectable by the surveys).

Current Population Trend

Reliable data on trends in population abundance for the ~~Alaska~~Arctic stock of ringed seals or the portion of the stock within U.S. waters are not available.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is not ~~un~~available for the ~~Alaska~~Arctic stock of ringed seals or any portion of the stock within U.S. waters. Until additional data become available, the default pinniped maximum theoretical net productivity rate of 12% will be used for this stock (NMFS 2016).

POTENTIAL BIOLOGICAL REMOVAL

PBR is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for pinniped stocks listed as threatened under the Endangered Species Act (ESA) (NMFS 2016). Using the negatively biased N_{MIN} for ringed seals in the U.S. portion of the ~~Bering Sea~~Arctic stock, ~~a~~ PBR ~~for ringed seals in this area =~~is 4,755 seals (158,507 × 0.06 × 0.5). ~~However, this is not an estimate of~~This PBR ~~for the entire stock because a reliable estimate of~~is negatively biased because of its dependence on the negatively biased N_{MIN} estimate~~is not available for the entire stock (i.e., N_{MIN} is not available for the Chukchi and Beaufort seas)~~.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals between ~~2013~~2014 and ~~2017~~2018 is listed, by marine mammal stock, in ~~Delean et al. (2020)~~Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. The minimum estimated mean annual level of human-caused mortality and serious injury for the portion of the ~~Alaska~~Arctic ringed seal~~s~~ stock in U.S. waters between ~~2013~~2014 and ~~2017~~2018 is ~~700~~6,459 seals: ~~2.4~~5 in U.S. commercial fisheries, ~~697~~6,454 in the Alaska Native subsistence harvest (average statewide harvest, including struck and lost animals, in 2015, based on a recently published analysis (Nelson et al. 2019) that is higher and likely more accurate than previous estimates; see below), 0.2 in marine debris, and ~~0.4~~0.2 ~~due to other causes (~~incidental to Marine Mammal Protection Act (MMPA)-authorized research~~)~~. ~~This is a minimum estimate of the Alaska Native subsistence harvest because only a small proportion of the communities that harvest ice seals are surveyed each year.~~ Additional potential threats most likely to result in direct human-caused mortality or serious injury of this stock include the increased potential for oil spills due to an increase in vessel traffic in Alaska waters (with changes in sea-ice coverage).

Fisheries Information

Information ~~(including observer programs, observer coverage, and observed incidental takes of marine mammals)~~ for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is ~~presented~~available in Appendi~~ces~~x 3~~-6~~ of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

Between ~~2013~~2014 and ~~2017~~2018, incidental mortality and serious injury of ringed seals in U.S. waters was reported in ~~one~~two of the federally-managed U.S. commercial fisheries in Alaska monitored for incidental mortality and serious injury by fisheries observers: the Bering Sea/Aleutian Islands flatfish trawl and Bering Sea/Aleutian Islands pollock trawl fisher~~y~~ies (Table 1; Breiwick 2013; MML, unpubl. data). Based on observer data from ~~2013~~2014 to ~~2017~~2018, the minimum average annual rate of mortality and serious injury incidental to U.S. commercial fishing operations is ~~2.4~~ 4.8 ringed seals.

One ringed seal mortality resulting from entanglement in unidentified commercial gear in U.S. waters was reported to the NMFS Alaska Region marine mammal stranding network in 2017 (Young et al. in press), resulting in a mean annual mortality and serious injury rate of 0.2 ringed seals between 2014 and 2018 (Table 3). This mortality and serious injury estimate results from an actual count of verified human-caused deaths and serious injuries and is a minimum because not all entangled animals strand nor are all stranded animals found, reported, or have the cause of death determined.

Table 1. Summary of incidental mortality and serious injury of ~~Alaska~~Arctic ringed seals in U.S. waters due to U.S. commercial fisheries between ~~2013~~2014 and ~~2017~~2018 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix ~~6~~3 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality (CV)	Mean estimated annual mortality
Bering Sea/Aleutian Is. flatfish trawl	~~2013~~ 2014 2015 2016 2017 2018	obs data	~~100~~ 100 100 99 100 100	~~3~~ 0 1 0 8 14	~~3~~ 0 1 (0.05) 0 8.0 (0.01) 14 (0.02)	~~2.4~~ 4.6 (CV = 0.01)
Bering Sea/Aleutian Is. pollock trawl	2017	obs data	100	1[a]	N/A	0.2 (CV = N/A)

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality (CV)	Mean estimated annual mortality
Minimum total estimated annual mortality						~~2.4~~ 4.8 (CV = 0.01)

[a]This seal was discovered during a vessel offload. Because it could not be associated with a haul number, it was not included in the bycatch estimate for the fishery.

Alaska Native Subsistence/Harvest Information

NMFS signed an agreement with the Ice Seal Committee (ISC; 2006) to co-manage Alaska ice seal populations. This co-management agreement promotes full and equal participation by Alaska Natives in decisions affecting the subsistence management of ice seals (to the maximum extent allowed by law) as a tool for conserving ice seal populations in Alaska (https://www.fisheries.noaa.gov/alaska/marine-mammal-protection/co-management-marine-mammals-alaska, accessed August 2020).

Ringed seals are an important resource for Alaska Native subsistence hunters. Approximately 64 coastal communities in Alaska, from Bristol Bay to the Beaufort Sea, ~~regularly~~ harvest ice seals (~~Ice Seal Committee~~ISC 2019). The ~~Ice Seal Committee~~ISC, as co-managers with NMFS, recognizes the importance of harvest information and has collected it since 2008. Annual household survey results compiled in a statewide harvest report include historical ice seal harvest information from 1960 to 2017 (Quakenbush et al. 2011, ~~Ice Seal Committee~~ISC 2019). ~~Ringed seal harvest information for 2013-2017 is available for 12 communities (see Table 2). However, a number of other communities harvest ice seals and were not surveyed between 2013 and 2017, including a few communities that have never been surveyed.~~

~~Household harvest surveys are designed to estimate the harvest within each surveyed community, but because of differences in ringed seal availability, cultural hunting practices, and environmental conditions, it is not appropriate to extrapolate harvest numbers beyond that community. The number of communities surveyed and successive annual surveys in the same communities have also been limited. For example, between 2013 and 2017, only 12 of a possible 64 (19%) coastal communities were surveyed for ice seal harvest; and, of the 12 communities, only 2 were surveyed for two or more consecutive years (Ice Seal Committee 2019). Thus, annual community-level harvest estimates totaled across communities provide a partial (i.e., minimum) estimate of annual statewide harvest. The geographic distribution of communities with annual harvest estimates also varies among years, so total annual estimates across communities may be geographically or otherwise biased. Between 2013 and 2017, the minimum annual ringed seal harvest estimates totaled across surveyed communities ranged from 185 (in a year that only one community was surveyed) to 1,306 ringed seals (in a year that seven communities were surveyed) (Table 2). Based on the available harvest data from these 12 communities (Table 2), a minimum estimate of the average annual ringed seal harvest between 2013 and 2017 is 697 seals. The Ice Seal Committee is working for a better understanding of ice seal harvest by conducting more consecutive surveys in more communities and one of their goals is to report a statewide ice seal harvest estimate.~~To estimate the recent subsistence harvest of ice seals, Nelson et al. (2019) used ice seal harvest survey data collected from 1992 to 2014 for 41 of 55 communities that regularly hunt ice seals, as well as the per capita removal estimates (based on the 2015 human population) from the surveyed communities, to estimate the average regional and statewide subsistence harvest (Table 2). The best statewide estimate of the average number of ringed seals harvested in 2015, including struck and lost animals, is 6,454 seals (Nelson et al. 2019). The authors also found stable or decreasing trends in the annual numbers of ice seals harvested (Nelson et al. 2019).

Table 2. Average regional and statewide subsistence harvest (including struck and lost animals) of Arctic ringed seals in 2015 (Nelson et al. 2019). See Figure 1 in Nelson et al. (2019) for a list of the communities in each region.

Region	**Average harvest (including struck and lost animals)**
North Slope Borough	1,146
Maniilaq	493
Kawerak	2,287
Association of Village Council Presidents	2,484
Bristol Bay Native Association	44
Statewide total	6,454

~~**Table 2.** Alaska ringed seal minimum harvest estimates between 2013 and 2017 (Ice Seal Committee 2019). Empty cells represent the years in which the communities were not surveyed for harvest information.~~

~~**Community**~~	~~**Ringed seal minimum harvest estimates**~~				
	~~**2013**~~	~~**2014**~~	~~**2015**~~	~~**2016**~~	~~**2017**~~
~~Nuiqsut~~		~~58~~			
~~Utqiaġvik (formerly Barrow)~~		~~428~~			
~~Point Hope~~		~~246~~			
~~Kotzebue~~		~~69~~			
~~Deering~~	~~7~~				
~~Shishmaref~~		~~296~~			
~~Scammon Bay~~	~~189~~				
~~Hooper Bay~~	~~667~~	~~158~~	~~185~~	~~546~~	~~193~~
~~Tununak~~				~~117~~	
~~Tuntutuliak~~	~~75~~				
~~Eek~~	~~13~~				
~~Quinhagak~~	~~160~~	~~51~~		~~26~~	
~~Minimum total~~	~~1,111~~	~~1,306~~	~~185~~	~~689~~	~~193~~

Other Mortality

Reports ~~from~~to the NMFS Alaska Region marine mammal stranding network of ringed seals entangled in marine debris or with injuries caused by other types of human interaction are another source of mortality and serious injury data. These mortality and serious injury estimates result from an actual count of verified human-caused deaths and serious injuries and are minimums because not all entangled animals strand nor are all stranded animals found, reported, or have the cause of death determined. ~~From 2013 to 2017, reports to the NMFS Alaska Region stranding network~~One ringed seal mortality due to entanglement in marine debris in U.S. waters was reported in 2017, result~~ed~~ing in a mean annual mortality and serious injury rate of 0.2 ringed seals ~~observed entangled in marine debris~~between 2014 and 2018 (Table 3; ~~Delean et al. 2020~~Young et al. in press).

~~In 2016, a r~~Ringed seal mortality~~,~~ due to ~~a~~ gunshot wound~~s~~ ~~to the head, was~~ reported to the NMFS Alaska Region stranding network (~~Delean et al. 2020~~Young et al. in press)~~. This seal was~~ is presumed to be animals struck and lost ~~animal from~~in the Alaska Native subsistence hunt and, therefore, ~~it~~ is not included in the mean annual mortality and serious injury rate for ~~2013~~2014 to ~~2017~~2018.

Mortality and serious injury may occasionally occur incidental to marine mammal research activities authorized under MMPA permits issued to a variety of government, academic, and other research organizations. Between ~~2013~~2014 and ~~2017~~2018, there ~~were~~was ~~two~~one report~~s~~, ~~(one each in 2013 and~~ 2016~~)~~, of a mortality incidental to research on the ~~Alaska~~Arctic stock of ringed seals (Table 3; ~~Delean et al. 2020~~Young et al. in press), resulting in a mean annual mortality and serious injury rate of ~~0.4~~0.2 ringed seals ~~from this stock~~.

In 2011, NMFS and the U.S. Fish and Wildlife Service declared an Unusual Mortality Event (UME) for pinnipeds in the Bering and Chukchi seas, due to the unusual number of sick or dead seals and walruses discovered with skin lesions, bald patches, and other symptoms. The UME occurred from 1 May 2011 to 31 December 2016 and primarily affected ice seals, including ringed seals, bearded seals, ribbon seals, and spotted seals. The investigation concluded that the skin and hair symptoms were signs of a molt abnormality; however, no infectious disease agent or environmental cause for the UME symptoms and mortality was identified (~~https://www.fisheries.noaa.gov/alaska/marine-life-distress/diseased-ice-seals~~https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events, accessed ~~December 2019~~August 2020). Patchy baldness and delayed molt, however, continue to be observed in limited numbers (<20 per year) of harvested and beachcast ringed seals, bearded seals, ribbon seals, and spotted seals in Alaska.

Since 1 June 2018, elevated numbers of ice seal strandings have occurred in the Bering and Chukchi seas in Alaska and NMFS declared a UME for bearded seals, ringed seals, and spotted seals from 1 June 2018 to present in the Bering and Chukchi seas (https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events, accessed August 2020). As of 31 July 2020, 298 ice seal strandings of all age classes have been reported, including 88 bearded seals, 72 ringed seals, 49 spotted seals, and 89 unidentified seals. A subset of seals has been sampled for genetics and harmful algal bloom exposure and a few have had histopathology samples collected.

Table 3. Summary of ~~Alaska~~Arctic ringed seal mortality and serious injury in U.S. waters, by year and type, reported to the NMFS Alaska Region marine mammal stranding network and NMFS Office of Protected Resources between ~~2013~~2014 and ~~2017~~2018 (~~Delean et al. 2020~~Young et al. in press). Animals that were disentangled and released with non-serious injuries have been excluded from this table.

Cause of injury	~~2013~~	2014	2015	2016	2017	2018	Mean annual mortality
Entangled in unidentified commercial gear		0	0	0	1	0	0.2
Entangled in marine debris	~~0~~	0	0	0	1	0	0.2
Incidental to MMPA-authorized research	~~1~~	0	0	1	0	0	~~0.4~~0.2
Total in commercial fisheries							0.2
Total in marine debris							0.2
Total ~~due to other causes (~~incidental to MMPA-authorized research~~)~~							~~0.4~~0.2

STATUS OF STOCK

On 28 December 2012, NMFS listed the Arctic ringed seal~~s~~ subspecies (*P. h. hispida*)~~ and, thus,~~ which corresponds to the ~~Alaska~~Arctic stock of ringed seals, as threatened under the ESA (77 FR 76706). The primary concern for this population is the ongoing and anticipated loss of sea ice and snow cover ~~stemming~~resulting from climate change, which is expected to pose a significant threat to the persistence of these seals in the foreseeable future (based on projections through the end of the 21st century; Kelly et al. 2010a). Because of its threatened status under the ESA, this stock is designated as depleted under the MMPA and is classified as a strategic stock. ~~A minimum~~The best estimate of the mean annual level of human-caused mortality and serious injury in the U.S. waters portion of the stock is ~~700~~6,459 ringed seals, which is ~~less~~greater than the negatively biased PBR of 4,755 seals ~~calculated for only those ringed seals in the U.S. portion of the Bering Sea~~. However, because this exceedance of PBR stems from an unrealistically low N_{MIN}, it should not be taken as indicative of a risk to this stock. The PBR was obtained from an N_{MIN} that is known to be an extreme underestimate of the abundance in the U.S. waters of the Bering Sea, which in turn is just a portion of the Arctic ringed seal stock in U.S. waters, and the best estimate of human-caused mortality and serious injury is for the entire U.S. portion of the stock, including, for example, Alaska Native subsistence takes in the Chukchi and Beaufort seas. Previous estimates from the U.S. waters of the Chukchi Sea (Bengtson et al. 2005) and results from a recent (2016) NOAA survey of those waters indicate that there are several hundreds of thousands of ringed seals in that region that are not included in N_{MIN} because the former results are outdated and the latter have not yet been published. Furthermore, ringed seals are known to remain abundant in the U.S. waters of the Beaufort Sea (which are also not included in N_{MIN}) based, for example, on hunter reports to the ISC and NOAA test surveys conducted in 2019. NMFS believes with high confidence that the number of ringed seals in Alaska waters greatly exceeds the number of individuals that would be required for the current take to balance the PBR (i.e., N_{MIN} × Mortality and Serious Injury / PBR = 215,310 individuals). Therefore, the apparent exceedance of PBR in this case reflects inadequacy in the abundance estimates, rather than an indication of excessive take. The minimum estimated mean annual rate of U.S. commercial fishery-related mortality and serious injury (~~2.4~~5 seals) is less than 10% of the negatively biased PBR (10% of PBR = ~~475~~476)~~ calculated for the Bering Sea~~ and, therefore, can be considered insignificant and approaching a zero mortality and serious injury rate. Population trends and status of this stock relative to its Optimum Sustainable Population are unknown.

There are key uncertainties in the assessment of the ~~Alaska~~Arctic stock of ringed seals. Abundance and mortality and serious injury estimates are not available for the vast majority of the stock's range. Within U.S. waters, where abundance estimates are being developed and data are currently available on mortality and serious injury in commercial fisheries and the Alaska Native subsistence harvest, key abundance estimates for the Beaufort and Chukchi seas are not yet available. ~~and t~~The negatively biased N_{MIN} used here, based on a 2012 Bering Sea ~~abundance~~density estimate ~~by~~from Conn et al. (2014), was calculated using only a ~~limited~~ sub-sample of the data and ~~may~~is likely to be an underestimate for the U.S. waters of the Bering Sea because of availability bias. Also, it represents just a portion of the population of ringed seals in U.S. waters and is, therefore, not very reliable for comparison with mortality and serious injury numbers for the entire U.S. portion of the stock.~~ Similarly, counts of harvest by Alaska Natives are taken from surveys conducted in a few recent years for a fraction of the communities known to harvest marine mammals and so are considered minimum estimates.~~ Based on the best available information, ringed seals are likely to be highly sensitive to climate change.

HABITAT CONCERNS

The main concern about the conservation status of ringed seals ~~stems from the likelihood that their preferred sea ice and snow habitats are being modified by the warming climate~~is long-term habitat loss and modification resulting from climate change (77 FR 76706, 28 December 2012).~~ Future scientific projections are for continued and perhaps accelerated warming (Kelly et al. 2010a). Climate models consistently project overall diminishing ice and snow cover through the 21st century with regional variation in the timing and severity of those loses. Increasing atmospheric concentrations of greenhouse gases are driving climate warming and increasing acidification of the ringed seal's habitat. Changes in ocean temperature, acidification, and ice cover threaten prey communities on which ringed seals depend (Kelly et al. 2010a).~~ Laidre et al. (2008) concluded that on a worldwide basis ringed seals were likely to be highly sensitive to climate change based on an analysis of various life-~~-~~history features that could be affected by climate.

~~The greatest impacts to ringed seals from diminished ice cover will be mediated through diminished snow accumulation. While winter precipitation is forecasted to increase in a warming Arctic (Walsh et al. 2005), the duration of ice cover will be substantially reduced, and the net effect will be lower snow accumulation on the ice (Hezel et al. 2012).~~Climate models consistently project substantial reductions in sea ice and on-ice snow depths (Kelly et al. 2010a, Hezel et al. 2012). Ringed seals excavate subnivean lairs (snow caves) in drifts over their breathing holes in the ice, in which they rest, give birth, and nurse their pups for 5-9 weeks during late winter and spring (Chapskii 1940, McLaren 1958, Smith and Stirling 1975).~~ Snow depths of at least 50-65 cm are required for functional birth lairs (Smith and Stirling 1975, Lydersen and Gjertz 1986, Kelly 1988b, Lydersen 1998, Lukin et al. 2006). Such depths typically are found only where 20-30 cm or more of snow has accumulated on flat ice and then drifted along pressure ridges or ice hummocks (Lydersen et al. 1990, Hammill and Smith 1991, Lydersen and Ryg 1991, Smith and Lydersen 1991). According to climate model projections, snow cover is forecasted to be inadequate for the formation and occupation of birth lairs within this century over the Alaska stock's entire range (Kelly et al. 2010a). Without the protection of these lairs, ringed seals—especially newborns—are vulnerable to freezing and predation~~Substantial data indicate high pup mortality due to hypothermia and predation as a consequence of inadequate snow cover (e.g., Kumlien 1879, ~~McLaren 1958,~~ Lukin and Potelov 1978, ~~Smith and Hammill 1980,~~ Lydersen and Smith 1989, Smith and Lydersen 1991, Hammill and Smith 1991, Stirling and Smith 2004). Decreases in ice, and especially on-ice snow depths, are expected to lead to increased juvenile mortality from premature weaning, hypothermia, and predation (Kelly et al. 2010a). Changes in the ringed seal's habitat will be rapid relative to their generation time and, thereby, will limit adaptive responses (Kelly et al. 2010a).~~ As ringed seal populations decline, the significance of currently lower-level threats—such as ocean acidification, increases in human activities, and changes in populations of predators, prey, competitors, and parasites—may increase.~~

A second major concern, driven primarily by the production of carbon dioxide (CO_2) emissions, is the modification of habitat by ocean acidification, which may alter prey populations and other important aspects of the marine ecosystem. Ocean acidification, a result of increased CO_2 in the atmosphere, may affect ringed seal survival and recruitment through disruption of trophic regimes that are dependent on calcifying organisms. The nature and timing of such impacts are extremely uncertain. As discussed by Kelly et al. (2010a), ~~C~~changes in ringed seal prey, anticipated in response to ocean warming and loss of sea ice, have the potential for negative impacts, but the possibilities are complex. Ecosystem responses may have very long lags as they propagate through trophic webs. Because of ringed seals' apparent dietary flexibility, this threat may be of less immediate concern than the threats from sea-~~-~~ice degradation.

Additional habitat concerns include the potential effects from increased shipping (particularly in the Bering Strait)~~ and oil and gas exploration activities (particularly in the outer continental shelf leasing areas)~~, such as disturbance from vessel traffic~~, seismic exploration noise, or~~ and the potential for oil spills.

CITATIONS

Amano, M., A. Hayano, and N. Miyazaki. 2002. Geographic variation in the skull of the ringed seal, *Pusa hispida*. J. Mammal. 83:370-380.

Bengtson, J. L., L. M. Hiruki-Raring, M. A. Simpkins, and P. L. Boveng. 2005. Ringed and bearded seal densities in the eastern Chukchi Sea, 1999-2000. Polar Biol. 28:833-845.

Berta, A., and M. Churchill. 2012. Pinniped taxonomy: review of currently recognized species and subspecies, and evidence used for their description. Mammal Rev. 42:207-234.

Breiwick, J. M. 2013. North Pacific marine mammal bycatch estimation methodology and results, 2007-2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-260, 40 p.

Burns, J. J. 1970. Remarks on the distribution and natural history of pagophilic pinnipeds in the Bering and Chukchi seas. J. Mammal. 51:445-454.

Chapskii, K. K. 1940. The ringed seal of western seas of the Soviet Arctic (The morphological characteristic, biology and hunting production), p. 147. *In* N. A. Smirnov (ed.), Proceedings of the Arctic Scientific Research Institute, Chief Administration of the Northern Sea Route. Izd. Glavsevmorputi, Leningrad, Moscow. (Translated from Russian by the Fisheries Research Board of Canada, Ottawa, Canada, Translation Series No. 1665, 147 p.)

Conn, P. B., J. M. Ver Hoef, B. T. McClintock, E. E. Moreland, J. M. London, M. F. Cameron, S. P. Dahle, and P. L. Boveng. 2014. Estimating multispecies abundance using automated detection systems: ice-associated seals in the Bering Sea. Methods Ecol. Evol. 5:1280-1293. DOI: dx.doi.org/10.1111/2041-210X.12127 .

Crawford, J. A., K. J. Frost, L. T. Quakenbush, and A. Whiting. 2012. Different habitat use strategies by subadult and adult ringed seals (*Phoca hispida*) in the Bering and Chukchi seas. Polar Biol. 35:241-255.

Davis, C. S., I. Stirling, C. Strobeck, and D. W. Coltman. 2008. Population structure of ice-breeding seals. Mol. Biol. 17:3078-3094.

~~Delean, B. J., V. T. Helker, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, J. Jannot, and N. C. Young. 2020. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2013-2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-401, 86 p.~~

Fedoseev, G. A. 1975. Ecotypes of the ringed seal (*Pusa hispida* Schreber, 1777) and their reproductive capabilities. Biology of the Seal. Proceedings of a Symposium held in Guelph, 14-17 August 1972. Rapports et Proces-verbaux des Réunions. Conseil International pour l'Éxploration de la Mer. 169:156-160.

Finley, K. J., G. W. Miller, R. A. Davis, and W. R. Koski. 1983. A distinctive large breeding population of ringed seals (*Phoca hispida*) inhabiting the Baffin Bay pack ice. Arctic 36:162-173.

Freitas, C., K. M. Kovacs, R. A. Ims, M. A. Fedak, and C. Lydersen. 2008. Ringed seal post-moulting movement tactics and habitat selection. Oecologia 155:193-204.

Frost, K. J. 1985. The ringed seal (*Phoca hispida*), p. 79-87. *In* J. J. Burns, K. J. Frost, and L. F. Lowry (eds.), Marine Mammal Species Accounts. Alaska Department of Fish and Game, Juneau, AK.

Frost, K. J., and L. F. Lowry. 1984. Trophic relationships of vertebrate consumers in the Alaskan Beaufort Sea, p. 381-401. *In* P. W. Barnes, D. M. Schell, and E. Reimnitz (eds.), The Alaskan Beaufort Sea: Ecosystems and Environments. Academic Press, Inc., New York, NY.

Hammill, M. O., and T. G. Smith. 1991. The role of predation in the ecology of the ringed seal in Barrow Strait, Northwest Territories, Canada. Mar. Mammal Sci. 7:123-135.

~~Härkönen, T., O. Stenman, M. Jüssi, I. Jüssi, R. Sagitov, and M. Verevkin. 1998. Population size and distribution of the Baltic ringed seal (*Phoca hispida botnica*), p. 167-180. *In* M. P. Heide-Jørgensen and C. Lydersen (eds.), Ringed Seals in the North Atlantic. NAMMCO Scientific Publications, Vol. 1, Tromsø, Norway.~~

Harwood, L. A., and I. Stirling. 1992. Distribution of ringed seals in the southeastern Beaufort Sea during late summer. Can. J. Zool. 70(5):891-900.

Harwood, L. A., T. G. Smith, and J. C. Auld. 2012. Fall migration of ringed seals (*Phoca hispida*) through the Beaufort and Chukchi seas, 2001-02. Arctic 65:35-44.

Harwood, L. A., T. G. Smith, J. C. Auld, H. Melling, and D. J. Yurkowski. 2015. Seasonal movements and diving of ringed seals, *Pusa hispida,* in the western Canadian Arctic, 1999-2001 and 2010-11. Arctic 68(2):193-209.

Hezel, P. J., X. Zhang, C. M. Bitz, B. P. Kelly, and F. Massonnet. 2012. Projected decline in spring snow depth on Arctic sea ice caused by progressively later autumn open ocean freeze-up this century. Geophys. Res. Lett. 39:L17505.

Hyvärinen, H., and M. Nieminen. 1990. Differentiation of the ringed seal in the Baltic Sea, Lake Ladoga and Lake Saimaa. Finnish Game Res. 47:21-27.

Ice Seal Committee (ISC). 2019. The subsistence harvest of ice seals in Alaska – a compilation of existing information, 1960-2017. 86 p. Available online: http://www.north-slope.org/departments/wildlife-management/co-management-organizations/ice-seal-committee . Accessed ~~December 2019~~August 2020.

Kelly, B. P. 1988a. Ringed seal, *Phoca hispida*, p. 57-75. *In* J. W. Lentfer (ed.), Selected Marine Mammals of Alaska: Species Accounts with Research and Management Recommendations. Marine Mammal Commission, Washington, DC.

Kelly, B. P. 1988b. Locating and characterizing ringed seal lairs and breathing holes in coordination with surveys using forward looking infra-red sensors. Fisheries and Oceans Freshwater Institute Final Report. 17 p.

Kelly, B. P., M. Ponce, D. A. Tallmon, B. J. Swanson, and S. K. Sell. 2009. Genetic diversity of ringed seals sampled at breeding sites; implications for population structure and sensitivity to sea ice loss. University of Alaska Southeast, North Pacific Research Board 631 Final Report. 28 p.

Kelly, B. P., J. L. Bengtson, P. L. Boveng, M. F. Cameron, S. P. Dahle, J. K. Jansen, E. A. Logerwell, J. E. Overland, C. L. Sabine, G. T. Waring, and J. M. Wilder. 2010a. Status review of the ringed seal (*Phoca hispida*). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-212, 250 p.

Kelly, B. P., O. H. Badajos, M. Kunnasranta, J. R. Moran, M. Martinez-Bakker, D. Wartzok, and P. Boveng. 2010b. Seasonal home ranges and fidelity to breeding sites among ringed seals. Polar Biol. 33:1095-1109.

King, J. E. 1983. Seals of the World. 2nd edition. British Museum (Natural History), London. 240 p.

Kumlien, L. 1879. Mammals, p. 55-61. *In* Contributions to the Natural History of Arctic America Made in Connection with the Howgate Polar Expedition 1877-78. Government Printing Office, Washington, DC.

Kunnasranta, M. 2001. Behavioural biology of two ringed seal (*Phoca hispida*) subspecies in the large European lakes Saimaa and Ladoga. Ph.D. Dissertation, University of Joensuu, Joensuu, Finland. 86 p.

Laidre, K. L., I. Stirling, L. F. Lowry, Ø. Wiig, M. P. Heide-Jørgensen, and S. H. Ferguson. 2008. Quantifying the sensitivity of arctic marine mammals to climate-induced habitat change. Ecol. Appl. 18(2):S97-S125.

Laidre, K., H. Stern, K. M. Kovacs, L. Lowry, S. E. Moore, E. V. Regehr, S. H. Ferguson, Ø. Wiig, P. Boveng, R. P. Angliss, E. W. Born, D. Litovka, L. Quakenbush, C. Lydersen, D. Vongraven, and F. Ugarte. 2015. Arctic marine mammal population status, sea ice habitat loss, and conservation recommendations for the 21st century. Conservation Biology 29:724-737.

Lukin, L. R., and V. A. Potelov. 1978. Living conditions and distribution of ringed seal in the White Sea in the winter. Soviet J. Mar. Biol. 4:684-690.

Lukin, L. P., G. N. Ognetov, and N. S. Boiko. 2006. Ecology of the ringed seal in the White Sea. UrO RAN, Ekaterinburg, Russia. 165 p. (Translated from Russian by the Baltic Fund for Nature (BFN), State University of St. Petersburg, Russia.)

Lydersen, C. 1998. Status and biology of ringed seals (*Phoca hispida*) in Svalbard, p. 46-62. *In* M. P. Heide-Jørgensen and C. Lydersen (eds.), Ringed Seals in the North Atlantic. NAMMCO Scientific Publications, Vol. 1. Tromsø, Norway.

Lydersen, C., and I. Gjertz. 1986. Studies of the ringed seal (*Phoca hispida* Schreber 1775) in its breeding habitat in Kongsfjorden, Svalbard. Polar Res. 4:57-63.

Lydersen, C., and M. Ryg. 1991. Evaluating breeding habitat and populations of ringed seals *Phoca hispida* in Svalbard fjords. Polar Rec. 27:223-228.

Lydersen, C., and T. G. Smith. 1989. Avian predation on ringed seal *Phoca hispida* pups. Polar Biol. 9:489-490.

Lydersen, C., P. M. Jensen, and E. Lydersen. 1990. A survey of the Van Mijen Fiord, Svalbard, as habitat for ringed seals, *Phoca hispida*. Holarctic Ecol. 13:130-133.

Lydersen, C., J. Vaquie-Garcia, E. Lydersen, G. N. Christensen, and K. M. Kovacs. 2017. Novel terrestrial haul-out behaviour by ringed seals (*Pusa hispida*) in Svalbard, in association with harbour seals (*Phoca vitulina*). Polar Res. 36, 1374124. DOI: dx.doi.org/10.1080/17518369.2017.1374124 .

Martinez-Bakker, M. E., S. K. Sell, B. J. Swanson, B. P. Kelly, and D. A. Tallmon. 2013. Combined genetic and telemetry data reveal high rates of gene flow, migration, and long-distance dispersal potential in Arctic ringed seals (*Pusa hispida*). PLoS ONE 8:e77125.

McLaren, I. A. 1958. The biology of the ringed seal (*Phoca hispida* Schreber) in the eastern Canadian Arctic. Bull. Fish. Res. Board Can. 118:97.

Moreland, E., M. Cameron, and P. Boveng. 2013. Bering Okhotsk Seal Surveys (BOSS), joint U.S.-Russian aerial surveys for ice-associated seals, 2012-13. Alaska Fisheries Science Center Quarterly Report (July-August-September 2013):1-6.

Müller-Wille, L. L. 1969. Biometrical comparison of four populations of *Phoca hispida* Schreb. in the Baltic and White seas and lakes Ladoga and Saimaa. Commentationes Biologicae Societas Scientiarum Fennica 31:1-12.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed ~~December 2019~~August 2020.

Nelson, M. A., L. T. Quakenbush, B. D. Taras, and Ice Seal Committee. 2019. Subsistence harvest of ringed, bearded, spotted, and ribbon seals in Alaska is sustainable. Endang. Species Res. 40:1-16. DOI: dx.doi.org/10.3354/esr00973 .

Nyman, T., M. Valtonen, J. Aspi, M. Ruokonen, M. Kunnasranta, and J. U. Palo. 2014. Demographic histories and genetic diversities of Fennoscandian marine and landlocked ringed seal subspecies. Ecol. Evol. 4:3420-3434.

Ognev, S. I. 1935. Mammals of the U.S.S.R. and Adjacent Countries. Vol. 3. Carnivora. Glavpushnina NKVT, Moscow, Russia. 641 p. (Translated from Russian by the Israel Program for Scientific Translations, Jerusalem, Israel. 741 p.)

Palo, J. 2003. Genetic diversity and phylogeography of landlocked seals. Dissertation. University of Helsinki, Helsinki, Finland. 29 p.

Palo, J. U., H. S. Mäkinen, E. Helle, O. Stenman, and R. Väinölä. 2001. Microsatellite variation in ringed seals (*Phoca hispida*): genetic structure and history of the Baltic Sea population. Heredity 86:609-617.

Palo, J. U., H. Hyvärinen, E. Helle, H. S. Mäkinen, and R. Väinölä. 2003. Postglacial loss of microsatellite variation in the landlocked Lake Saimaa ringed seal. Conserv. Genet. 4:117-128.

Quakenbush, L., J. Citta, and J. Crawford. 2011. Biology of the ringed seal (*Phoca hispida*) in Alaska, 1960–2010. Final Report to NMFS. Arctic Marine Mammal Program, Alaska Department of Fish and Game, Fairbanks, AK. 72 p.

Rice, D. W. 1998. Marine Mammals of the World: Systematics and Distribution. Society for Marine Mammalogy, Lawrence, KS. 231 p.

~~Smith, T. G., and M. O. Hammill. 1980. A survey of the breeding habitat of ringed seals and a study of their behavior during the spring haul-out period in southeastern Baffin Island. Addendum to the Final Report to the Eastern Arctic Marine Environmental Studies (EAMES) project. Department of Fisheries and Oceans, Arctic Biological Station, Canadian Manuscript Report of Fisheries and Aquatic Sciences, No. 1561. 47 p.~~

Smith, T. G., and C. Lydersen. 1991. Availability of suitable land-fast ice and predation as factors limiting ringed seal populations, *Phoca hispida*, in Svalbard. Polar Res. 10:585-594.

Smith, T. G., and I. Stirling. 1975. The breeding habitat of the ringed seal (*Phoca hispida*). The birth lair and associated structures. Can. J. Zool. 53:1297-1305.

Stirling, I., and T. G. Smith. 2004. Implications of warm temperatures, and an unusual rain event for the survival of ringed seals on the coast of southeastern Baffin Island. Arctic 57:59-67.

~~Trukhin, A. M. 2000. Ringed seal on the eastern coast of Sakhalin Island, p. 4. *In* V. M. Belkovich, A. N. Boltunov, and I. V. J. Smelova (eds.), Marine Mammals of the Holarctic. 2000. Materials from the International Conference, Archangel, Russia. Pravda Severa. (Translated from Russian by Olga Romanenko, 4 p.)~~

Valtonen, M., J. Palo, M. Ruokonen, M. Kunnasranta, and T. Nyman. 2012. Spatial and temporal variation in genetic diversity of an endangered freshwater seal. Conserv. Genet. 13:1231-1245.

~~Walsh, J. E., O. Anisimov, J. O. M. Hagen, T. Jakobsson, J. Oerlemans, T. D. Prowse, V. Romanovsky, N. Savelieva, M. Serreze, A. Shiklomanov, I. Shiklomanov, and S. Solomon. 2005. Section 6.2. Precipitation and evapotranspiration, p. 184-189. *In* Arctic Climate Impact Assessment. Cambridge University Press, Cambridge, UK.~~

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC.

RIBBON SEAL (*Histriophoca fasciata*)~~: Alaska Stock~~

STOCK DEFINITION AND GEOGRAPHIC RANGE

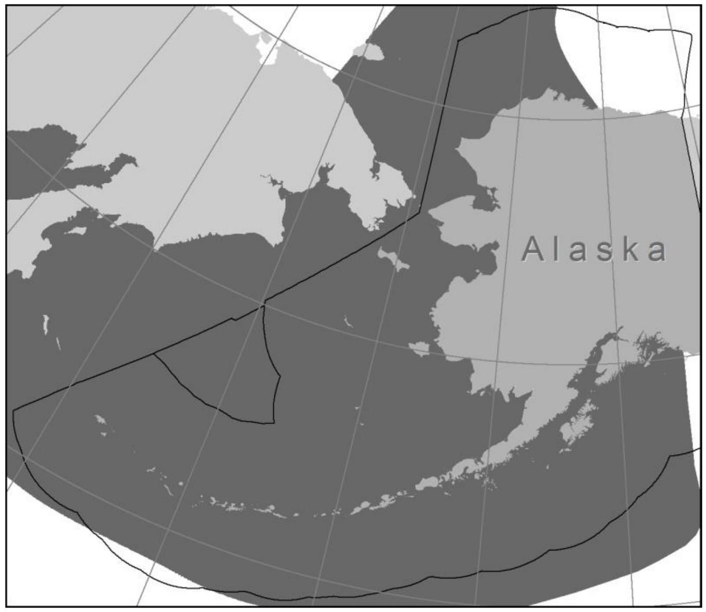

Figure 1. The ~~Alaska stock of~~ ribbon seal stock is defined as the ~~portion of their distribution in U.S. waters~~*Histriophoca fasciata* species~~.~~ ~~The~~ (dark shaded areas depict the combined summer and winter distribution). This stock assessment considers only the portion of the stock occurring in U.S. waters (i.e., ~~T~~the U.S. Exclusive Economic Zone ~~is~~ delineated by ~~the solid~~a black line).

Ribbon seals inhabit the North Pacific Ocean and adjacent parts of the Arctic Ocean. In Alaska waters, ribbon seals range from the North Pacific Ocean and Bering Sea into the Chukchi and western Beaufort seas (Fig. 1). Ribbon seals are very rarely seen on shorefast ice or land. From late March to early May, ribbon seals inhabit the Bering Sea ice front (Burns 1970, 1981; Braham et al. 1984). They are most abundant in the northern part of the ice front in the central and western parts of the Bering Sea (Burns 1970, Burns et al. 1981). As the ice recedes in May to mid-July, the seals move farther north in the Bering Sea, where they haul out on the receding ice edge and remnant ice (Burns 1970, 1981; Burns et al. 1981). As the ice melts, seals become more concentrated, with at least part of the Bering Sea population moving to the Bering Strait and the southern part of the Chukchi Sea. Ten ribbon seals satellite tagged in the spring of 2005 near the eastern coast of Kamchatka spent the summer and fall throughout the Bering Sea (Boveng et al. 2013). However, of 72 ribbon seals satellite tagged in the central Bering Sea ~~during~~from 2007 to ~~-~~2010, 21 seals (29%) moved to the Bering Strait, Chukchi Sea, or Arctic Basin as the ice retreated northward, while the other 51 tagged seals ~~(51 seals)~~ did not pass north of the Bering Strait (Boveng et al. 2013). ~~Year-long p~~Passive acoustic sampling~~, 2008-2009, on the Chukchi Plateau also~~ detected ribbon seal calls ~~in October and November 2008~~in August to early/mid-November in the Chukchi Sea and on the Chukchi Plateau (Moore et al. 2012, Hannay et al. 2013, Jones et al. 2014, Frouin-Mouy et al. 2019), as well as in the western Beaufort Sea in September to early November (Frouin-Mouy et al. 2019), similarly indicating presence of some ribbon seals north of the Bering Strait during summer and fall. The 72 seals tagged in the central Bering Sea and the 10 seals tagged near Kamchatka dispersed widely, occupying coastal areas as well as the middle of the Bering Sea, both on and off the continental shelf (Boveng et al. 2013).

~~The following information was considered in classifying stock structure based on the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: geographic distribution continuous; 2) Population response data: unknown; 3) Phenotypic data: unknown; and 4) Genotypic data: unknown. Based on this limited information and the absence of significant fishery interactions, there is currently no strong evidence to support delineation of the distribution of ribbon seals into more than one stock (Boveng et al. 2013). Therefore, only the Alaska stock of ribbon seals is recognized in U.S. waters.~~This stock is defined as the *Histriophoca fasciata* species; however, this stock assessment considers only the portion of the stock found within U.S. waters bounded by the U.S. Exclusive Economic Zone (EEZ; Fig. 1), because the relevant stock assessment data on abundance and human-caused mortality and serious injury are generally not available for the broader range of the stock or even for waters adjacent to the U.S. EEZ.

POPULATION SIZE

~~A reliable population estimate for the entire stock is not available, but research has developed survey methods and partial, but useful, abundance estimates.~~ In the spring of 2012 and 2013, U.S. and Russian researchers conducted aerial abundance and distribution surveys ~~of~~over the entire ice-covered portions of the Bering Sea and Sea of Okhotsk (Moreland et al. 2013). Conn et al. (2014), using a ~~very limited~~ sub-sample of the data collected from the U.S. portion of the Bering Sea in 2012, calculated an abundance estimate of ~~approximately~~ 184,697 ribbon seals (95% CI: 139,617-240,225) in those waters. Although this is a preliminary abundance estimate, ~~this abundance~~it is also the best available and it is a reasonable estimate for the entire ~~U.S. population~~portion of the stock in U.S. waters because relatively few ribbon seals are expected north of the Bering Strait during the surveys. When the final analyses for the Bering Sea and Sea of Okhotsk are complete, they will provide the first range-wide estimates of ribbon seal abundance.

Minimum Population Estimate

The minimum population estimate (N_{MIN}) for a stock is usually calculated using Equation 1 from the potential biological removal (PBR) guidelines (~~Wade and Angliss 1997~~NMFS 2016): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$, which approximates the 20th percentile of a distribution that is assumed to be log-normal. However, ~~T~~the ~~2012 Bering Sea~~ abundance estimate ~~by~~based on Conn et al. (2014)~~, however,~~ was calculated using a Bayesian hierarchical framework, ~~and~~ so ~~it is more accurate to~~we used the 20th percentile of the posterior distribution of abundance estimates ~~in place of the CV in~~as a more direct estimator of N_{MIN} than Equation 1 to provide an N_{MIN} of 163,086 ribbon seals in ~~this stock~~the U.S. Bering Sea in the spring.

Current Population Trend

Reliable data on trends in population abundance for the ~~Alaska stock of~~ ribbon seal stock or for the portion of the stock within U.S. waters are not ~~un~~available.~~ This stock is thought to occupy its entire historically-observed range (Boveng et al. 2013).~~

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is not ~~un~~available for the ~~Alaska stock of~~ ribbon seal stock or for any portion of the stock within U.S. waters. Until additional data become available, the default pinniped maximum theoretical net productivity rate of 12% will be used for this stock (~~Wade and Angliss 1997~~NMFS 2016).

POTENTIAL BIOLOGICAL REMOVAL

PBR is defined as the product of the minimum population estimate~~ (N_{MIN})~~, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 1.0, ~~the~~a value that may be used for stocks ~~thought to be stable~~that are not known to be decreasing and are taken primarily by aboriginal subsistence hunters, provided there have not been recent increases in the levels of takes (~~Wade and Angliss 1997~~NMFS 2016). ~~Thus~~Using the N_{MIN} based on Conn et al. (2014) for ribbon seals in the U.S. portion of the stock, the PBR ~~for the Alaska stock of ribbon seals =~~is 9,785 seals (163,086 × 0.06 × 1.0).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals ~~in 2012-2016~~between 2014 and 2018 is listed, by marine mammal stock, in ~~Helker et al. (in press)~~Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. The ~~total~~minimum estimated mean annual level of human-caused mortality and serious injury for the portion of the ~~Alaska~~ ribbon seal stock in U.S. waters ~~in 2012-2016~~between 2014 and 2018 is ~~3.9~~163 seals: ~~1.1~~0.9 in U.S. commercial fisheries ~~(from 2012-2016 data)~~ and ~~2.8~~162 in the Alaska Native subsistence harvest (~~from 2011-2015 data~~average statewide harvest, including struck and lost animals, in 2015, based on a recently published analysis (Nelson et al. 2019) that is higher and likely more accurate than previous estimates; see below).~~ This is a minimum estimate of the Alaska Native subsistence harvest because only a small proportion of the communities that harvest ice seals are surveyed each year.~~ Additional potential threats most likely to result in direct human-caused mortality or serious injury of this stock include the increased potential for oil spills due to an increase in vessel traffic in Alaska waters (with changes in sea-ice coverage).

Fisheries Information

Information ~~(including observer programs, observer coverage, and observed incidental takes of marine mammals)~~ for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is ~~presented~~available in Appendi~~ces~~x 3~~-6~~ of the Alaska Stock Assessment Reports (observer coverage) and in the

NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

~~During 2012-2016~~Between 2014 and 2018, incidental mortality and serious injury of ribbon seals in U.S. waters occurred in four of the federally-managed U.S. commercial fisheries in Alaska monitored for incidental mortality and serious injury by fisheries observers: the Bering Sea/Aleutian Islands flatfish trawl, Bering Sea/Aleutian Islands pollock trawl, Bering Sea/Aleutian Islands Pacific cod trawl, and Bering Sea/Aleutian Islands rockfish trawl fisheries (Table 1; Breiwick 2013; MML, unpubl. data). The minimum estimated ~~minimum~~ mean annual mortality and serious injury rate incidental to U.S. commercial fisheries ~~in 2012-2016~~between 2014 and 2018 is ~~1.1~~0.9 ribbon seals, based exclusively on observer data.

Table 1. Summary of incidental mortality and serious injury of ~~Alaska~~ ribbon seals in U.S. waters due to U.S. commercial fisheries ~~in 2012-2016~~between 2014 and 2018 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix ~~6~~3 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality (CV)	Mean estimated annual mortality
Bering Sea/Aleutian Is. flatfish trawl	~~2012~~ ~~2013~~ 2014 2015 2016 2017 2018	obs data	~~99~~ ~~99~~ ~~99~~100 ~~99~~100 99 100 100	~~1~~ ~~0~~ 1 0 0 0 0	~~1~~ ~~0~~ 1 (0.04) 0 0 0 0	~~0.4~~0.2 (CV = ~~0.03~~0.04)
Bering Sea/Aleutian Is. pollock trawl	~~2012~~ ~~2013~~ 2014 2015 2016 2017 2018	obs data	~~98~~ ~~97~~ 98 99 99 99 99	~~0~~ ~~0~~ 0 0 1 0 0	~~0~~ ~~0~~ 0 0 1.0 (0.13) 0 0	0.2 (CV = 0.13)
Bering Sea/Aleutian Is. Pacific cod trawl	~~2012~~ ~~2013~~ 2014 2015 2016 2017 2018	obs data	~~68~~ ~~80~~ 80 72 68 68 73	~~0~~ ~~0~~ 1 0 0 0 0	~~0~~ ~~0~~ ~~1.4~~1.3 (0.49) 0 0 0 0	0.3 (CV = ~~0.55~~0.49)
Bering Sea/Aleutian Is. rockfish trawl	~~2012~~ ~~2013~~ 2014 2015 2016 2017 2018	obs data	~~100~~ ~~99~~ ~~99~~100 100 ~~99~~100 100 100	~~0~~ ~~0~~ 1 0 0 0 0	~~0~~ ~~0~~ 1 (0) 0 0 0 0	0.2 (CV = 0~~.01~~)
Minimum total estimated annual mortality						~~1.1~~0.9 (CV = ~~0.14~~0.15)

Alaska Native Subsistence/Harvest Information

NMFS signed an agreement with the Ice Seal Committee (ISC; 2006) to co-manage Alaska ice seal populations. This co-management agreement promotes full and equal participation by Alaska Natives in decisions affecting the subsistence management of ice seals (to the maximum extent allowed by law) as a tool for conserving ice seal populations in Alaska (https://www.fisheries.noaa.gov/alaska/marine-mammal-protection/co-management-marine-mammals-alaska, accessed August 2020).

Ribbon seals are an important resource for Alaska Native subsistence hunters. Approximately 64 ~~Alaska~~ coastal communities in Alaska, from Bristol Bay to the Beaufort Sea, ~~regularly~~ harvest ice seals (~~Ice Seal Committee~~ISC ~~2017~~2019). The ~~Ice Seal Committee~~ISC, as co-managers with NMFS, recognizes the importance of harvest information and has collected it since 2008. Annual household survey results compiled in a statewide harvest report include historical ice seal harvest information from 1960 to ~~2015~~2017 (Quakenbush and Citta 2008, ~~Ice Seal Committee~~ISC ~~2017~~2019). ~~Ribbon seal harvest information for 2011-2015 is available for 16 communities (see Table 2). However, a number of other communities harvest ice seals and were not surveyed in 2011-2015, including a few communities that have never been surveyed.~~

~~Household harvest surveys are designed to estimate the harvest within each surveyed community, but because of differences in ribbon seal availability, cultural hunting practices, and environmental conditions, it is not appropriate to extrapolate harvest numbers beyond that community. The number of communities surveyed and successive annual surveys in the same communities have also been limited. For example, during 2011-2015, 16 of 64 coastal communities were surveyed for ice seal harvests and, of the 16 communities, only 4 were surveyed for two or more consecutive years (Ice Seal Committee 2017). Thus, annual community-level harvest estimates totaled across communities provide a partial (i.e., minimum) estimate of annual statewide harvest. The geographic distribution of communities with annual harvest estimates also varies among years, so total annual estimates across communities may be geographically or otherwise biased. During 2011-2015, the minimum annual ribbon seal harvest estimates totaled across surveyed communities ranged from 0 to 8 seals (Table 2). Based on the available harvest data from these 16 communities (Table 2), a minimum estimate of the average annual ribbon seal harvest in 2011-2015 is 2.8 seals. The Ice Seal Committee is working for a better understanding of ice seal harvest by conducting more consecutive surveys in more communities, and one of their goals is to report a statewide ice seal harvest estimate.~~ To estimate the recent subsistence harvest of ice seals, Nelson et al. (2019) used ice seal harvest survey data collected from 1992 to 2014 for 41 of 55 communities that regularly hunt ice seals, as well as the per capita removal estimates (based on the 2015 human population) from the surveyed communities, to estimate the average regional and statewide subsistence harvest (Table 2). The best statewide estimate of the average number of ribbon seals harvested in 2015, including struck and lost animals, is 162 seals (Nelson et al. 2019). The authors also found stable or decreasing trends in the annual numbers of ice seals harvested (Nelson et al. 2019).

Table 2. Average regional and statewide subsistence harvest (including struck and lost animals) of ribbon seals in 2015 (Nelson et al. 2019). See Figure 1 in Nelson et al. (2019) for a list of the communities in each region.

Region	**Average harvest (including struck and lost animals)**
North Slope Borough	0
Maniilaq	9
Kawerak	130
Association of Village Council Presidents	23
Bristol Bay Native Association	0
Statewide total	162

~~**Table 2.** Alaska ribbon seal minimum harvest estimates in 2011-2015 (Ice Seal Committee 2017). Empty cells represent the years in which the communities were not surveyed for harvest information.~~

~~**Community**~~	~~**Ribbon seal minimum harvest estimates**~~				
	~~**2011**~~	~~**2012**~~	~~**2013**~~	~~**2014**~~	~~**2015**~~
~~Nuiqsut~~				~~0~~	
~~Utqiaġvik (formerly Barrow)~~				~~0~~	
~~Point Lay~~		~~0~~			

Community	Ribbon seal minimum harvest estimates				
	2011	2012	2013	2014	2015
Kivalina	0				
Noatak	1				
Buckland	0				
Deering	0				
Golovin		0			
Emmonak	0				
Scammon Bay	4	2			
Hooper Bay	0	4	0	0	0
Tununak	0	0			
Tuntutuliak			0		
Quinhagak	3	0	0	0	
Togiak	0				
Dillingham		0			
Minimum total	8	6	0	0	0

Other Mortality

In 2011, NMFS and the U.S. Fish and Wildlife Service declared an Unusual Mortality Event (UME) for pinnipeds in the Bering and Chukchi seas, due to the unusual number of sick or dead seals and walruses discovered with skin lesions, bald patches, and other symptoms. The UME occurred from 1 May 2011 to 31 December 2016 and primarily affected ice seals, including ringed seals, bearded seals, ribbon seals, and spotted seals. The investigation concluded that the skin and hair symptoms were signs of a molt abnormality; however, no infectious disease agent or environmental cause for the UME symptoms and mortality was identified (https://alaskafisheries.noaa.gov/pr/ice-sealshttps://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events, accessed December 2018August 2020). Patchy baldness and delayed molt, however, continue to be observed in limited numbers (<20 per year) of harvested and beach-cast ringed seals, bearded seals, ribbon seals, and spotted seals in Alaska.

Since 1 June 2018, elevated numbers of ice seal strandings have occurred in the Bering and Chukchi seas in Alaska and NMFS declared a UME for bearded seals, ringed seals, and spotted seals from 1 June 2018 to present in the Bering and Chukchi seas (https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events, accessed August 2020). As of 31 July 2020, 298 ice seal strandings of all age classes have been reported, including 88 bearded seals, 72 ringed seals, 49 spotted seals, and 89 unidentified seals. Although the UME was not declared for ribbon seals, some of the unidentified carcasses could have been ribbon seals that were too decomposed to be identified. A subset of seals has been sampled for genetics and harmful algal bloom exposure and a few have had histopathology samples collected.

STATUS OF STOCK

Ribbon seals are not designated as depleted under the Marine Mammal Protection Act (MMPA) or listed as threatened or endangered under the Endangered Species Act (ESA). NMFS completed a comprehensive status review of ribbon seals under the ESA in 2013 (Boveng et al. 2013) and concluded that listing ribbon seals was not warranted at that time (78 FR 41371, 10 July 2013). The ribbon seal stock is not considered a strategic stock. The best estimate of the mean annual level of human-caused mortality and serious injury in the portion of the stock in U.S. waters is 163 ribbon seals, which is less than the PBR (9,785 seals). The minimum estimated mean annual rate of U.S. commercial fishery-related mortality and serious injury (0.9 seals) is less than 10% of the PBR (10% of PBR = 979) and, therefore, can be considered insignificant and approaching a zero mortality and serious injury rate. Population trends and status of this stock relative to its Optimum Sustainable Population are unknown. The minimum population estimate of ribbon seals in U.S. waters is 163,086 seals, with a PBR of 9,785. Because the estimated annual level of U.S. commercial fishery-related mortality and serious injury (1.1) is less than 10% of PBR

~~(10% of PBR = 979), it can be considered insignificant and approaching zero mortality and serious injury rate. A minimum estimate of the total annual level of human-caused mortality and serious injury is 3.9 ribbon seals. The Alaska stock of ribbon seals is not considered a strategic stock. Population trends and status of this stock relative to its Optimum Sustainable Population are unknown.~~

There are key uncertainties in the assessment of the ~~Alaska stock of~~ ribbon seal stock. The N_{MIN} used here, based on a 2012 Bering Sea ~~abundance~~density estimate ~~by~~from Conn et al. (2014) was calculated us~~es~~ing only a ~~very limited~~ sub-sample of the survey data ~~from the U.S. portion of the Bering Sea~~ and may be biased. ~~Similarly, counts of harvest by Alaska Natives are taken from surveys of only a fraction of the communities known to harvest marine mammals and so are considered minimum estimates.~~ Based on the best available information, ribbon seals are likely to be moderately sensitive to climate change.

HABITAT CONCERNS

The main concern about the conservation status of ribbon seals ~~stems from the likelihood that a warming climate is reducing their preferred sea-ice habitats~~is long-term habitat loss and modification resulting from climate change (Boveng et al. 2013). Laidre et al. (2008) concluded that on a worldwide basis ribbon seals were likely to be moderately sensitive to climate change, based on an analysis of various life-history features that could be affected by climate. ~~Scientific projections are for continued and perhaps accelerated warming (Boveng et al. 2013).~~Climate models consistently project substantial reductions in both the extent and timing of sea ice within the range of ribbon seals in Alaska waters; however, the sea ice in the Bering Sea is expected to continue forming annually in winter for the foreseeable future. Ribbon seals are closely associated with sea ice, particularly during the periods of reproduction and molting. The presence of sea ice is considered a requirement for whelping and nursing young, providing a platform out of the water to facilitate these life-history events. Similarly, the molt is believed to be promoted by elevated skin temperatures that, in polar regions, can only be achieved when seals haul out of the water. There will likely be more frequent years in which ice coverage is reduced, resulting in a decline in the long-term average ice extent; however, ribbon seals will likely continue to encounter sufficient ice to support adequate vital rates. ~~Ribbon seals, along with other seals that are dependent on sea ice for at least part of their life history (e.g., whelping and nursing young), will be vulnerable to reductions in sea ice.~~

A second major concern, driven primarily by the production of carbon dioxide (CO_2) emissions, is the modification of habitat by ocean acidification, which may alter prey populations and other important aspects of the marine ecosystem. Ocean acidification, a result of increased CO_2 in the atmosphere, may affect ribbon seal survival and recruitment through disruption of trophic regimes that are dependent on calcifying organisms. The nature and timing of such impacts are extremely uncertain. ~~Laidre et al. (2008) concluded that on a worldwide basis ribbon seals were likely to be moderately sensitive to climate change, based on an analysis of various life history features that could be affected by climate.~~As described in Boveng et al. (2013), changes in ribbon seal prey, anticipated in response to ocean warming and loss of sea ice, have the potential for negative impacts, but the possibilities are complex. Ecosystem responses may have very long lags as they propagate through trophic webs. Because of ribbon seals' apparent dietary flexibility, this threat may be of less immediate concern than the threats from sea-ice degradation.

Additional habitat concerns include the potential effects from increased shipping (particularly in the Bering Strait) ~~and oil and gas exploration and development activities~~, such as disturbance from vessel traffic~~, seismic exploration noise,~~ and the potential for oil spills.

CITATIONS

Boveng, P. L., J. L. Bengtson, M. F. Cameron, S. P. Dahle, E. A. Logerwell, J. M. London, J. E. Overland, J. T. Sterling, D. E. Stevenson, B. L. Taylor, and H. L. Ziel. 2013. Status review of the ribbon seal (*Histriophoca fasciata*). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-255, 174 p.

Braham, H. W., J. J. Burns, G. A. Fedoseev, and B. D. Krogman. 1984. Habitat partitioning by ice-associated pinnipeds: distribution and density of seals and walruses in the Bering Sea, April 1976, p. 25-47. *In* F. H. Fay and G. A. Fedoseev (eds.), Soviet-American cooperative research on marine mammals. Vol. 1. Pinnipeds. U.S. Dep. Commer., NOAA Tech. Rep. NMFS-12.

Breiwick, J. M. 2013. North Pacific marine mammal bycatch estimation methodology and results, 2007-2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-260, 40 p.

Burns, J. J. 1970. Remarks on the distribution and natural history of pagophilic pinnipeds in the Bering and Chukchi Seas. J. Mammal. 51:445-454.

Burns, J. J. 1981. Ribbon seal-*Phoca fasciata*, p. 89-109. *In* S. H. Ridgway and R. J. Harrison (eds.), Handbook of Marine Mammals. Vol. 2. Seals. Academic Press, New York.

Burns, J. J., L. H. Shapiro, and F. H. Fay. 1981. Ice as marine mammal habitat in the Bering Sea, p. 781-797. *In* D. W. Hood and J. A. Calder (eds.), The Eastern Bering Sea Shelf: Oceanography and Resources. Vol. 2. U.S. Dep. Commer., NOAA, Office of Marine Pollution Assessment, Juneau, AK.

Conn, P. B., J. M. Ver Hoef, B. T. McClintock, E. E. Moreland, J. M. London, M. F. Cameron, S. P. Dahle, and P. L. Boveng. 2014. Estimating multispecies abundance using automated detection systems: ice-associated seals in the Bering Sea. Methods Ecol. Evol. 5:1280-1293. DOI: dx.doi.org/10.1111/2041-210X.12127 .

~~Dizon, A. E., C. Lockyer, W. F. Perrin, D. P. DeMaster, and J. Sisson. 1992. Rethinking the stock concept: a phylogeographic approach. Conserv. Biol. 6:24-36.~~

Frouin-Mouy, H., X. Mouy, C. L. Berchok, S. B. Blackwell, and K. M. Stafford. 2019. Acoustic occurrence and behavior of ribbon seals (*Histriophoca fasciata*) in the Bering, Chukchi, and Beaufort seas. Polar Biol. 42(4):657-674.

~~Helker, V. T., M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2012-2016. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX, XXX p.~~

Hannay D. E., J. Delarue, X. Mouy, B. S. Martin, D. Leary, J. N. Oswald, and J. Vallarta. 2013. Marine mammal acoustic detections in the northeastern Chukchi Sea, September 2007–July 2011. Continental Shelf Research 67:127-146.

Ice Seal Committee (ISC). ~~2017~~2019. The subsistence harvest of ice seals in Alaska – a compilation of existing information, 1960-~~2015~~2017. ~~78~~86 p. Available online: http://www.north-slope.org/departments/wildlife-management/co-management-organizations/ice-seal-committee . Accessed ~~December 2018~~August 2020.

Jones, J. M., B. J. Thayre, E. H. Roth, M. Mahoney, I. Sia, K. Merculief, C. Jackson, C. Zeller, M. Clare, A. Bacon, S. Weaver, Z. Gentes, R. J. Small, I. Stirling, S. M. Wiggins, and J. A. Hildebrand. 2014. Ringed, bearded, and ribbon seal vocalizations north of Barrow, Alaska: seasonal presence and relationship with sea ice. Arctic 67(2):203-222.

Laidre, K. L., I. Stirling, L. F. Lowry, Ø. Wiig, M. P. Heide-Jørgensen, and S. H. Ferguson. 2008. Quantifying the sensitivity of Arctic marine mammals to climate-induced habitat change. Ecol. Appl. 18(2):S97-S125.

Moore, S. E., K. M. Stafford, H. Melling, C. Berchok, Ø. Wiig, K. M. Kovacs, C. Lydersen, and J. Richter-Menge. 2012. Comparing marine mammal acoustic habitats in Atlantic and Pacific sectors of the High Arctic: year-long records from Fram Strait and the Chukchi Plateau. Polar Biol. 35:475-480. DOI: dx.doi.org/10.1007/s00300-011-1086-y .

Moreland, E., M. Cameron, and P. Boveng. 2013. Bering Okhotsk Seal Surveys (BOSS): joint U.S.-Russian aerial surveys for ice associated-seals, 2012-13. Alaska Fisheries Science Center Quarterly Report (July-August-September 2013).

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed August 2020.

Nelson, M. A., L. T. Quakenbush, B. D. Taras, and Ice Seal Committee. 2019. Subsistence harvest of ringed, bearded, spotted, and ribbon seals in Alaska is sustainable. Endang. Species Res. 40:1-16. DOI: dx.doi.org/10.3354/esr00973 .

Quakenbush, L., and J. Citta. 2008. Biology of the ribbon seal in Alaska. Report to NMFS. Arctic Marine Mammal Program, Alaska Department of Fish and Game, Fairbanks, AK. 45 p.

~~Wade, P. R., and R. Angliss. 1997. Guidelines for assessing marine mammal stocks: report of the GAMMS Workshop April 3-5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12, 93 p.~~

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX.

BELUGA WHALE (*Delphinapterus leucas*): Beaufort Sea Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Beluga whales are distributed throughout seasonally ice-covered arctic and subarctic waters of the Northern Hemisphere (Gurevich 1980)~~ and~~. In ice-covered regions, they are closely associated with open leads and polynyas~~ in ice-covered regions~~ (Hazard 1988). In Alaska, depending on season and region, beluga whales may occur in both offshore and coastal waters, with summer concentrations in upper Cook Inlet, Bristol Bay, ~~the~~ eastern Bering Sea (i.e., Yukon River Delta, ~~and~~ Norton Sound), eastern Chukchi Sea, and Beaufort Sea (Mackenzie River Delta) (Hazard 1988, O'Corry-Crowe et al. ~~1997~~2018) (Fig. 1). Seasonal distribution is affected by ice cover, tidal conditions, access to prey, temperature, and human interaction (Lowry 1985). Data from satellite transmitters attached to ~~a few~~beluga whales from the Beaufort Sea, Eastern Chukchi Sea, ~~and~~ Eastern Bering Sea, and Bristol Bay stocks ~~show~~identify ranges that are relatively distinct month to month for these ~~populations~~stocks' summering areas and autumn migratory routes (e.g., Hauser et al. 2014, Citta et al. 2017, Lowry et al. 2019). ~~The few t~~Transmitters that lasted through the winter showed that beluga whales from these summering areas overwinter in the Bering Sea; these stocks ~~may use separate wintering locations and probably remain separated through the winter~~are not known to overlap in space and time in the Bering Sea (Suydam 2009, Citta et al. 2017, Lowry et al. 2019).

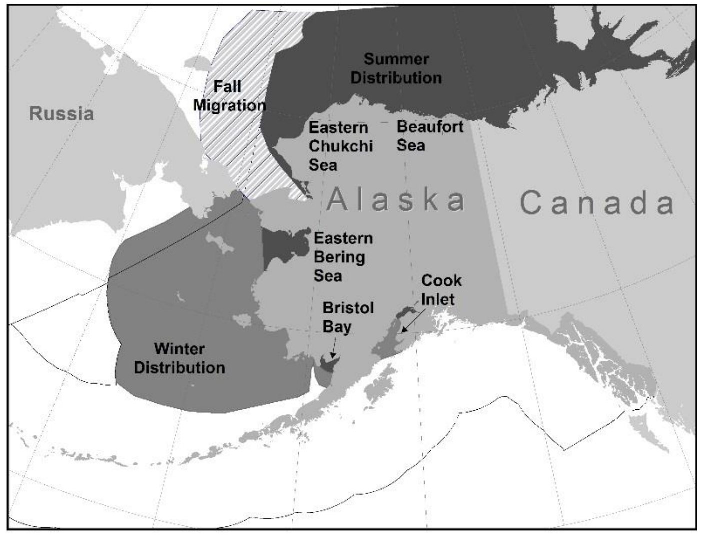

Figure 1. Approximate distribution for all five beluga whale stocks. Summering areas are dark gray, wintering areas are lighter gray, and the hashed area is a region used by the Eastern Chukchi Sea and Beaufort Sea stocks for autumn migration. The U.S. Exclusive Economic Zone is delineated by a black line.

New genetic analyses have further defined five of the summering aggregations in the Bering, Chukchi, and Beaufort seas as follows: Bristol Bay, eastern Bering Sea (Norton Sound), eastern Chukchi Sea (Kasegaluk Lagoon), eastern Beaufort Sea (Mackenzie-Amundsen), and Gulf of Anadyr (Anadyr Bay) (O'Corry-Crowe et al. 2018). These genetic analyses, combined with new telemetry data, demonstrate that the demographically distinct summering aggregations return to discrete wintering areas and disperse and interbreed over limited distances but do not appear to interbreed extensively (O'Corry-Crowe et al. 2018).

The Beaufort Sea and Eastern Chukchi Sea stocks of beluga whales migrate between the Bering and Beaufort seas. Beaufort Sea beluga whales depart ~~from~~ the Bering Sea in early spring, migrate through the Chukchi Sea and into the Canadian waters of the Beaufort Sea where they remain in the summer and fall, returning to the Bering Sea in late fall. Eastern Chukchi Sea beluga whales ~~migrate out of~~depart the Bering Sea in late spring and early summer, ~~into~~migrate through the Chukchi Sea and into the western Beaufort Sea where they remain in the summer, returning to the Bering Sea in the fall. The Eastern Bering Sea beluga whale stock remains in the Bering Sea but ~~moves~~migrates south near Bristol Bay in winter and returns north to Norton Sound and the mouth of the Yukon River in summer (Suydam 2009, Hauser et al. 2014, Citta et al. 2017, Lowry et al. 2019). Beluga whales ~~found~~tagged in Bristol Bay (Quakenbush 2003; Citta et al. 2016, 2017) and Cook Inlet (~~Hobbs et al. 2005,~~ Goetz et al. 2012~~,~~; Shelden et al. 2015, 2018; Lowry et al. 2019) remain in those areas throughout the year, showing only small seasonal shifts in distribution.

The following information was considered in classifying beluga whale stock structure based on the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: geographic distribution discontinuous in summer (Frost and Lowry 1990); 2) Population response data: distinct population trends among regions occupied in summering areas (O'Corry-Crowe et al. 2018); 3) Phenotypic data: unknown; and 4) Genotypic data: mitochondrial DNA analyses indicate distinct differences among the five summering areas (O'Corry-Crowe et al. ~~1997~~2018). Based on this information, five beluga whale stocks are recognized within U.S. waters: 1) Cook Inlet, 2) Bristol Bay, 3) Eastern Bering Sea, 4) Eastern Chukchi Sea, and 5) Beaufort Sea (Fig. 1).

POPULATION SIZE

The sources of information to estimate abundance for beluga whales in ~~the~~ waters of northern Alaska and western Canada have included both opportunistic and systematic observations. Duval (1993) reported an estimate of 21,000 beluga whales for the Beaufort Sea stock, similar to that reported by Seaman et al. (1985). The most recent aerial survey ~~was~~ conducted in July 1992 ~~and~~ resulted in an estimate of 19,629 beluga whales (CV = 0.229) in the eastern Beaufort Sea (Harwood et al. 1996). To account for availability bias, a correction factor (CF), which was not data-based, has been recommended for the Beaufort Sea beluga whale stock (Duval 1993), resulting in a population estimate of 39,258 whales (19,629 × 2). A coefficient of variation (CV) for the CF is not available; however, this CF was considered negatively biased by the Alaska Scientific Review Group (SRG) considering that aerial survey CFs for this ~~species~~stock ~~have been~~were estimated ~~to be~~ between 2.5 and 3.27 (Frost and Lowry 1995). Additionally, the 1992 surveys did not encompass the entire summer range of Beaufort Sea beluga whales (Richard et al. 2001), thus, are negatively biased.

During summer 2019, the governments of the United States and Canada supported independent aerial line-transect surveys in the eastern Beaufort Sea to conduct an abundance survey for bowhead whales. Those data are also being analyzed to derive abundance estimates for the Beaufort Sea stock of beluga whales.

Minimum Population Estimate

For the Beaufort Sea beluga whale stock, the minimum population estimate (N_{MIN}) is calculated according to Equation 1 from the potential biological removal (PBR) guidelines (~~Wade and Angliss 1997~~NMFS 2016): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the population estimate (N) of 39,258 whales and an associated CV(N) of 0.229, N_{MIN} for this stock would be 32,453 whales. However, because the survey data are more than 8 years old, it is not considered a reliable minimum population estimate for calculating a PBR and N_{MIN} is considered unknown.

Current Population Trend

The current population trend of the Beaufort Sea stock of beluga whales is unknown. Aerial surveys ~~off~~seaward of the Mackenzie River Delta between 1982-1985 and 2007-2009 indicate that the stock in that area is at least stable or increasing (Harwood and Kingsley 2013).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is not ~~un~~available for the Beaufort Sea beluga whale stock. ~~Hence, u~~Until additional data become available, the default cetacean maximum theoretical net productivity rate ~~(R_{MAX}) for cetaceans~~ of 4% will be used for this stock (~~Wade and Angliss 1997~~NMFS 2016).

POTENTIAL BIOLOGICAL REMOVAL

PBR is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 1.0, ~~the~~a value that may be used for ~~cetacean~~ stocks that are ~~thought to be stable in the presence of a~~not known to be decreasing and are taken primarily by aboriginal subsistence ~~harvest~~hunters, provided there have not been recent increases in the levels of takes (~~Wade and Angliss 1997~~NMFS 2016). However, the 2016 guidelines for preparing Stock Assessment Reports (NMFS 2016) state that abundance estimates older than 8 years should not be used to calculate PBR due to a decline in confidence in the reliability of an aged abundance estimate. Therefore, the PBR for this stock is considered undetermined.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

~~Detailed i~~Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals ~~in 2011-2015~~between 2014 and 2018 is listed, by marine mammal stock, in ~~Helker et al. (2017)~~Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. The ~~total~~minimum estimated mean annual level of human-caused mortality and serious injury for Beaufort Sea beluga whales ~~in 2011-2015~~between 2014 and 2018 is ~~139~~102 beluga whales: ~~47~~27 in subsistence takes by Alaska Natives and ~~92~~75 in subsistence takes by Canadian ~~Natives~~Inuvialuit.

Fisheries Information

~~Detailed i~~Information ~~(including observer programs, observer coverage, and observed incidental takes of marine mammals)~~ for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is ~~presented~~available in Appendi~~ces~~x 3~~-6~~ of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

There ~~are~~were no reports of mortality or serious injury of this stock incidental to U.S. commercial fisheries or subsistence fisheries in Alaska between 2014 and 2018.

Alaska Native Subsistence/Harvest Information

NMFS signed an agreement with the Alaska Beluga Whale Committee (ABWC; 2000) to co-manage western Alaska beluga whale populations in the Bering Sea (including Bristol Bay), Chukchi Sea, and Beaufort Sea. This co-management agreement promotes full and equal participation by Alaska Natives in decisions affecting the subsistence management of beluga whales (to the maximum extent allowed by law) as a tool for conserving beluga whale populations in Alaska (https://www.fisheries.noaa.gov/alaska/marine-mammal-protection/co-management-marine-mammals-alaska, accessed August 2020).

The subsistence take of Beaufort Sea beluga whales ~~from this stock~~ within U.S. waters is reported by the ~~Alaska Beluga Whale Committee (~~ABWC~~)~~. The most recent Alaska Native subsistence harvest estimates for the Beaufort Sea beluga whale stock are provided in Table 1 (ABWC, unpubl. data, ~~2016~~2019). ~~Given these data, t~~The annual subsistence take by Alaska Native hunters averaged ~~47~~27 Beaufort Sea beluga whales landed ~~during 2011-2015~~between 2014 and 2018. It should be noted that beluga whales harvested at Utqiaġvik (formerly Barrow) in spring are assumed to be from the Beaufort Sea stock, while those harvested in summer are assumed to be from the Eastern Chukchi Sea stock.

Table 1. Summary of Beaufort Sea beluga whales landed by Alaska Native subsistence hunters ~~in 2011-2015~~between 2014 and 2018 (ABWC, unpubl. data, ~~2016~~2019). These are minimum estimates of the total number of beluga whales taken, because not all landed whales and struck and lost ~~data~~whales are ~~not~~ consistently ~~provided~~reported.

Year	Reported total number landed
~~2011~~	~~42~~
~~2012~~	~~92~~
~~2013~~	~~35~~
2014	24
2015	43
2016	43
2017	10
2018	13
Mean annual number landed	~~47~~27

Canadian ~~Native~~Inuvialuit Subsistence/Harvest Information

The subsistence take of beluga whales within the Canadian waters of the Beaufort Sea is reported by the Fisheries Joint Management Committee (FJMC). The data are collected through on-site harvest monitoring conducted by the FJMC at Inuvialuit communities in the Mackenzie River Delta, Northwest Territories. The Canadian Inuvialuit subsistence harvest estimates for the Beaufort Sea beluga whale stock ~~in 2011-2015~~between 2014 and 2018 are provided in Table 2 (FJMC Beluga Monitor Program, FJMC, Inuvik, NT, Canada). Given these data, the annual subsistence take in Canada averaged ~~92~~75 beluga whales ~~in 2011-2015~~between 2014 and 2018.

Thus, the estimated mean annual subsistence take of Beaufort Sea beluga whales in U.S. and Canadian waters ~~in 2011-2015~~between 2014 and 2018 is ~~139~~102 whales (~~47~~27 + ~~92~~75).

Table 2. Summary of ~~the~~Beaufort Sea beluga whales harvested by Canadian Inuvialuit subsistence hunters ~~harvest of Beaufort Sea beluga whales in 2011-2015~~between 2014 and 2018 (FJMC, unpubl. data). N/A indicates that data are not available.

Year	Landed	Struck and lost	Total (landed + struck and lost)
~~2011~~	~~98~~	~~4~~	~~102~~
~~2012~~	~~73~~	~~2~~	~~75~~
~~2013~~	~~90~~	~~2~~	~~92~~
2014	104	2	106
2015*	~~82~~75	1	~~83~~76
2016	48	1	49
2017	66	N/A	66
2018	76	2	78
Mean annual number taken (landed + struck and lost)			~~92~~75

*The number of beluga whales landed in 2015 was changed from 82 to 75 whales (resulting in a change in the total harvest from 83 to 76 whales) based on updated harvest information from the FJMC (FJMC, unpubl. data).

STATUS OF STOCK

No fishery-related mortality or serious injury has been reported for the Beaufort Sea stock of beluga whales between 2014 and 2018; therefore, the mean annual ~~U.S. commercial fishery-related~~ mortality and serious injury rate incidental to U.S. commercial fisheries can be considered insignificant and approaching a zero mortality and serious injury rate. The ~~total~~minimum estimated mean annual level of human-caused mortality and serious injury for this stock is ~~139~~102 beluga whales. Beaufort Sea beluga whales are not designated as depleted under the Marine Mammal Protection Act or listed as threatened or endangered under the Endangered Species Act. Therefore, the Beaufort Sea beluga whale stock is classified as a non-strategic stock. At this time, it is not possible to assess the status of this stock relative to its Optimum Sustainable Population.

There are key uncertainties in the assessment of the Beaufort Sea stock of beluga whales. The most recently analyzed surveys were conducted more than 8 years ago and did not cover the entire population; given the lack of information on population trend, the abundance estimates are not used to calculate an N_{MIN} and the PBR level is undetermined.

HABITAT CONCERNS

Evidence indicates that the arctic climate is changing rapidly and significantly, and one result of this change is a reduction in the extent and duration of sea ice in ~~at least~~ some regions (ACIA 2004, Johannessen et al. 2004). These changes are likely to affect marine mammal species in the Arctic. Ice-associated animals, such as the beluga whale, are sensitive to changes in arctic weather, sea-surface temperatures, and sea-ice extent, and the concomitant effect on prey availability. There are indications that decreases in seasonal sea ice have influenced beluga whale phenology; however, Beaufort Sea beluga whales did not show a statistically significant change in the timing of their southward migration in response to changes in sea ice (Hauser et al. 2017). An offshore shift in distribution of Beaufort Sea beluga whales between an earlier sample in 1982-1985 and a later sample in 2007-2009 was attributed either to increased habitat due to more open water or potential~~ly a~~ response to industrial activity (Harwood and Kingsley 2013). Decreases in seasonal sea ice may also increase the risk of killer whale predation (O'Corry-Crowe et al. 2016). There are insufficient data to make reliable predictions of the effects of arctic climate change on beluga whales; however, Laidre et al. (2008) and Heide-Jørgensen et al. (2010) concluded that on a worldwide basis beluga whales were likely to be less sensitive to climate change than other arctic cetaceans because of their wide distribution and flexible behavior. Increased human activity in the Arctic, including increased oil and gas exploration and development and increased nearshore development, has the potential to impact beluga whale habitat (Moore et al. 2000, Lowry et al. 2006). However, predicting the type and magnitude of these impacts is difficult.

CITATIONS

Arctic Climate Impact Assessment (ACIA). 2004. Impacts of a Warming Arctic: Arctic Climate Impact Assessment. Cambridge University Press, Cambridge, UK.

Citta, J. J., L. T. Quakenbush, K. J. Frost, L. Lowry, R. C. Hobbs, and H. Aderman. 2016. Movements of beluga whales (*Delphinapterus leucas*) in Bristol Bay, Alaska. Mar. Mammal Sci. 32:1272-1298. DOI: dx.doi.org/10.1111/mms.12337 .

Citta, J. J., P. Richard, L. F. Lowry, G. O'Corry-Crowe, M. Marcoux, R. Suydam, L. T. Quakenbush, R. C. Hobbs, D. I. Litovka, K. J. Frost, T. Gray, J. Orr, B. Tinker, H. Aderman, and M. L. Druckenmiller. 2017. Satellite telemetry reveals population specific winter ranges of beluga whales in the Bering Sea. Mar. Mammal Sci. 33:236-250. DOI: dx.doi.org/10.1111/mms.12357 .

Dizon, A. E., C. Lockyer, W. F. Perrin, D. P. DeMaster, and J. Sisson. 1992. Rethinking the stock concept: a phylogeographic approach. Conserv. Biol. 6:24-36.

Duval, W. S. 1993. Proceedings of a workshop on Beaufort Sea beluga: February 3-6, 1992, Vancouver, BC. Env. Studies Res. Found. Report No. 123. Calgary. 33 p. + appendices.

Frost, K. J., and L. F. Lowry. 1990. Distribution, abundance, and movements of beluga whales, *Delphinapterus leucas*, in coastal waters of western Alaska, p. 39-57. *In* T. G. Smith, D. J. St. Aubin, and J. R. Geraci (eds.), Advances in research on the beluga whale, *Delphinapterus leucas*. Can. Bull. Fish. Aquat. Sci. 224.

Frost, K. J., and L. F. Lowry. 1995. Radio tag based correction factors for use in beluga whale population estimates. Working paper for Alaska Beluga Whale Committee Scientific Workshop, Anchorage, AK, 5-7 April 1995. 12 p. Available from Alaska Department of Fish and Game, 1300 College Rd., Fairbanks, AK 99701.

Goetz, K. T., P. W. Robinson, R. C. Hobbs, K. L. Laidre, L. A. Huckstadt, and K. E. W. Shelden. 2012. Movement and dive behavior of beluga whales in Cook Inlet, Alaska. AFSC Processed Rep. 2012-03, 40 p. Alaska Fisheries Science Center, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Gurevich, V. S. 1980. Worldwide distribution and migration patterns of the white whale (beluga), *Delphinapterus leucas*. Rep. Int. Whal. Comm. 30:465-480.

Harwood, L. A., and M. C. S. Kingsley. 2013. Trends in the offshore distribution and relative abundance of Beaufort Sea belugas, 1982-85 vs 2007-09. Arctic 66(3):247-256.

Harwood, L. A., S. Innes, P. Norton, and M. C. S. Kingsley. 1996. Distribution and abundance of beluga whales in the Mackenzie Estuary, southeast Beaufort Sea and west Amundsen Gulf during late July 1992. Can. J. Fish. Aquat. Sci. 53:2262-2273.

Hauser, D. D. W., K. L. Laidre, R. S. Suydam, and P. R. Richard. 2014. Population-specific home ranges and migration timing of Pacific Arctic beluga whales (*Delphinapterus leucas*). Polar Biol. 37:1171-1183. DOI: dx.doi.org/10.1007/s00300-014-1510-1 .

Hauser, D. D. W., K. L. Laidre, K. M. Stafford, H. L. Stern, R. S. Suydam, and P. R. Richard. 2017. Decadal shifts in autumn migration timing by Pacific Arctic beluga whales are related to delayed annual sea ice formation. Glob. Change Biol. 23:2206-2217. DOI: dx.doi.org/10.1111/gcb.13564 .

Hazard, K. 1988. Beluga whale, *Delphinapterus leucas*, p. 195-235. *In* J. W. Lentfer (ed.), Selected Marine Mammals of Alaska. Species Accounts with Research and Management Recommendations. Marine Mammal Commission, Washington, DC.

Heide-Jørgensen, M., K. Laidre, D. Borchers, T. Marques, H. Stern, and M. Simon. 2010. The effect of sea-ice loss on beluga whales (*Delphinapterus leucas*) in West Greenland. Polar Res. 29:198-208. DOI: dx.doi.org/10.1111/j.1751-8369.2009.00142.x .

~~Helker, V. T., M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. 2017. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2011-2015. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-354, 112 p.~~

~~Hobbs, R. C., K. L. Laidre, D. J. Vos, B. A. Mahoney, and M. Eagleton. 2005. Movements and area use of belugas, *Delphinapterus leucas*, in a subarctic Alaskan estuary. Arctic 58(4):331-340.~~

Johannessen, O. M., L. Bengtsson, M. W. Miles, S. I. Kuzmina, V. A. Semenov, G. V. Alexseev, A. P. Nagurnyi, V. F. Zakharov, L. P. Bobylev, L. H. Pettersson, K. Hasselmann, and H. P. Cattle. 2004. Arctic climate change: observed and modelled temperature and sea-ice variability. Tellus~~.~~ A 56~~A~~(4):328-341. DOI: dx.doi.org/10.3402/tellusa.v56i4.14418 .

Laidre, K. L., I. Stirling, L. Lowry, Ø. Wiig, M. P. Heide-Jørgensen, and S. Ferguson. 2008. Quantifying the sensitivity of arctic marine mammals to climate-induced habitat change. Ecol. Appl. 18(2):S97-S125.

Lowry, L. F. 1985. The belukha whale (*Delphinapterus leucas*), p. 3-13. *In* J. J. Burns, K. J. Frost, and L. F. Lowry (eds.), Marine mammal species accounts. Alaska Department of Fish and Game, Game Tech. Bull. 7.

Lowry, L., G. O'Corry-Crowe, and D. Goodman. 2006. *Delphinapterus leucas* (Cook Inlet population). In: IUCN 2006. 2006 IUCN Red List of Threatened Species.

Lowry, L. F., J. J. Citta, G. O'Corry-Crowe, L. T. Quakenbush, K. J. Frost, R. Suydam, R. C. Hobbs, and T. Gray. 2019. Distribution, abundance, harvest, and status of western Alaska beluga whale, *Delphinapterus leucas*, stocks. Mar. Fish. Rev. 81(3-4):54-71.

Moore, S. E., K. E. W. Shelden, L. K. Litzky, B. A. Mahoney, and D. J. Rugh. 2000. Beluga, *Delphinapterus leucas*, habitat associations in Cook Inlet, Alaska. Mar. Fish. Rev. 62(3):60-80.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed ~~June 2018~~August 2020.

~~O'Corry-Crowe, G. M., R. S. Suydam, A. Rosenberg, K. J. Frost, and A. E. Dizon. 1997. Phylogeography, population structure and dispersal patterns of the beluga whale *Delphinapterus leucas* in the western Nearctic revealed by mitochondrial DNA. Mol. Ecol. 6:955-970.~~

O'Corry-Crowe, G., A. R. Mahoney, R. Suydam, L. Quakenbush, A. Whiting, L. Lowry, and L. Harwood. 2016. Genetic profiling links changing sea-ice to shifting beluga whale migration patterns. Biol. Lett. 12:20160404. DOI: dx.doi.org/10.1098/rsbl.2016.0404 .

O'Corry-Crowe, G., R. Suydam, L. Quakenbush, B. Potgieter, L. Harwood, D. Litovka, T. Ferrer, J. Citta, V. Burkanov, K. Frost, and B. Mahoney. 2018. Migratory culture, population structure and stock identity in North Pacific beluga whales (*Delphinapterus leucas*). PLoS ONE 13(3):e0194201.

Quakenbush, L. 2003. Summer movements of beluga whales captured in the Kvichak River in May 2002 and 2003. Alaska Beluga Whale Committee Report 03-03. 15 p.

Richard P. R., A. R. Martin, and J. R. Orr. 2001. Summer and autumn movements of belugas of the eastern Beaufort Sea stock. Arctic 54: 223-236.

Seaman, G. A., K. J. Frost, and L. F. Lowry. 1985. Investigations of belukha whales in coastal waters of western and northern Alaska. Part I. Distribution, abundance and movements. U.S. Dep. Commer., NOAA, OCSEAP Final Report 56:153-220. Available from NOAA-OMA-OAD, Alaska Office, 701 C. Street, P.O. Box 56, Anchorage, AK 99513.

Shelden, K. E. W., K. T. Goetz, D. J. Rugh, D. G. Calkins, B. A. Mahoney, and R. C. Hobbs. 2015. Spatio-temporal changes in beluga whale, *Delphinapterus leucas*, distribution: results from aerial surveys (1977-2014), opportunistic sightings (1975-2014), and satellite tagging (1999-2003) in Cook Inlet, Alaska. Mar. Fish. Rev. 77(2):1-31 + appendices. DOI: dx.doi.org/10.7755/MFR.77.2.1 .

Shelden, K. E. W., K. T. Goetz, R. C. Hobbs, L. K. Hoberecht, K. L. Laidre, B. A. Mahoney, T. L. McGuire, S. A. Norman, G. O'Corry-Crowe, D. J. Vos, G. M. Ylitalo, S. A. Mizroch, S. Atkinson, K. A. Burek-Huntington, and C. Garner. 2018. Beluga whale, *Delphinapterus leucas*, satellite-tagging and health assessments in Cook Inlet, Alaska, 1999 to 2002. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-369, 227 p.

Suydam, R. S. 2009. Age, growth, reproduction, and movements of beluga whales (*Delphinapterus leucas*) from the eastern Chukchi Sea. Ph.D. Dissertation, University of Washington, School of Aquatic and Fishery Sciences, Seattle, WA.

~~Wade, P. R., and R. Angliss. 1997. Guidelines for assessing marine mammal stocks: report of the GAMMS Workshop April 3-5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12, 93 p.~~

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC.

BELUGA WHALE (*Delphinapterus leucas*): Eastern Chukchi Sea Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Beluga whales are distributed throughout seasonally ice-covered arctic and subarctic waters of the Northern Hemisphere (Gurevich 1980)~~ and~~. In ice-covered regions, they are closely associated with open leads and polynyas~~ in ice-covered regions~~ (Hazard 1988). In Alaska, depending on season and region, beluga whales may occur in both offshore and coastal waters, with summer concentrations in upper Cook Inlet, Bristol Bay, ~~the ~~eastern Bering Sea (i.e., Yukon River Delta, ~~and ~~Norton Sound), eastern Chukchi Sea, and Beaufort Sea (Mackenzie River Delta) (Hazard 1988, O'Corry-Crowe et al. ~~1997~~2018) (Fig. 1). Seasonal distribution is affected by ice cover, tidal conditions, access to prey, temperature, and human interaction (Lowry 1985). Data from satellite transmitters attached to ~~a few~~beluga whales from the Beaufort Sea, Eastern Chukchi Sea, ~~and~~ Eastern Bering Sea, and Bristol Bay stocks ~~show~~identify ranges that are relatively distinct month to month for these ~~populations~~stocks' summering areas and autumn migratory routes (e.g., Hauser et al. 2014, Citta et al. 2017, Lowry et al. 2019). ~~The few t~~Transmitters that lasted through the winter showed that beluga whales from these summering areas overwinter in the Bering Sea; these stocks ~~may use separate wintering locations and probably remain separated through the winter~~are not known to overlap in space and time in the Bering Sea (Suydam 2009, Citta et al. 2017, Lowry et al. 2019).

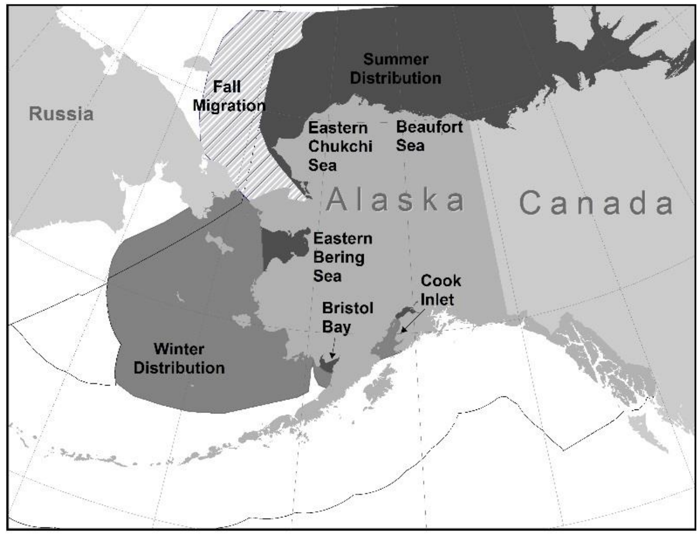

Figure 1. Approximate distribution for all five beluga whale stocks. Summering areas are dark gray, wintering areas are lighter gray, and the hashed area is a region used by the Eastern Chukchi Sea and Beaufort Sea stocks for autumn migration. The U.S. Exclusive Economic Zone is delineated by a black line.

New genetic analyses have further defined five of the summering aggregations in the Bering, Chukchi, and Beaufort seas as follows: Bristol Bay, eastern Bering Sea (Norton Sound), eastern Chukchi Sea (Kasegaluk Lagoon), eastern Beaufort Sea (Mackenzie-Amundsen), and Gulf of Anadyr (Anadyr Bay) (O'Corry-Crowe et al. 2018). These genetic analyses, combined with new telemetry data, demonstrate that the demographically distinct summering aggregations return to discrete wintering areas and disperse and interbreed over limited distances but do not appear to interbreed extensively (O'Corry-Crowe et al. 2018).

The Beaufort Sea and Eastern Chukchi Sea stocks of beluga whales migrate between the Bering and Beaufort seas. Beaufort Sea beluga whales depart ~~from ~~the Bering Sea in early spring, migrate through the Chukchi Sea and into the Canadian waters of the Beaufort Sea where they remain in the summer and fall, returning to the Bering Sea in late fall. Eastern Chukchi Sea beluga whales ~~migrate out of~~depart the Bering Sea in late spring and early summer, ~~into~~migrate through the Chukchi Sea and into the western Beaufort Sea where they remain in the summer, returning to the Bering Sea in the fall. The Eastern Bering Sea beluga whale stock remains in the Bering Sea but ~~moves~~migrates south near Bristol Bay in winter and returns north to Norton Sound and the mouth of the Yukon River in summer (Suydam 2009, Hauser et al. 2014, Citta et al. 2017, Lowry et al. 2019). Beluga whales ~~found~~tagged in Bristol Bay (Quakenbush 2003; Citta et al. 2016, 2017) and Cook Inlet (~~Hobbs et al. 2005, ~~Goetz et al. 2012~~,~~; Shelden et al. 2015, 2018; Lowry et al. 2019) remain in those areas throughout the year, showing only small seasonal shifts in distribution.

At least some of the Eastern Chukchi Sea beluga whales move ~~into~~along coastal areas~~, including Kasegaluk Lagoon,~~ in late June and animals are sighted in the area until about mid-July (Frost and Lowry 1990, Frost et al. 1993, Suydam et al. 2001). Data from satellite tags attached to Eastern Chukchi Sea beluga whales captured in

Kasegaluk Lagoon during the summer showed these whales traveled 1,100 km north of the Alaska coastline, into the Canadian Beaufort Sea within 3 months (Suydam et al. 2001, Hauser et al. 2014). ~~This~~These movements indicated ~~some~~ overlap in distribution with the Beaufort Sea beluga whale stock during late summer. Satellite-telemetry data from ~~23~~24 whales tagged ~~during~~from 1998 to ~~-~~2007 suggest variation in movement patterns for different age and/or sex classes during July to ~~-~~September (Suydam et al. 2005, Hauser et al. 2014). Compared to tagged adult females, tagged ~~A~~adult males used deeper waters and remained there for the ~~duration of the~~ summer. All beluga whales that moved into the Arctic Ocean (north of 75°N) were males, and males traveled through 90% pack ice to reach deeper waters in the Beaufort Sea and Arctic Ocean (79-80°N) by late July/early August. In September, males occupied the southern Canada Basin and Beaufort Sea shelf and slope, maintaining a small core area over Barrow Canyon and a larger core area over the eastern Canada Basin slope. In October, the male distribution shifted south and west, with one core area extending over the Beaufort Sea slope into Barrow Canyon and another over Herald Shoal in the Chukchi Sea. Adult ~~and immature~~ females ~~beluga whales remained at or near the shelf break in the Chukchi Sea~~ranged from just offshore of the Kasegaluk Lagoon system to Barrow Canyon in July. In August, the distribution of females was limited to Barrow Canyon and the adjacent western Beaufort Sea shelf and slope. In September, the female distribution expanded to include the southern Canada Basin, before shifting south and west in October to the Chukchi Sea and western Beaufort Sea (Hauser et al. 2014). ~~After October~~In late autumn, only ~~three~~six tags continued to transmit and those whales migrated south through the eastern Bering Strait into the northern Bering Sea, remaining north of Saint Lawrence Island during the winter (Hauser et al. 2014, Citta et al. 2017). A whale tagged in the eastern Chukchi Sea in 2007 overwintered in the waters north of Saint Lawrence Island during 2007/2008, then moved towards ~~near~~ King Island in April and May before moving north through the Bering Strait in late May and early June (Suydam 2009).

The following information was considered in classifying beluga whale stock structure based on the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: geographic distribution discontinuous in summer (Frost and Lowry 1990); 2) Population response data: distinct population trends among regions occupied in summering areas (O'Corry-Crowe et al. 2018); 3) Phenotypic data: unknown; and 4) Genotypic data: mitochondrial DNA analyses indicate distinct differences among the five summering areas (O'Corry-Crowe et al. ~~1997~~2018). Based on this information, five beluga whale stocks are recognized within U.S. waters: 1) Cook Inlet, 2) Bristol Bay, 3) Eastern Bering Sea, 4) Eastern Chukchi Sea (Fig. 1), and 5) Beaufort Sea ~~(Fig. 1)~~.

POPULATION SIZE

Frost et al. (1993) estimated the minimum size of the Eastern Chukchi Sea beluga whale stock at 1,200 whales, based on whale counts ~~of animals~~ from aerial surveys conducted ~~during~~from 1989 to ~~-~~1991. Survey effort was concentrated ~~along the~~ sea side of the 170-km long Kasegaluk Lagoon, an area known to be regularly used by beluga whales during the open-water season. The offshore areas that these beluga whales are known to frequent were not surveyed. Therefore, the~~se~~ targeted surveys provided only a minimum count. If this count is corrected using radio-telemetry data~~,~~ for the proportion of ~~animals~~whales that were diving and thus not visible at the surface (2.62: Frost and Lowry 1995), and for the proportion of newborns and yearlings not observed due to small size and dark coloration (1.18: Brodie 1971), the total corrected abundance estimate for the Eastern Chukchi Sea stock is 3,710 whales (1,200 × 2.62 × 1.18).

During 25 June to 6 July 1998, aerial surveys were conducted in the eastern Chukchi Sea (DeMaster et al. 1998). The maximum single day count (1,172 whales) was derived from a photographic count of a large aggregation near Icy Cape (1,018 whales), plus whales counted along an ice edge transect (154 whales). This count is an underestimate, because it was clear to the observers that many more whales were present along and in the ice than they were able to count and only a small portion of the ice edge habitat was surveyed. Furthermore, only one of five beluga whales equipped with satellite tags a few days earlier remained within the survey area ~~on the day~~when the peak count occurred (DeMaster et al. 1998). It is not possible to estimate abundance from the 1998 survey. Not only were a large number of whales unavailable for counting, but the large Icy Cape aggregation was in shallow, clear water (DeMaster et al. 1998) and a correction factor (to account for missed whales) does not exist for beluga whales encountered in such conditions.

In July 2002, aerial surveys were conducted again in the eastern Chukchi Sea (Lowry and Frost 2002). Those surveys resulted in a peak count of 582 whales. A correction factor for ~~animals~~whales that were not ~~available~~visible for ~~the~~this count is not available. Offshore sightings during this survey combined with satellite-tag data collected in 2001 (Lowry and Frost 2001, 2002) indicate that nearshore surveys for beluga whales will only result in partial counts ~~of~~for this stock.

A new strategy for deriving a population abundance estimate for the Eastern Chukchi Sea stock of beluga whales was based on summer aerial survey data from the Beaufort Sea, after the stock had migrated through the eastern Chukchi Sea. Analyses of satellite telemetry data from beluga whales belonging to the Eastern Chukchi Sea and Beaufort Sea stocks (Hauser et al. 2014) identified an area in the Beaufort Sea (140°W to 157°W) and period (19 July-20 August) when the two stocks did not overlap (Lowry et al. 2017). These ~~A~~aerial surveys were conducted as part of the ~~Alaska Fisheries Science Center Marine Mammal Laboratory's~~ Aerial Surveys of Arctic Marine Mammals (ASAMM) project in the northeastern Chukchi and Alaska Beaufort seas ~~in late June through~~from 19 July to 20 August 2012-2017 (Clarke et al. ~~2013~~2018). A geographically stratified ~~L~~line-transect analysis that was based on the assumption that the Beaufort Sea and Eastern Chukchi Sea stocks are geographically segregated from mid-July through August (Hauser et al. 2014) resulted in ~~an~~the following population estimates of ~~5,547 surface-visible~~the Eastern Chukchi Sea beluga whales ~~(CV = 0.22)~~ in the study area for each year from 2012 to 2017, respectively: 7,355 (CV=0.47), 6,813 (CV=0.47), 16,598 (CV=0.49), 6,456 (CV=0.48), 6,965 (CV=0.49) and 13,305 (CV=0.51) (~~Lowry et al. 2017~~Givens et al. 2019). These estimates incorporate a correction factor of 1.85 (Lowry et al. 2017) for whales that were submerged and, therefore, not visible to the aerial observers. ~~Data from satellite-linked dive recorders were used to develop correction factors to~~These estimates do not account for ~~animals~~whales that ~~were missed because they were~~might have been outside ~~of~~ the ~~study~~project area ~~or diving too deep to be seen, resulting in a total abundance estimate of 20,752 beluga whales (CV = 0.70) (Lowry et al. 2017)~~during the survey period.

The assumption that Eastern Chukchi Sea beluga whales are isolated from Beaufort Sea beluga whales is possibly flawed based on three lines of evidence: the assumption of a lack of overlap within the Alaska Beaufort Sea from late July to late August is based on satellite-tag data that are dated (few beluga whales from either stock have been tagged in the last decade); the assumed distribution of all Eastern Chukchi Sea and Beaufort Sea beluga whales in July and August cannot be determined from tags that were deployed at the same time and in locations that were too far apart for the tagged whales to overlap in July and August (all Eastern Chukchi Sea beluga whales were tagged near Point Lay in July and all Beaufort Sea beluga whales were tagged in the Mackenzie Delta mainly in July and in August, although numbers in these areas indicate the stocks were more wide-spread at this time); and genetic evidence from harvested beluga whales indicates that Beaufort Sea beluga whales are sometimes found in the Chukchi Sea in late July (O'Corry-Crowe et al. 2018). However, the Givens et al. (2019) abundance estimate reflects the best available data for Eastern Chukchi Sea beluga whales at this time.

Minimum Population Estimate

For the Eastern Chukchi Sea beluga whale stock, the minimum population estimate (N_{MIN}) is calculated according to Equation 1 from the potential biological removal (PBR) guidelines (~~Wade and Angliss 1997~~NMFS 2016): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{1/2})$. Using the 2017 population estimate of ~~20,752~~13,305 and the associated coefficient of variation (CV) of ~~0.70~~0.51, N_{MIN} for this stock is ~~12,194~~8,875 whales; however, this N_{MIN} may be positively biased due to possible overlap between the Eastern Chukchi Sea and Beaufort Sea stocks of beluga whales during the survey in late July to late August.

Current Population Trend

~~The population trend for the Eastern Chukchi Sea beluga whale stock is unknown.~~There is no statistically significant trend in the abundance of the Eastern Chukchi Sea beluga whale stock inside the ASAMM study area from 19 July to 20 August in 2012-2017 (Givens et al. 2019). However, the interannual variation among the abundance estimates and the estimated CVs are both large.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is not ~~un~~available for ~~this~~the Eastern Chukchi Sea beluga whale stock. ~~Hence, u~~Until additional data become available, the default cetacean maximum theoretical net productivity rate ~~(R_{MAX}) for cetaceans~~ of 4% will be used for this stock (~~Wade and Angliss 1997~~NMFS 2016).

POTENTIAL BIOLOGICAL REMOVAL

PBR is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 1.0, ~~the~~a value that may be used for ~~cetacean~~ stocks that are ~~thought to be stable in the presence of a~~not known to be decreasing and are taken primarily by aboriginal subsistence ~~harvest~~hunters, provided there have not been recent increases in the levels of takes (~~DeMaster 1995, Wade and Angliss 1997~~NMFS 2016). Therefore, the PBR for this stock is ~~244~~178 beluga whales (~~12,194~~8,875 × 0.02 × 1.0).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

~~Detailed i~~Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals ~~in 2011-2015~~between 2014 and 2018 is listed, by marine mammal stock, in ~~Helker et al. (2017)~~Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. The ~~total~~minimum estimated mean annual level of human-caused mortality and serious injury for Eastern Chukchi Sea beluga whales ~~in 2011-2015~~between 2014 and 2018 is ~~67~~55 beluga whales~~: 0.2 in U.S. commercial fisheries and 67~~ in subsistence takes by Alaska Natives~~ (including 0.4 incidental to Marine Mammal Protection Act (MMPA) authorized research). Assignment of mortality and serious injury to the Eastern Chukchi Sea, Eastern Bering Sea, and Bristol Bay stocks when stock is unknown, and the event occurred at a time and in an area where the three stocks could occur, may result in overestimating stock specific mortality and serious injury in federal commercial fisheries.~~ Potential threats most likely to result in direct human-caused mortality and serious injury of this stock include entanglement in fishing gear.

Fisheries Information

~~Detailed i~~Information ~~(including observer programs, observer coverage, and observed incidental takes of marine mammals)~~ for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is ~~presented~~available in Appendi~~ces~~x 3~~-6~~ of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

~~During 2011-2015, one beluga whale mortality occurred in the Bering Sea/Aleutian Islands pollock trawl fishery (Table 1; Breiwick 2013; MML, unpubl. data). A genetics sample was collected but has not been analyzed. Since the stock of the beluga whale is unknown, and the event occurred at a time and in an area where the Eastern Chukchi Sea, Eastern Bering Sea, and Bristol Bay stocks could occur, this mortality has been assigned to all three stocks (NMFS 2016)~~

~~**Table 1.** Summary of incidental mortality and serious injury of Eastern Chukchi Sea beluga whales due to U.S. commercial fisheries in 2011-2015 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix 6 of the Alaska Stock Assessment Reports.~~

~~**Fishery name**~~	~~**Years**~~	~~**Data type**~~	~~**Percent observer coverage**~~	~~**Observed mortality**~~	~~**Estimated mortality**~~	~~**Mean estimated annual mortality**~~
~~Bering Sea/Aleutian Is. pollock trawl~~	~~2011~~ ~~2012~~ ~~2013~~ ~~2014~~ ~~2015~~	~~obs data~~	~~98~~ ~~98~~ ~~97~~ ~~98~~ ~~99~~	~~0~~ ~~0~~ ~~1~~ ~~0~~ ~~0~~	~~0~~ ~~0~~ ~~1.0~~ ~~0~~ ~~0~~	~~0.2~~ ~~(CV = 0.09)~~
~~Minimum total estimated annual mortality~~						~~0.2~~ ~~(CV = 0.16)~~

In the nearshore waters of the southeastern Chukchi Sea, substantial efforts occur in gillnet (mostly set nets) and personal-use fisheries. Although a potential source of mortality, there have been no reported beluga whale takes as a result of these fisheries and such incidental takes could be counted as subsistence harvest.

~~The minimum mean annual~~There were no reports of mortality ~~and~~or serious injury ~~rate~~of this stock incidental to U.S. commercial fisheries or subsistence fisheries in Alaska ~~in 2011-2015~~between 2014 and 2018~~ is 0.2 beluga whales from this stock~~.

Alaska Native Subsistence/Harvest Information

NMFS signed an agreement with the Alaska Beluga Whale Committee (ABWC; 2000) to co-manage western Alaska beluga whale populations in the Bering Sea (including Bristol Bay), Chukchi Sea, and Beaufort Sea. This co-management agreement promotes full and equal participation by Alaska Natives in decisions affecting the subsistence management of beluga whales (to the maximum extent allowed by law) as a tool for conserving beluga whale populations in Alaska (https://www.fisheries.noaa.gov/alaska/marine-mammal-protection/co-management-marine-mammals-alaska, accessed August 2020).

The subsistence take of Eastern Chukchi Sea beluga whales ~~from the Eastern Chukchi Sea stock~~ is ~~provided~~reported by the ~~Alaska Beluga Whale Committee (~~ABWC~~)~~. The most recent subsistence harvest estimates for the Eastern Chukchi Sea stock are provided in Table ~~2~~1 (ABWC, unpubl. data, ~~2016~~2019). The annual subsistence take by Alaska Native ~~villages~~hunters averaged ~~67~~55 Eastern Chukchi Sea beluga whales landed ~~from the Eastern Chukchi Sea stock in 2011-2015~~between 2014 and 2018. It should be noted that beluga whales harvested at Utqiaġvik (formerly Barrow) in spring are assumed to be from the Beaufort Sea stock, while those harvested in summer are assumed to be from the Eastern Chukchi Sea stock.

Table ~~2~~1. Summary of Eastern Chukchi Sea beluga whales landed by Alaska Native subsistence hunters ~~in 2011-2015~~between 2014 and 2018 (ABWC, unpubl. data, ~~2016~~2019). It should be noted that ~~the 2011 report includes~~these harvest levels include takes ~~at Kivalina (2 in 2011) and Kotzebue/Noatak (30 in 2011)~~from Kotzebue Sound (10 in 2014, 1 in 2015, 9 in 2016, 2 in 2017, and 15 in 2018) which are likely ~~are~~ from a population that is genetically distinct from the ~~whales that comprise the~~ Eastern Chukchi Sea beluga whale stock. These are minimum estimates of the total number of beluga whales taken, ~~since~~because not all landed whales and ~~the~~ struck and lost ~~data~~whales are ~~not~~ consistently ~~provided~~reported.

Year	Reported total number landed
~~2011~~	~~64~~
~~2012~~	~~52~~
~~2013~~	~~87~~
2014*	~~59~~60
2015	72
2016	23
2017	40
2018	80
Mean annual number landed	~~67~~55

*The number of beluga whales landed in 2014 was changed from 59 to 60 whales based on updated harvest information from the ABWC (ABWC, unpubl. data, 2019).

~~**Other Mortality**~~

~~Mortality and serious injury may occasionally occur incidental to marine mammal research activities authorized under MMPA permits issued to a variety of government, academic, and other research organizations. Two beluga whale deaths occurred incidental to research on ice seals in the Beaufort Sea in 2012 (Helker et al. 2017), resulting in a mean annual mortality and serious injury rate of 0.4 beluga whales from this stock in 2011-2015. Since these animals were subsequently used for subsistence purposes by Alaska Natives, this mortality is accounted for in the harvest data for 2012 (Table 2).~~

STATUS OF STOCK

~~A minimum estimate of~~No fishery-related mortality or serious injury has been reported for the Eastern Chukchi Sea stock of beluga whales between 2014 and 2018; therefore, the mean annual mortality and serious injury rate incidental to U.S. commercial fisheries ~~(0.2 beluga whales) is less than 10% of the PBR (10% of PBR = 24 whales) and, thus,~~ can be considered insignificant and approaching a zero mortality and serious injury rate. The ~~total~~minimum estimated mean annual level of human-caused mortality and serious injury (~~67~~55 beluga whales) is less than the PBR (~~244~~178 whales). Eastern Chukchi Sea beluga whales are not designated as depleted under the Marine Mammal Protection Act or listed as threatened or endangered under the Endangered Species Act. Therefore, the Eastern Chukchi Sea stock of beluga whales is not classified as a strategic stock. The historical level and overall population trend is unknown and, given the uncertainty of the data, we are unable at this time to assess the status of this stock relative to its Optimum Sustainable Population. Recent data indicate no statistically significant trend from 2012 to 2017 (Givens et al. 2019).

There are ~~some~~ key uncertainties in the assessment of the Eastern Chukchi Sea stock of beluga whales. The proportion of the stock within the ASAMM study area during the survey period used in the Lowry et al. (2017) and Givens et al. (2019) abundance analyses is unknown. The assumption that the Eastern Chukchi Sea and Beaufort Sea stocks are geographically segregated during the July-August time period used in Lowry et al.'s (2017) and Givens et al.'s (2019) abundance estimates is based on a relatively limited number of whales tagged between 1993 and 2007. Beaufort Sea beluga whales are found in Kotzebue (Chukchi Sea) in July of some years, indicating that the two stocks may overlap in July. This may result in a positive bias in the estimate of abundance for the Eastern Chukchi Sea stock. Coastal subsistence fisheries ~~will~~can occasionally cause incidental mortality or serious injury of a beluga whale; these incidental takes used for subsistence purposes are not always reported to the ABWC as a fishery interaction and may be included in the ~~estimate of~~ subsistence harvest reports for the stock.

HABITAT CONCERNS

Evidence indicates that the arctic climate is changing rapidly and significantly, and one result of this change is a reduction in the extent and duration of sea ice in ~~at least~~ some regions (ACIA 2004, Johannessen et al. 2004). These changes are likely to affect marine mammal species in the Arctic. Ice-associated animals, such as the beluga whale, are sensitive to changes in arctic weather, sea-surface temperatures, and sea-ice extent, and the concomitant effect on prey availability. There are indications that decreases in seasonal sea ice have influenced beluga whale phenology. ~~Decreases in seasonal sea ice may also increase the risk of killer whale predation (O'Corry-Crowe et al. 2016).~~ Eastern Chukchi Sea beluga whales tagged between 2004 and 2012 were distributed farther north and east in September-November than those tagged between 1993 and 2002 (Hauser et al. 2017). Further, the median date at which tagged whales departed the Beaufort and Chukchi seas during their southbound migrations was 14-33 days later overall in 2004-2012 versus 1993-2002 (Hauser et al. 2017). Decreases in seasonal sea ice may also increase the risk of killer whale predation (O'Corry-Crowe et al. 2016).

There are insufficient data to make reliable predictions of the effects ~~from~~of arctic climate change on beluga whales; however, Laidre et al. (2008) and Heide-Jørgensen et al. (2010) concluded that on a worldwide basis beluga whales were likely to be less sensitive to climate change than other arctic cetaceans because of their wide distribution and flexible behavior. Stafford et al. (2016) found that dive behavior of Eastern Chukchi Sea beluga whales was correlated to wind speed and direction. When winds were from the WSW, whales made shallow dives likely exploiting the front developed by the Alaska Coastal Current between the coast and the deep Arctic basin. Strong winds from the ENE resulted in deeper, longer dives (Stafford et al. 2016). East winds are increasing in the Arctic (Pickart et al. 2009), thus, beluga whales may be spending more time diving at greater depths. Increased human activity in the Arctic, including increased oil and gas exploration and development and increased nearshore development, has the potential to impact beluga whale habitat (Moore et al. 2000, Lowry et al. 2006). However, predicting the type and magnitude of these impacts is difficult.

CITATIONS

Arctic Climate Impact Assessment (ACIA). 2004. Impacts of a Warming Arctic: Arctic Climate Impact Assessment. Cambridge University Press, Cambridge, UK.

~~Breiwick, J. M. 2013. North Pacific marine mammal bycatch estimation methodology and results, 2007-2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-260, 40 p.~~

Brodie, P. F. 1971. A reconsideration of aspects of growth, reproduction, and behavior of the white whale with reference to the Cumberland Sound, Baffin Island, population. J. Fish. Res. Bd. Can. 28:1309-1318.

Citta, J. J., L. T. Quakenbush, K. J. Frost, L. Lowry, R. C. Hobbs, and H. Aderman. 2016. Movements of beluga whales (*Delphinapterus leucas*) in Bristol Bay, Alaska. Mar. Mammal Sci. 32:1272-1298. DOI: dx.doi.org/10.1111/mms.12337 .

Citta, J. J., P. Richard, L. F. Lowry, G. O'Corry-Crowe, M. Marcoux, R. Suydam, L. T. Quakenbush, R. C. Hobbs, D. I. Litovka, K. J. Frost, T. Gray, J. Orr, B. Tinker, H. Aderman, and M. L. Druckenmiller. 2017. Satellite telemetry reveals population specific winter ranges of beluga whales in the Bering Sea. Mar. Mammal Sci. 33:236-250. DOI: dx.doi.org/10.1111/mms.12357 .

~~Clarke, J. T., C. L. Christman, A. A. Brower, and M. C. Ferguson. 2013. Distribution and relative abundance of marine mammals in the northeastern Chukchi and western Beaufort Seas, 2012. Annual Report, OCS Study BOEM 2013-00117. Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.~~

Clarke, J. T., A. A. Brower, M. C. Ferguson, and A. L. Willoughby. 2018. Distribution and relative abundance of marine mammals in the eastern Chukchi and western Beaufort Seas, 2017. Annual Report, OCS Study BOEM 2018-023. Marine Mammal Laboratory, Alaska Fisheries Science Center, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

DeMaster, D. P. 1995. Minutes from the 4-5 and 11 January 1995 meeting of the Alaska Scientific Review Group, Anchorage, Alaska. 27 p. + appendices. Available from Alaska Fisheries Science Center, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

DeMaster, D. P., W. Perryman, and L. F. Lowry. 1998. Beluga whale surveys in the eastern Chukchi Sea, July, 1998. Alaska Beluga Whale Committee Report 98-2. 16 p.

Dizon, A. E., C. Lockyer, W. F. Perrin, D. P. DeMaster, and J. Sisson. 1992. Rethinking the stock concept: a phylogeographic approach. Conserv. Biol. 6:24-36.

Frost, K. J., and L. F. Lowry. 1990. Distribution, abundance, and movements of beluga whales, *Delphinapterus leucas*, in coastal waters of western Alaska, p. 39-57. *In* T. G. Smith, D. J. St. Aubin, and J. R. Geraci (eds.), Advances in research on the beluga whale, *Delphinapterus leucas*. Can. Bull. Fish. Aquat. Sci. 224.

Frost, K. J., and L. F. Lowry. 1995. Radio tag based correction factors for use in beluga whale population estimates. Working paper for Alaska Beluga Whale Committee Scientific Workshop, Anchorage, AK, 5-7 April 1995. 12 p. Available from Alaska Department of Fish and Game, 1300 College Rd., Fairbanks, AK 99701.

Frost, K. J., L. F. Lowry, and G. Carroll. 1993. Beluga whale and spotted seal use of a coastal lagoon system in the northeastern Chukchi Sea. Arctic 46:8-16.

Givens, G. H., M. C. Ferguson, J. T. Clarke, A. Willoughby, A. Brower, and R. Suydam. 2019. Abundance of the Eastern Chukchi Sea stock of beluga whales, 2012-2017. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/68a/ASI/09). 15 p.

Goetz, K. T., P. W. Robinson, R. C. Hobbs, K. L. Laidre, L. A. Huckstadt, and K. E. W. Shelden. 2012. Movement and dive behavior of beluga whales in Cook Inlet, Alaska. AFSC Processed Rep. 2012-03, 40 p. Alaska Fisheries Science Center, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Gurevich, V. S. 1980. Worldwide distribution and migration patterns of the white whale (beluga), *Delphinapterus leucas*. Rep. Int. Whal. Comm. 30:465-480.

Hauser, D. D. W., K. L. Laidre, R. S. Suydam, and P. R. Richard. 2014. Population-specific home ranges and migration timing of Pacific Arctic beluga whales (*Delphinapterus leucas*). Polar Biol. 37(8):1171-1183. DOI: dx.doi.org/10.1007/s00300-014-1510-1 .

Hauser, D. D. W., K. L. Laidre, K. M. Stafford, H. L. Stern, R. S. Suydam, and P. R. Richard. 2017. Decadal shifts in autumn migration timing by Pacific Arctic beluga whales are related to delayed annual sea ice formation. Glob. Change Biol. 23:2206-2217. DOI: dx.doi.org/10.1111/gcb.13564 .

Hazard, K. 1988. Beluga whale, *Delphinapterus leucas*, p. 195-235. *In* J. W. Lentfer (ed.), Selected Marine Mammals of Alaska. Species Accounts with Research and Management Recommendations. Marine Mammal Commission, Washington, DC.

Heide-Jørgensen, M., K. Laidre, D. Borchers, T. Marques, H. Stern, and M. Simon. 2010. The effect of sea-ice loss on beluga whales (*Delphinapterus leucas*) in West Greenland. Polar Res. 29:198–208. DOI: dx.doi.org/10.1111/j.1751-8369.2009.00142.x .

~~Helker, V. T., M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. 2017. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2011-2015. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-354, 112 p.~~

~~Hobbs, R. C., K. L. Laidre, D. J. Vos, B. A. Mahoney, and M. Eagleton. 2005. Movements and area use of belugas, *Delphinapterus leucas*, in a subarctic Alaskan estuary. Arctic 58(4):331-340.~~

Johannessen, O. M., L. Bengtson, M. W. Miles, S. I. Kuzmina, V. A. Semenov, G. V. Alexseev, A. P. Nagurnyi, V. F. Zakharov, L. P. Bobylev, L. H. Pettersson, K. Hasselmann, and H. P. Cattle. 2004. Arctic climate change: observed and modeled temperature and sea-ice variability. Tellus 56A:328-341.

Laidre, K. L., I. Stirling, L. Lowry, Ø. Wiig, M. P. Heide-Jørgensen, and S. Ferguson. 2008. Quantifying the sensitivity of Arctic marine mammals to climate-induced habitat change. Ecol. Appl. 18(2):S97-S125.

Lowry, L. F. 1985. The belukha whale (*Delphinapterus leucas*), p. 3-13. *In* J. J. Burns, K. J. Frost, and L. F. Lowry (eds.), Marine mammals species accounts. Alaska Department of Fish and Game, Game Tech. Bull. 7.

Lowry, L., and K. Frost. 2001. Beluga whale surveys in the Chukchi Sea, July 2001. Alaska Beluga Whale Committee Rep. 01-1 submitted to NMFS, Juneau, AK. 9 p.

Lowry, L., and K. Frost. 2002. Beluga whale surveys in the eastern Chukchi Sea, July 2002. Alaska Beluga Whale Committee Report 02-2 submitted to NMFS, Juneau, AK. 10 p.

Lowry, L., G. O'Corry-Crowe, and D. Goodman. 2006. *Delphinapterus leucas* (Cook Inlet population). *In* IUCN 2006. 2006 IUCN Red List of Threatened Species.

Lowry, L. F., M. C. S. Kingsley, D. D. W. Hauser, J. Clarke, and R. Suydam. 2017. Aerial survey estimates of abundance of the Eastern Chukchi Sea stock of beluga whales (*Delphinapterus leucas*) in 2012. Arctic 70(3):273-286. DOI: dx.doi.org/10.14430/arctic4667 .

Lowry, L. F., J. J. Citta, G. O'Corry-Crowe, L. T. Quakenbush, K. J. Frost, R. Suydam, R. C. Hobbs, and T. Gray. 2019. Distribution, abundance, harvest, and status of western Alaska beluga whale, *Delphinapterus leucas*, stocks. Mar. Fish. Rev. 81(3-4):54-71.

Moore, S. E., K. E. W. Shelden, L. K. Litzky, B. A. Mahoney, and D. J. Rugh. 2000. Beluga, *Delphinapterus leucas*, habitat associations in Cook Inlet, Alaska. Mar. Fish. Rev. 62(3):60-80.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed ~~June 2018~~August 2020.

~~O'Corry-Crowe, G. M., R. S. Suydam, A. Rosenberg, K. J. Frost, and A. E. Dizon. 1997. Phylogeography, population structure and dispersal patterns of the beluga whale *Delphinapterus leucas* in the western Nearctic revealed by mitochondrial DNA. Mol. Ecol. 6:955-970.~~

O'Corry-Crowe G., A. R. Mahoney, R. Suydam, L. Quakenbush A. Whiting, L. Lowry, and L. Harwood. 2016. Genetic profiling links changing sea-ice to shifting beluga whale migration patterns. Biol. Lett. 12:20160404. DOI: dx.doi.org/10.1098/rsbl.2016.0404 .

O'Corry-Crowe, G., R. Suydam, L. Quakenbush, B. Potgieter, L. Harwood, D. Litovka, T. Ferrer, J. Citta, V. Burkanov, K. Frost, and B. Mahoney. 2018. Migratory culture, population structure and stock identity in North Pacific beluga whales (*Delphinapterus leucas*). PLoS ONE 13(3):e0194201.

Pickart, R. S., G. W. K. Moore, D. J. Torres, P. S. Fratantoni, R. A. Goldsmith, and J. Yang. 2009. Upwelling on the continental slope of the Alaskan Beaufort Sea: storms, ice, and oceanographic response. J. Geophys. Res. 114:C00A13. DOI: dx.doi.org/10.1029/2008JC005009 .

Quakenbush, L. 2003. Summer movements of beluga whales captured in the Kvichak River in May 2002 and 2003. Alaska Beluga Whale Committee Report 03-03. 15 p.

Shelden, K. E. W., K. T. Goetz, D. J. Rugh, D. G. Calkins, B. A. Mahoney, and R. C. Hobbs. 2015. Spatio-temporal changes in beluga whale, *Delphinapterus leucas*, distribution: results from aerial surveys (1977-2014), opportunistic sightings (1975-2014), and satellite tagging (1999-2003) in Cook Inlet, Alaska. Mar. Fish. Rev. 77(2):1-31 + appendices. DOI: dx.doi.org/10.7755/MFR.77.2.1 .

Stafford, K. M., J. J. Citta, S. R. Okkonen, and R. S. Suydam. 2016. Wind-dependent beluga whale dive behavior in Barrow Canyon, Alaska. Deep Sea Res. II 118:57-65. DOI: dx.doi.org/10.1016/j.dsr.2016.10.006 .

Suydam, R. S. 2009. Age, growth, reproduction, and movements of beluga whales (*Delphinapterus leucas*) from the eastern Chukchi Sea. Ph.D. Dissertation University of Washington, School of Aquatic and Fishery Sciences, Seattle, WA.

Suydam, R. S., L. F. Lowry, K. J. Frost, G. M. O'Corry-Crowe, and D. Pikok, Jr. 2001. Satellite tracking of Eastern Chukchi Sea beluga whales into the Arctic Ocean. Arctic 54(3):237-243.

Suydam, R. S., L. F. Lowry, and K. J. Frost. 2005. Distribution and movements of beluga whales from the Eastern Chukchi Sea stock during summer and early autumn. OCS Study MMS 2005-035 Final Report. 48 p.

~~Wade, P. R., and R. Angliss. 1997. Guidelines for assessing marine mammal stocks: report of the GAMMS Workshop April 3-5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12, 93 p.~~

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC.

BELUGA WHALE (*Delphinapterus leucas*): Eastern Bering Sea Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

-Beluga whales are distributed throughout seasonally ice-covered arctic and subarctic waters of the Northern Hemisphere (Gurevich 1980)~~ and~~. In ice-covered regions, they are closely associated with open leads and polynyas~~ in ice-covered regions~~ (Hazard 1988). In Alaska, depending on season and region, beluga whales may occur in both offshore and coastal waters, with summer concentrations in upper Cook Inlet, Bristol Bay, ~~the~~ eastern Bering Sea (i.e., Yukon River Delta, ~~and~~ Norton Sound), eastern Chukchi Sea, and Beaufort Sea (Mackenzie River Delta) (Hazard 1988, O'Corry-Crowe et al. ~~1997~~2018) (Fig. 1). Seasonal distribution is affected by ice cover, tidal conditions, access to prey, temperature, and human interaction (Lowry 1985). Data from satellite transmitters attached to ~~a few~~ beluga whales from the Beaufort Sea, Eastern Chukchi Sea, ~~and~~ Eastern Bering Sea, and Bristol Bay stocks ~~show~~identify ranges that are relatively distinct month to month for these ~~populations~~stocks' summering areas and autumn migratory routes (e.g., Hauser et al. 2014, Citta et al. 2017, Lowry et al. 2019). ~~The few t~~Transmitters that lasted through the winter showed that beluga whales from these summering areas overwinter in the Bering Sea; these stocks ~~may use separate wintering locations and probably remain separated through the winter~~are not known to overlap in space and time in the Bering Sea (Suydam 2009, Citta et al. 2017, Lowry et al. 2019).

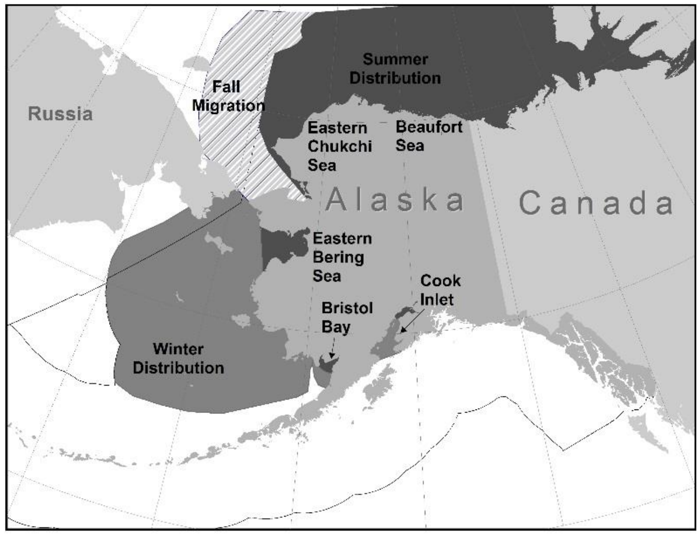

Figure 1. Approximate distribution for all five beluga whale stocks. Summering areas are dark gray, wintering areas are lighter gray, and the hashed area is a region used by the Eastern Chukchi Sea and Beaufort Sea stocks for autumn migration. The U.S. Exclusive Economic Zone is delineated by a black line.

New genetic analyses have further defined five of the summering aggregations in the Bering, Chukchi, and Beaufort seas as follows: Bristol Bay, eastern Bering Sea (Norton Sound), eastern Chukchi Sea (Kasegaluk Lagoon), eastern Beaufort Sea (Mackenzie-Amundsen), and Gulf of Anadyr (Anadyr Bay) (O'Corry-Crowe et al. 2018). These genetic analyses, combined with new telemetry data, demonstrate that the demographically distinct summering aggregations return to discrete wintering areas and disperse and interbreed over limited distances but do not appear to interbreed extensively (O'Corry-Crowe et al. 2018).

–The Beaufort Sea and Eastern Chukchi Sea stocks of beluga whales migrate between the Bering and Beaufort seas. Beaufort Sea beluga whales depart ~~from~~ the Bering Sea in early spring, migrate through the Chukchi Sea and into the Canadian waters of the Beaufort Sea where they remain in the summer and fall, returning to the Bering Sea in late fall. Eastern Chukchi Sea beluga whales ~~migrate out of~~depart the Bering Sea in late spring and early summer, ~~into~~migrate through the Chukchi Sea and into the western Beaufort Sea where they remain in the summer, returning to the Bering Sea in the fall.~~ The Eastern Bering Sea stock remains in the Bering Sea but moves south near Bristol Bay in winter and returns north to Norton Sound and the mouth of the Yukon River in summer (Suydam 2009, Hauser et al. 2014, Citta et al. 2017).~~ Beluga whales ~~found~~tagged in Bristol Bay (Quakenbush 2003; Citta et al. 2016, 2017) and Cook Inlet (~~Hobbs et al. 2005, ~~Goetz et al. 2012~~,~~; Shelden et al. 2015, 2018; Lowry et al. 2019) remain in those areas throughout the year, showing only small seasonal shifts in distribution.

The Eastern Bering Sea beluga whale stock remains in the Bering Sea but migrates south near Bristol Bay in winter and returns north to Norton Sound and the mouth of the Yukon River in summer (Suydam 2009, Hauser et al. 2014, Citta et al. 2017, Lowry et al. 2019). Two beluga whales from the Eastern Bering Sea stock were tagged with satellite transmitters in autumn 2012 near Nome. The beluga whales ~~moved~~migrated south from Nome through ice-~~–~~covered shelf waters during the winter, swimming ~~south~~ near Hagemeister Island and the Walrus Islands in Bristol Bay, before returning to Norton Sound ~~in the~~by spring (Citta et al. 2017). A beluga whale tagged near Nome in ~~September~~November 2016 ~~has~~ remained in ~~the vicinity of Nome and~~western Norton Sound ~~through mid-January 2017 due to low ice cover in the Bering Sea (Alaska Beluga Whale Committee, unpubl. data)~~and adjacent waters of the eastern Bering Sea through April 2017 (Lowry et al. 2019). In May-June, the whale migrated into Norton Sound and the mouth of the Yukon River Delta, where it remained through October, when it returned to western Norton Sound.

The following information was considered in classifying beluga whale stock structure based on the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: geographic distribution discontinuous in summer (Frost and Lowry 1990); 2) Population response data: distinct population trends among regions occupied in summering areas (O'Corry-Crowe et al. 2018); 3) Phenotypic data: unknown; and 4) Genotypic data: mitochondrial DNA analyses indicate distinct differences among the five summering areas (O'Corry-Crowe et al. ~~1997~~2018). Based on this information, five beluga whale stocks are recognized within U.S. waters: 1) Cook Inlet, 2) Bristol Bay, 3) Eastern Bering Sea (Fig. 1), 4) Eastern Chukchi Sea, and 5) Beaufort Sea ~~(Fig. 1)~~.

POPULATION SIZE

The Alaska Beluga Whale Committee (ABWC) has been working to develop a population estimate for the Eastern Bering Sea stock since the first systematic aerial surveys of the Norton Sound/Yukon River Delta region during May, June, and September 1992 and June 1993-1995 (Lowry et al. 1999). Beluga whale density estimates were calculated for the June 1992 surveys using strip-transect methods~~,~~ and for the June 1993-1995 surveys using line-transect methods. Correction factors were applied to account for whales that were missed during the surveys (those below the surface and not visible and dark colored neonates). Lowry et al. (1999) concluded that the best abundance estimate for the Eastern Bering Sea stock was 17,675 beluga whales (95% CI: 9,056-34,515, not accounting for variance in correction factors), based on counts made in early June 1995. Additional aerial surveys of the Norton Sound/Yukon River Delta region were conducted in June 1999 and 2000 (Lowry et al. 2017). Unlike previous survey years, ~~in 1999~~ sea ice persisted in western Norton Sound in 1999, resulting in a ~~much~~ different distribution of beluga whales, and the data were not used for population estimation. In 2000, systematic transect lines were flown covering the entire study region, and the data were analyzed using a covariate line-transect model. Results indicate 3,497 beluga whales (coefficient of variation (CV) = 0.37) were seen at the surface in the study area (Lowry et al. 2017). If this estimate were doubled (Reeves et al. 2011) to correct for the proportion of whales that were diving, and thus not visible at the surface, the total abundance for the Eastern Bering Sea stock would be 6,994 beluga whales (95% CI: 3,162-15,472). In 2017, NMFS conducted a line-transect aerial survey for beluga whales in the Norton Sound/Yukon River Delta region. Using a geographically stratified line-transect analysis (Lowry et al. 2017), the data from the 2017 survey resulted in an estimated 4,621 beluga whales (CV = 0.12, 95% CI: 3,635-5,873) at the surface (NMFS, unpubl. data). Multiplying by a factor of two (Reeves et al. 2011), to correct for beluga whales not visible at the surface, results in an estimated total abundance of 9,242 beluga whales. The abundance estimates from 2000 and 2017 likely underestimate the actual population abundance because some beluga whales from this population could have been outside the study area (e.g., in the Yukon River) during the survey periods, and the correction factor of 2.0 (Reeves et al. 2011) might be too low to account for the difficulty in detecting beluga whales in the turbid coastal waters near the Yukon River Delta (Lowry et al. 2019). Furthermore, the CVs for the abundance estimates for 2000 and 2017 are underestimated because the arbitrary correction factor for missed animals has no associated CV.

Minimum Population Estimate

For the Eastern Bering Sea stock of beluga whales, the minimum population estimate (N_{MIN}) is calculated according to Equation 1 from the potential biological removal (PBR) guidelines (~~Wade and Angliss 1997~~NMFS 2016): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the 2017 population estimate (N) of ~~6,994~~9,242 whales and an associated ~~coefficient of variation~~ CV(N) of ~~0.37~~0.12, N_{MIN} for ~~this~~the Eastern Bering Sea stock is ~~5,173~~8,357 beluga whales. ~~However, because the survey data are more than 8 years old, it is not considered a reliable minimum population estimate for calculating a PBR, and N_{MIN} is considered unknown.~~

Current Population Trend

Surveys to estimate population abundance in the ~~Norton Sound~~eastern Bering Sea were not conducted prior to 1992. Annual estimates of population size from surveys flown in 1992-1995 and 1999-2000 have varied widely, due partly to differences in survey coverage and conditions between years. ~~Available data do not allow an~~

~~evaluation of population trend for the Eastern Bering Sea stock.~~ The abundance estimates from the surveys conducted in 2000 and 2017 were not significantly different (Lowry et al. 2019).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is not ~~un~~available for the Eastern Bering Sea stock of beluga whales. Lowry et al. (2008) estimated the rate of increase of the Bristol Bay beluga whale stock was 4.8% per year (95% CI: ~~=~~2.1%-7.5%) over a 12-year period. However, until additional data become available specific to the Eastern Bering Sea stock, the default cetacean maximum theoretical net productivity rate ~~(R_{MAX})~~ of 4% will be used for this stock (~~Wade and Angliss 1997~~NMFS 2016).

POTENTIAL BIOLOGICAL REMOVAL

PBR is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 1.0, ~~the~~a value that may be used for ~~cetacean~~ stocks that are ~~thought to be stable in the presence of a~~not known to be decreasing and are taken primarily by aboriginal subsistence ~~harvest~~hunters, provided there have not been recent increases in the levels of takes (~~Wade and Angliss 1997~~NMFS 2016). ~~However, the 2016 guidelines for preparing Stock Assessment Reports (NMFS 2016) state that abundance estimates older than 8 years should not be used to calculate PBR due to a decline in confidence in the reliability of an aged abundance estimate. Therefore, the PBR for the Eastern Bering Sea stock of beluga whales is considered undetermined.~~ Thus, the PBR for the Eastern Bering Sea stock is 167 beluga whales (8,357 × 0.02 × 1.0).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

~~Detailed i~~Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals ~~in 2011-2015~~between 2014 and 2018 is listed, by marine mammal stock, in ~~Helker et al. (2017)~~Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. The ~~total~~minimum estimated mean annual level of human-caused mortality and serious injury for Eastern Bering Sea beluga whales ~~in 2011-2015~~between 2014 and 2018 is ~~206~~198 beluga whales ~~: 0.2 in U.S. commercial fisheries and 206~~ in subsistence takes by Alaska Natives (including two takes in a commercial salmon gillnet fishery and one take in a subsistence salmon gillnet fishery).~~; however,~~

~~a~~A reliable estimate of mortality and serious injury in U.S. commercial fisheries is not available because there has never been an observer program for nearshore commercial fisheries in the eastern Bering Sea region. ~~Assignment of mortality and serious injury to the Eastern Chukchi Sea, Eastern Bering Sea, and Bristol Bay stocks when stock is unknown, and the event occurred at a time and in an area where the three stocks could occur, may result in overestimating stock specific mortality and serious injury in federal commercial fisheries.~~ Potential threats most likely to result in direct human-caused mortality or serious injury of this stock include entanglement in fishing gear.

Fisheries Information

~~Detailed i~~Information ~~(including observer programs, observer coverage, and observed incidental takes of marine mammals)~~ for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is ~~presented~~available in Appendi~~ces~~x 3~~-6~~ of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

~~During 2011-2015, one beluga whale mortality occurred in the Bering Sea/Aleutian Islands pollock trawl fishery (Table 1; Breiwick 2013; MML, unpubl. data). A genetics sample was collected but has not been analyzed. Since the stock of the beluga whale is unknown, and the event occurred at a time and in an area where the Eastern Chukchi Sea, Eastern Bering Sea, and Bristol Bay stocks could occur, this mortality has been assigned to all three stocks (NMFS 2016).~~There were no reports of mortality or serious injury of this stock incidental to U.S. commercial fisheries in Alaska between 2014 and 2018.

~~**Table 1.** Summary of incidental mortality and serious injury of Eastern Bering Sea beluga whales due to U.S. commercial fisheries in 2011-2015 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix 6 of the Alaska Stock Assessment Reports.~~

~~**Fishery name**~~	~~**Years**~~	~~**Data type**~~	~~**Percent observer coverage**~~	~~**Observed mortality**~~	~~**Estimated mortality**~~	~~**Mean estimated annual mortality**~~
~~Bering Sea/Aleutian Is. pollock trawl~~	~~2011~~ ~~2012~~ ~~2013~~ ~~2014~~ ~~2015~~	~~obs data~~	~~98~~ ~~98~~ ~~97~~ ~~98~~ ~~99~~	~~0~~ ~~0~~ ~~1~~ ~~0~~ ~~0~~	~~0~~ ~~0~~ ~~1.0~~ ~~0~~ ~~0~~	~~0.2 (CV = 0.09)~~
~~Minimum total estimated annual mortality~~						~~0.2 (CV = 0.16)~~

In the nearshore waters of the ~~E~~eastern Bering Sea, substantial effort occurs in commercial and subsistence fisheries, mostly for salmon and herring. The salmon fishery uses gillnet gear similar to that used in Bristol Bay, where it is known that beluga whales ~~have been~~are incidentally taken (Frost et al. 1984). In 2018, three beluga whale takes in the Kuskokwim, Yukon, Norton Sound, Kotzebue salmon gillnet fishery were reported to the NMFS Alaska Region marine mammal stranding network: one beluga whale was caught in a subsistence fishery net and two whales were caught in commercial fishery nets (Young et al. in press). However, ~~there are no useful~~complete data on beluga whale incidental takes from this stock are not available because there have never been observer programs in these commercial fisheries and there is no reporting requirement for takes in personal use fisheries. NMFS ~~assumes~~understands that all beluga whales ~~killed~~caught in these fisheries are used for subsistence purposes, regardless of the method of harvest, and are reported to the ABWC. ~~These~~Reports of incidental takes in fishing gear are included in the NMFS human-caused mortality and injury reports (e.g., Young et al. in press) as subsistence takes and NMFS assumes that they are included in the Alaska Native Subsistence/Harvest Information section, below.

The minimum mean annual mortality and serious injury rate incidental to U.S. commercial fisheries ~~in 2011-2015~~between 2014 and 2018 is ~~0.2~~zero beluga whales from this stock. However, because there has never been an observer program for state-managed nearshore commercial fisheries in the eastern Bering Sea~~ region~~, a reliable estimate of the mortality and serious injury incidental to U.S. commercial fisheries is not available.

Alaska Native Subsistence/Harvest Information

NMFS signed an agreement with the ABWC (2000) to co-manage western Alaska beluga whale populations in the Bering Sea (including Bristol Bay), Chukchi Sea, and Beaufort Sea. This co-management agreement promotes full and equal participation by Alaska Natives in decisions affecting the subsistence management of beluga whales (to the maximum extent allowed by law) as a tool for conserving beluga whale populations in Alaska (https://www.fisheries.noaa.gov/alaska/marine-mammal-protection/co-management-marine-mammals-alaska, accessed August 2020).

The subsistence take of Eastern Bering Sea beluga whales ~~from the Eastern Bering Sea stock~~ is ~~provided~~reported by the ABWC. The most recent subsistence harvest estimates for ~~the~~this stock are provided in Table ~~2~~1 (ABWC, unpubl. data, ~~2016~~2019). Beluga whales harvested in Kuskokwim villages are included in the total harvest for the Eastern Bering Sea beluga whale stock. The annual subsistence take by Alaska Native ~~villages~~hunters averaged ~~206~~198 Eastern Bering Sea beluga whales landed ~~from the Eastern Bering Sea stock in 2011-2015~~between 2014 and 2018.

Table ~~2~~1. Summary of Eastern Bering Sea beluga whales landed by Alaska Native subsistence hunters ~~in 2011-2015~~between 2014 and 2018 (ABWC, unpubl. data, ~~2016~~2019). These are minimum estimates of the total number of beluga whales taken, ~~since~~because not all landed whales and struck and lost ~~data~~whales are ~~not~~ consistently ~~provided~~reported.

Year	Reported total number landed
~~2011~~	~~205~~
~~2012~~	~~181~~
~~2013~~	~~216~~
2014[a]	~~237~~239
2015[b]	~~193~~197
2016	184
2017	186
2018	182
Mean annual number landed	~~206~~198

[a]The number of beluga whales landed in 2014 was changed from 237 to 239 whales based on updated harvest information from the ABWC (ABWC, unpubl. data, 2019).
[b]The number of beluga whales landed in 2015 was changed from 193 to 197 whales based on updated harvest information from the ABWC (ABWC, unpubl. data, 2019).

STATUS OF STOCK

~~A minimum estimate of~~No fishery-related mortality or serious injury incidental to U.S. commercial fisheries has been reported for the Eastern Bering Sea stock of beluga whales between 2014 and 2018; therefore, the mean annual mortality and serious injury rate incidental to U.S. commercial fisheries ~~is 0.2 whales. Because the PBR is undetermined, the mean annual U.S. commercial fishery-related mortality and serious injury rate that~~ can be considered insignificant and approaching a zero mortality and serious injury rate ~~is unknown~~. The ~~total~~minimum estimated mean annual level of human-caused mortality and serious injury is ~~206~~198 beluga whales, which exceeds the calculated PBR of 167 beluga whales. Therefore, the Eastern Bering Sea stock of beluga whales is classified as a strategic stock. Eastern Bering Sea beluga whales are not designated as depleted under the Marine Mammal Protection Act or listed as threatened or endangered under the Endangered Species Act. ~~Therefore, the Eastern Bering Sea stock of beluga whales is classified as a non-strategic stock.~~

There are ~~some~~ key uncertainties in the assessment of the Eastern Bering Sea stock of beluga whales. The abundance is based on a line-transect survey; the resulting estimate is doubled to account for the proportion of whales that are diving and thus missed by the observers. It is not known whether doubling the estimate accurately accounts for whales missed. ~~The population rate of increase is unknown.~~ Coastal commercial fisheries that overlap with this stock have either never been observed or have not been observed recently, so mortality and serious injury of Eastern Bering Sea beluga whales in commercial fisheries ~~could be~~is likely underestimated. Coastal subsistence fisheries ~~for fish~~ will occasionally cause incidental mortality or serious injury of a beluga whale; these incidental takes used for subsistence purposes are ~~not always~~sometimes reported to the ABWC and included in the estimate of subsistence harvest for the stock.

HABITAT CONCERNS

Evidence indicates that the arctic climate is changing significantly and that one result of the change is a reduction in the extent and duration of sea ice in most regions of the Arctic (ACIA 2004, Johannessen et al. 2004). These changes are likely to affect marine mammal species in the Arctic. Ice-associated animals, such as the beluga whale, are sensitive to changes in arctic weather, sea-surface temperatures, and sea-ice extent, and the concomitant effect on prey availability. There are indications that decreases in seasonal sea ice have influenced beluga whale phenology. Lowry et al. (2019) reported that ABWC members who live and hunt in the eastern Bering Sea and Bristol Bay observed that sea ice has formed later, melted earlier, and has not been as thick as in previous decades. Furthermore, since 2013, hunters observed that some areas have remained ice free throughout winter and other areas have experienced extremely rapid ice retreat in spring. Decreases in seasonal sea ice may also increase the risk of killer whale predation (O'Corry-Crowe et al. 2016). It is unknown whether Eastern Bering Sea beluga whales have changed their areas of use in the winter; however, information from the Beaufort Sea and Eastern Chukchi Sea ~~populations~~stocks (Hauser et al. 2017), where tag data are more extensive, suggest that changes in timing of migration and winter distribution may have occurred. There are insufficient data to make reliable predictions of the effects of arctic climate change on beluga whales; however, Laidre et al. (2008) and Heide-Jørgensen et al. (2010)

concluded that on a worldwide basis beluga whales were likely to be less sensitive to climate change than other arctic cetaceans because of their wide distribution and flexible behavior.

Increased human activity in the Arctic, including increased oil and gas exploration and development and increased nearshore development, has the potential to impact beluga whale habitat for beluga whales (Moore et al. 2000, Lowry et al. 2006);. hHowever, predicting the type and magnitude of these impacts is difficult.

CITATIONS

Arctic Climate Impact Assessment (ACIA). 2004. Impacts of a Warming Arctic: Arctic Climate Impact Assessment. Cambridge University Press, Cambridge, UK.

~~Breiwick, J. M. 2013. North Pacific marine mammal bycatch estimation methodology and results, 2007-2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-260, 40 p.~~

Citta, J. J., L. T. Quakenbush, K. J. Frost, L. Lowry, R. C. Hobbs, and H. Aderman. 2016. Movements of beluga whales (*Delphinapterus leucas*) in Bristol Bay, Alaska. Mar. Mammal Sci. 32:1272-1298. DOI: dx.doi.org/10.1111/mms.12337 .

Citta, J. J., P. Richard, L. F. Lowry, G. O'Corry-Crowe, M. Marcoux, R. Suydam, L. T. Quakenbush, R. C. Hobbs, D. I. Litovka, K. J. Frost, T. Gray, J. Orr, B. Tinker, H. Aderman, and M. L. Druckenmiller. 2017. Satellite telemetry reveals population specific winter ranges of beluga whales in the Bering Sea. Mar. Mammal Sci. 33:236-250. DOI: dx.doi.org/10.1111/mms.12357 .

Dizon, A. E., C. Lockyer, W. F. Perrin, D. P. DeMaster, and J. Sisson. 1992. Rethinking the stock concept: a phylogeographic approach. Conserv. Biol. 6:24-36.

Frost, K. J., and L. F. Lowry. 1990. Distribution, abundance, and movements of beluga whales, *Delphinapterus leucas*, in coastal waters of western Alaska, p. 39-57. *In* T. G. Smith, D. J. St. Aubin, and J. R. Geraci (eds.), Advances in research on the beluga whale, *Delphinapterus leucas*. Can. Bull. Fish. Aquat. Sci. 224.

Frost, K. J., L. F. Lowry, and R. R. Nelson. 1984. Belukha whale studies in Bristol Bay, Alaska, p. 187-200. *In* Proceedings of the workshop on biological interactions among marine mammals and commercial fisheries in the southeastern Bering Sea, October 18-21, 1983, Anchorage AK. Alaska Sea Grant Report 84-1.

Goetz, K. T., P. W. Robinson, R. C. Hobbs, K. L. Laidre, L. A. Huckstadt, and K. E. W. Shelden. 2012. Movement and dive behavior of beluga whales in Cook Inlet, Alaska. AFSC Processed Rep. 2012-03, 40 p. Alaska Fisheries Science Center, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Gurevich, V. S. 1980. Worldwide distribution and migration patterns of the white whale (beluga), *Delphinapterus leucas*. Rep. Int. Whal. Comm. 30:465-480.

Hauser, D. D. W., K. L. Laidre, R. S. Suydam, and P. R. Richard. 2014. Population-specific home ranges and migration timing of Pacific Arctic beluga whales (*Delphinapterus leucas*). Polar Biol. 37:1171-1183. DOI: dx.doi.org/10.1007/s00300-014-1510-1 .

Hauser, D. D. W., K. L. Laidre, K. M. Stafford, H. L. Stern, R. S. Suydam, and P. R. Richard. 2017. Decadal shifts in autumn migration timing by Pacific Arctic beluga whales are related to delayed annual sea ice formation. Glob. Change Biol. 23:2206-2217. DOI: dx.doi.org/10.1111/gcb.13564 .

Hazard, K. 1988. Beluga whale, *Delphinapterus leucas*, p. 195-235. *In* J. W. Lentfer (ed.), Selected Marine Mammals of Alaska. Species Accounts with Research and Management Recommendations. Marine Mammal Commission, Washington, DC.

Heide-Jørgensen, M., K. Laidre, D. Borchers, T. Marques, H. Stern, and M. Simon. 2010. The effect of sea-ice loss on beluga whales (*Delphinapterus leucas*) in West Greenland. Polar Res. 29:198-208. DOI: dx.doi.org/10.1111/j.1751-8369.2009.00142.x .

~~Helker, V. T., M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. 2017. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2011-2015. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-354, 112 p.~~

~~Hobbs, R. C., K. L. Laidre, D. J. Vos, B. A. Mahoney, and M. Eagleton. 2005. Movements and area use of belugas, *Delphinapterus leucas*, in a subarctic Alaskan estuary. Arctic 58(4):331-340.~~

Johannessen, O. M., L. Bengtson, M. W. Miles, S. I. Kuzmina, V. A. Semenov, G. V. Alexseev, A. P. Nagurnyi, V. F. Zakharov, L. P. Bobylev, L. H. Pettersson, K. Hasselmann, and H. P. Cattle. 2004. Arctic climate change: observed and modeled temperature and sea-ice variability. Tellus 56A:328-341.

Laidre, K. L., I. Stirling, L. Lowry, Ø. Wiig, M. P. Heide-Jørgensen, and S. Ferguson. 2008. Quantifying the sensitivity of arctic marine mammals to climate-induced habitat change. Ecol. Appl. 18(2):S97-S125.

Lowry, L. F. 1985. The belukha whale (*Delphinapterus leucas*), p. 3-13. *In* J. J. Burns, K. J. Frost, and L. F. Lowry (eds.), Marine mammals species accounts. Alaska Department of Fish and Game, Game Tech. Bull. 7.

Lowry, L. F., D. P. DeMaster, and K. J. Frost. 1999. Alaska Beluga Whale Committee surveys of beluga whales in the eastern Bering Sea, 1992-1995. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/51/SM34). 22 p.

Lowry, L., G. O'Corry-Crowe, and D. Goodman, D. 2006. *Delphinapterus leucas* (Cook Inlet population). *In* IUCN 2006. 2006 IUCN Red List of Threatened Species.

Lowry, L. F., K. J. Frost, A. Zerbini, D. DeMaster, and R. R. Reeves. 2008. Trend in aerial counts of beluga or white whales (*Delphinapterus leucas*) in Bristol Bay, Alaska. J. Cetacean Res. Manage. 10(3):201-207.

Lowry, L. F., A. Zerbini, K. J. Frost, D. P. DeMaster, and R. C. Hobbs. 2017. Development of an abundance estimate for the Eastern Bering Sea stock of beluga whales (*Delphinapterus leucas*). J. Cetacean Res. Manage. 16:39-47.

Lowry, L. F., J. J. Citta, G. O'Corry-Crowe, L. T. Quakenbush, K. J. Frost, R. Suydam, R. C. Hobbs, and T. Gray. 2019. Distribution, abundance, harvest, and status of western Alaska beluga whale, *Delphinapterus leucas*, stocks. Mar. Fish. Rev. 81(3-4):54-71.

Moore, S. E., K. E. W. Shelden, L. K. Litzky, B. A. Mahoney, and D. J. Rugh. 2000. Beluga, *Delphinapterus leucas*, habitat associations in Cook Inlet, Alaska. Mar. Fish. Rev. 62(3):60-80.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed ~~June 2018~~August 2020.

~~O'Corry-Crowe, G. M., R. S. Suydam, A. Rosenberg, K. J. Frost, and A. E. Dizon. 1997. Phylogeography, population structure and dispersal patterns of the beluga whale *Delphinapterus leucas* in the western Nearctic revealed by mitochondrial DNA. Mol. Ecol. 6:955-970.~~

O'Corry-Crowe, G., A. R. Mahoney, R. Suydam, L. Quakenbush, A. Whiting, L. Lowry, and L. Harwood. 2016. Genetic profiling links changing sea-ice to shifting beluga whale migration patterns. Biol. Lett. 12:20160404. DOI: dx.doi.org/10.1098/rsbl.2016.0404 .

O'Corry-Crowe, G., R. Suydam, L. Quakenbush, B. Potgieter, L. Harwood, D. Litovka, T. Ferrer, J. Citta, V. Burkanov, K. Frost, and B. Mahoney. 2018. Migratory culture, population structure and stock identity in North Pacific beluga whales (*Delphinapterus leucas*). PLoS ONE 13(3):e0194201.

Quakenbush, L. 2003. Summer movements of beluga whales captured in the Kvichak River in May 2002 and 2003. Alaska Beluga Whale Committee Report 03-03. 15 p.

Reeves, R. R., R. L. Brownell, Jr., V. Burkanov, M. C. S. Kingsley, L. F. Lowry, and B. Taylor. 2011. Sustainability assessment of beluga (*Delphinapterus leucas*) live-capture removals in the Sakhalin–Amur region, Okhotsk Sea, Russia. Report of an independent scientific review panel. Occasional Paper of the Species Survival Commission, No. 44. IUCN, Gland, Switzerland. 34 p.

Shelden, K. E. W., K. T. Goetz, D. J. Rugh, D. G. Calkins, B. A. Mahoney, and R. C. Hobbs. 2015. Spatio-temporal changes in beluga whale, *Delphinapterus leucas*, distribution: results from aerial surveys (1977-2014), opportunistic sightings (1975-2014), and satellite tagging (1999-2003) in Cook Inlet, Alaska. Mar. Fish. Rev. 77(2):1-31 + appendices. DOI: dx.doi.org/10.7755/MFR.77.2.1 .

Shelden, K. E. W., K. T. Goetz, R. C. Hobbs, L. K. Hoberecht, K. L. Laidre, B. A. Mahoney, T. L. McGuire, S. A. Norman, G. O'Corry-Crowe, D. J. Vos, G. M. Ylitalo, S. A. Mizroch, S. Atkinson, K. A. Burek-Huntington, and C. Garner. 2018. Beluga whale, *Delphinapterus leucas*, satellite-tagging and health assessments in Cook Inlet, Alaska, 1999 to 2002. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-369, 227 p.

Suydam, R. S. 2009. Age, growth, reproduction, and movements of beluga whales (*Delphinapterus leucas*) from the eastern Chukchi Sea. Ph.D. Dissertation, University of Washington, School of Aquatic and Fishery Sciences, Seattle, WA.

~~Wade, P. R., and R. Angliss. 1997. Guidelines for assessing marine mammal stocks: report of the GAMMS Workshop April 3-5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12, 93 p.~~

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC.

BELUGA WHALE (*Delphinapterus leucas*): Bristol Bay Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

~~-~~ Beluga whales are distributed throughout seasonally ice-covered arctic and subarctic waters of the Northern Hemisphere (Gurevich 1980)~~ and~~. In ice-covered regions, they are closely associated with open leads and polynyas~~ in ice-covered regions~~ (Hazard 1988). In Alaska, depending on season and region, beluga whales may occur in both offshore and coastal waters, with summer concentrations in upper Cook Inlet, Bristol Bay, ~~the~~ eastern Bering Sea (i.e., Yukon River Delta, ~~and~~ Norton Sound), eastern Chukchi Sea, and Beaufort Sea (Mackenzie River Delta) (Hazard 1988, O'Corry-Crowe et al. ~~1997~~2018) (Fig. 1). Seasonal distribution is affected by ice cover, tidal conditions, access to prey, temperature, and human interaction (Lowry 1985). Data from satellite transmitters attached to ~~a few~~beluga whales from the Beaufort Sea, Eastern Chukchi Sea, ~~and~~ Eastern Bering Sea, and Bristol Bay stocks ~~show~~identify ranges that are relatively distinct month to month for these ~~populations~~stocks' summering areas and autumn migratory routes (e.g., Hauser et al. 2014, Citta et al. 2017, Lowry et al. 2019). ~~The few t~~Transmitters that lasted through the winter showed that beluga whales from these summering areas overwinter in the Bering Sea; these stocks ~~may use separate wintering locations and probably remain separated through the winter~~are not known to overlap in space and time (Suydam 2009, Citta et al. 2017, Lowry et al. 2019).

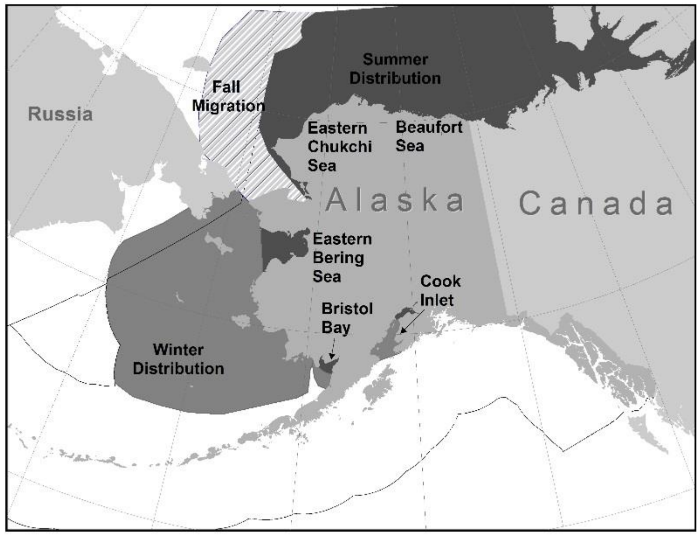

Figure 1. Approximate distribution for all five beluga whale stocks. Summering areas are dark gray, wintering areas are lighter gray, and the hashed area is a region used by the Eastern Chukchi Sea and Beaufort Sea stocks for autumn migration. The U.S. Exclusive Economic Zone is delineated by a black line.

New genetic analyses have further defined five of the summering aggregations in the Bering, Chukchi, and Beaufort seas as follows: Bristol Bay, eastern Bering Sea (Norton Sound), eastern Chukchi Sea (Kasegaluk Lagoon), eastern Beaufort Sea (Mackenzie-Amundsen), and Gulf of Anadyr (Anadyr Bay) (O'Corry-Crowe et al. 2018). These genetic analyses, combined with new telemetry data, demonstrate that the demographically distinct summering aggregations return to discrete wintering areas and disperse and interbreed over limited distances but do not appear to interbreed extensively (O'Corry-Crowe et al. 2018).

~~–~~The Beaufort Sea and Eastern Chukchi Sea stocks of beluga whales migrate between the Bering and Beaufort seas. Beaufort Sea beluga whales depart ~~from~~ the Bering Sea in early spring, migrate through the Chukchi Sea and into the Canadian waters of the Beaufort Sea where they remain in the summer and fall, returning to the Bering Sea in late fall. Eastern Chukchi Sea beluga whales ~~migrate out of~~depart the Bering Sea in late spring and early summer, ~~into~~migrate through the Chukchi Sea and into the western Beaufort Sea where they remain in the summer, returning to the Bering Sea in the fall. The Eastern Bering Sea beluga whale stock remains in the Bering Sea but ~~moves~~migrates south near Bristol Bay in winter and returns north to Norton Sound and the mouth of the Yukon River in summer (Suydam 2009, Hauser et al. 2014, Citta et al. 2017, Lowry et al. 2019). Beluga whales ~~found~~tagged in Bristol Bay (Quakenbush 2003; Citta et al. 2016, 2017) and Cook Inlet (~~Hobbs et al. 2005,~~ Goetz et al. 2012~~,~~; Shelden et al. 2015, 2018; Lowry et al. 2019) remain in those areas throughout the year, showing only small seasonal shifts in distribution.

Summer movement patterns of Bristol Bay beluga whales were determined from satellite-linked tags deployed on 10 animals in the Kvichak River ~~during~~in 2002 and 2003 and 22 whales in the Nushagak River ~~in~~from 2006 to ~~-~~2011 (Citta et al. 2016). Those whales used the shallow upper portions of Kvichak and Nushagak bays between May and August (Quakenbush 2003) and remained in the nearshore waters of Bristol Bay throughout

September and October (Quakenbush and Citta 2006). Data from two beluga whales whose tags ~~lasted~~transmitted into December and January showed they were in Nushagak and Kvichak bays, suggesting that some beluga whales do not leave the nearshore waters of Bristol Bay during the winter (Citta et al. 2017). Tags attached to whales in 2012, 2013, 2014, and 2016 ~~have~~ confirmed these movement observations (NMFS and Alaska SeaLife Center, unpubl. data; ~~https://alaskafisheries.noaa.gov/sites/default/files/andrews_limpettagging041514.pdf~~ https://www.fisheries.noaa.gov/resource/document/2014-cook-inlet-beluga-whale-science-conference-presentations, accessed August 2020).

The following information was considered in classifying beluga whale stock structure based on the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: geographic distribution discontinuous in summer (Frost and Lowry 1990); 2) Population response data: distinct population trends among regions occupied in summering areas (O'Corry-Crowe et al. 2018); 3) Phenotypic data: unknown; and 4) Genotypic data: mitochondrial DNA analyses indicate distinct differences among the five summering areas (O'Corry-Crowe et al. ~~1997~~2018). Based on this information, five beluga whale stocks are recognized within U.S. waters: 1) Cook Inlet, 2) Bristol Bay (Fig. 1), 3) Eastern Bering Sea, 4) Eastern Chukchi Sea, and 5) Beaufort Sea ~~(Fig. 1)~~.

POPULATION SIZE

The sources of information to estimate abundance for beluga whales in the waters of western and northern Alaska have included both opportunistic and systematic observations. Frost and Lowry (1990) compiled data collected from aerial surveys conducted in Bristol Bay between 1978 and 1987 that were specifically designed to estimate the ~~number of~~ beluga whale~~s~~ population. Surveys ~~did not cover the entire habitat of beluga whales but were directed to specific~~focused on areas ~~at the times of year when~~where beluga whales ~~are known~~had been found to ~~concentrate~~aggregate during the summer. Frost and Lowry (1990) reported an estimate of 1,000-1,500 whales for Bristol Bay, similar to that reported by Seaman et al. (1985). In 1994, the abundance was estimated at 1,555 beluga whales (Lowry and Frost 1998). That estimate was based on a maximum count of 503 whales, which was corrected using radio-telemetry data for the proportion of whales that were diving and thus not visible at the surface (2.62: Frost and Lowry 1995) and for the proportion of newborns and yearlings not observed due to their small size and dark coloration (1.18: Brodie 1971). The Alaska Department of Fish and Game and the Alaska Beluga Whale Committee (ABWC) conducted aerial beluga whale surveys in Bristol Bay in 1999, 2000, 2004, ~~and~~ 2005, and 2016, with average counts of 444, 421, 609, ~~and~~ 637, and 660 whales, respectively (Lowry et al. 2008, Lowry et al. 2019). The ~~results~~data from the 2004 and 2005 surveys ~~give~~result in an average count of 623 (coefficient of variation (CV) = 0.25) and, using the correction values above, a population estimate of 1,926 beluga whales (623 × 2.62 × 1.18). Using the count from the 2016 surveys and the correction values that have been applied in the past yields an estimated abundance of 2,040 beluga whales (CV = 0.26) in 2016 (660 × 2.62 × 1.18).

The Bristol Bay stock of beluga whales is genetically distinct. Citta et al. (2018) used a POPAN Jolly-Seber model to estimate abundance using genetic mark-recapture methods. Of the 516 individual whales identified from skin biopsies collected between 2002 and 2011, 75 beluga whales were identified (recaptured) in separate years, resulting in an estimate of 1,928 beluga whales (95% CI: 1,611-2,337), not including calves, which were not sampled (Citta et al. 2018).

Minimum Population Estimate

The survey technique used for estimating the abundance of beluga whales in this stock is a direct count which incorporates correction factors for submerged whales and calves. The abundance estimate is thought to be conservative because no correction was made for whales that were at the surface but were missed by the observers (Lowry and Frost 1998). The minimum population estimate (N_{MIN}) for ~~this~~the Bristol Bay beluga whale stock is calculated ~~using~~according to Equation 1 from the potential biological removal (PBR) guidelines (~~Wade and Angliss 1997~~NMFS 2016): $N_{MIN} = N/\exp(0.842 \times [\ln(1+[CV(N)]^2)]^{½})$. Using the population estimate (N) from the ~~2004 and 2005~~2016 surveys of ~~1,926~~2,040 and the ~~coefficient of variation (~~CV~~)~~ of ~~0.25~~0.26, N_{MIN} for the Bristol Bay stock is ~~1,565~~1,645 beluga whales. ~~However, because the survey data are more than 8 years old, it is not considered a reliable minimum population estimate for calculating a PBR, and N_{MIN} is considered unknown.~~

Current Population Trend

~~A survey program involving replicate aerial counts using standardized methods was conducted during 1993-2005. Data from 28 complete counts of Kvichak and Nushagak bays made in good or excellent survey conditions were analyzed, and results showed that the population increased by 65% over the 12-year period (Lowry et al. 2008).~~After a period of growth observed during surveys conducted from 1993 to 2005 where the population increased by 65% (Lowry et al. 2008), the estimate obtained from a survey conducted in 2016 was similar to those in 2004 and 2005 (Citta et al. 2019). Citta et al. (2019) concluded that population growth has now slowed or ceased entirely.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

The estimated rate of increase in abundance of beluga whales abundance in Bristol Bay duringfrom 1993 to -2005 was 4.8% per year (95% CI: =2.1%-7.5%: Lowry et al. 2008).;- however, because Tthis estimate exceedshas a large CV, the default cetacean maximum net productivity rate (R_{MAX}) of 4% (Wade and Angliss 1997NMFS 2016) will be used for this stock. It is not clear why thisthe stock should be increasinged at such a highthis rate between 1993 and 2005, but possibilities include recovery from research kills in the 1960s, a reduction in subsistence harvests, and a delayed response to increases in salmon stocks (Lowry et al. 2008). Genetic mark-recapture estimates that include whales sampled between 2002 and 2011 and the most recent aerial estimate from 2016 suggest the population growth previously observed has slowed or ceased (Citta et al. 2019, Lowry et al. 2019).

POTENTIAL BIOLOGICAL REMOVAL

PBR is defined as the product of the minimum population estimate, one-half the maximum theoreticalestimated net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. AsThe recovery factor (F_R) for this stock is 1.0, a value that may be used for stocks that are not known to be increasingdecreasing and are taken primarily by aboriginal subsistence hunters, provided there have not been recent increases in the levels of takes (NMFS 2016, Lowry et al. 20082019), the recovery factor (F_R) is 1.0 (Wade and Angliss 1997, DeMaster 1997; see discussion under PBR for the Eastern Bering Sea stock). However, the 2016 guidelines for preparing Stock Assessment Reports (NMFS 2016) state that abundance estimates older than 8 years should not be used to calculate PBR due to a decline in confidence in the reliability of an aged abundance estimate. Therefore, the PBR for this stock is considered undetermined. Using the N_{MIN} of 1,645, calculated from the 2016 aerial survey estimate of 2,040 (CV = 0.26), PBR for this stock is 33 beluga whales (1,645 × 0.02 × 1.0).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Detailed iInformation for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals in 2011-2015between 2014 and 2018 is listed, by marine mammal stock, in Helker et al. (2017)Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. The totalminimum estimated mean annual level of human-caused mortality and serious injury for Bristol Bay beluga whales in 2011-2015between 2014 and 2018 is 2518 beluga whales: 0.2 in U.S. commercial fisheries, 0.2 in subsistence fisheries, and 2518 in subsistence takes by Alaska Natives (including one take in a subsistence salmon set gillnet fishery), and 0.2 incidental to Marine Mammal Protection Act (MMPA)-authorized research. Estimates of mortality and serious injury incidental to Bristol Bay fisheries are likely to be underestimated because observers have never monitored the Bristol Bay commercial salmon set gillnet and drift gillnet fisheries, there is substantial participation in the subsistence salmon gillnet fishery in Bristol Bay but no established protocol for reporting incidental takes in non-commercial fisheries to NMFS, and beluga whales taken incidental to personal-use or commercial salmon fisheries may be used by Alaska Natives for subsistence purposes and may be reported as subsistence takes. Assignment of mortality and serious injury to the Eastern Chukchi Sea, Eastern Bering Sea, and Bristol Bay stocks when stock is unknown, and the event occurred at a time and in an area where the three stocks could occur, may result in overestimating stock specific mortality and serious injury in federal commercial fisheries. Potential threats most likely to result in direct human-caused mortality or serious injury of this stock include entanglement in fishing gear.

Fisheries Information

Detailed iInformation (including observer programs, observer coverage, and observed incidental takes of marine mammals) for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is presentedavailable in Appendiceesx 3-6 of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

During 2011-2015, oneNo beluga whale mortality or serious injury occurredwas observed in the Bering Sea/Aleutian Islands pollock trawlincidental to U.S. commercial fisheryies in Alaska between 2014 and 2018(Table 1; Breiwick 2013; MML, unpubl. data). A genetics sample was collected but has not been analyzed. Since the stock

~~of the beluga whale is unknown, and the event occurred at a time and in an area where the Eastern Chukchi Sea, Eastern Bering Sea, and Bristol Bay stocks could occur, this mortality has been assigned to all three stocks (NMFS 2016).~~

~~**Table 1.** Summary of incidental mortality and serious injury of Bristol Bay beluga whales due to U.S. commercial fisheries in 2011-2015 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix 6 of the Alaska Stock Assessment Reports.~~

~~**Fishery name**~~	~~**Years**~~	~~**Data type**~~	~~**Percent observer coverage**~~	~~**Observed mortality**~~	~~**Estimated mortality**~~	~~**Mean estimated annual mortality**~~
~~Bering Sea/Aleutian Is. pollock trawl~~	~~2011~~ ~~2012~~ ~~2013~~ ~~2014~~ ~~2015~~	~~obs data~~	~~98~~ ~~98~~ ~~97~~ ~~98~~ ~~99~~	~~0~~ ~~0~~ ~~1~~ ~~0~~ ~~0~~	~~0~~ ~~0~~ ~~1.0~~ ~~0~~ ~~0~~	~~0.2 (CV = 0.09)~~
~~Minimum total estimated annual mortality~~						~~0.2 (CV = 0.16)~~

The Bristol Bay commercial salmon set gillnet and drift gillnet fisheries combined had ~~2,752~~2,841 active permits listed in ~~2016 (Appendix 3 of the Alaska Stock Assessment Reports~~the NMFS 2019 LOF (https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020). These fisheries are known to have caused mortality of Bristol Bay beluga whales ~~from this stock in the past~~ (Frost et al. 1984). However, complete data on incidental takes of this stock are not available because ~~they~~there have never been ~~monitored by an~~ observer programs ~~so there is no reliable information on the number of animals that have been or are being taken~~in these commercial fisheries, and there is no reporting requirement for takes in personal-use fisheries.

~~There is substantial effort in a subsistence gillnet fishery for salmon in Bristol Bay. Beluga whales are occasionally entangled and killed in this fishery, but there is no established protocol to report incidental takes in non-commercial fisheries to NMFS. In 2013, one mortality of a beluga whale in a Bristol Bay subsistence salmon gillnet was reported to the NMFS Alaska Region stranding network and the ABWC (Table 2; Helker et al. 2017). Based on this stranding report, the minimum mean annual mortality and serious injury rate due to subsistence fishery interactions in 2011-2015 is 0.2 beluga whales. However, this figure is likely an underestimate because subsistence fishermen are not required to report marine mammal takes. Also, i~~It should be noted that in western Alaska, beluga whales taken incidental to personal-use or commercial salmon fisheries may be used by Alaska Natives for subsistence purposes and may be included in the subsistence harvest data reported below. ~~An additional three~~For example, one beluga whale~~s~~ that entangled in a Bristol Bay subsistence salmon set gillnet~~s (2 whales in 2013 and 1~~ in 2014~~)~~ ~~were~~was known to be used for subsistence purposes and ~~are~~is included in the subsistence harvest data for ~~2011-2015~~2014-2018 (Table ~~3~~1; ABWC, unpubl. data; ~~Helker et al. 2017~~Young et al. in press).

~~A~~The minimum mean annual mortality and serious injury rate incidental to U.S. commercial fisheries ~~in 2011-2015~~between 2014 and 2018 is ~~0.2~~zero beluga whales from this stock; however, a reliable estimate of the mortality rate incidental to U.S. commercial fisheries is not available because most coastal commercial fisheries that overlap with this stock have never been observed.

~~**Table 2.** Summary of Bristol Bay beluga whale mortality and serious injury, by year and type, reported to the Alaska Region marine mammal stranding network in 2011-2015 (Helker et al. 2017). Only cases of serious injury were recorded in this table; animals with non-serious injuries have been excluded.~~

~~**Cause of Injury**~~	~~**2011**~~	~~**2012**~~	~~**2013**~~	~~**2014**~~	~~**2015**~~	~~**Mean annual mortality**~~
~~Entangled in Bristol Bay subsistence salmon gillnet~~	~~0~~	~~0~~	~~1~~	~~0~~	~~0~~	~~0.2~~
~~Minimum total annual mortality~~						~~0.2~~

Alaska Native Subsistence/Harvest Information

NMFS signed an agreement with the ABWC (2000) to co-manage western Alaska beluga whale populations in the Bering Sea (including Bristol Bay), Chukchi Sea, and Beaufort Sea. This co-management agreement promotes full and equal participation by Alaska Natives in decisions affecting the subsistence management of beluga whales (to the maximum extent allowed by law) as a tool for conserving beluga whale populations in Alaska (https://www.fisheries.noaa.gov/alaska/marine-mammal-protection/co-management-marine-mammals-alaska, accessed August 2020).

~~Data on t~~The subsistence take of Bristol Bay beluga whales ~~from the Bristol Bay stock are provided~~is reported by the ABWC. The most recent subsistence harvest estimates for ~~this~~the Bristol Bay stock are provided in Table ~~3~~1 (ABWC, unpubl. data, ~~2016~~2019). These ~~data show the~~ annual subsistence take by Alaska Native ~~villages~~hunters averaged ~~25~~18 Bristol Bay beluga whales landed ~~from the Bristol Bay stock in 2011-2015~~between 2014 and 2018.

Table ~~3~~1. Summary of Bristol Bay beluga whales landed by Alaska Native subsistence hunters ~~in 2011-2015~~between 2014 and 2018 (ABWC, unpubl. data, ~~2016~~2019). These are minimum estimates ~~for~~of the total number of beluga whales taken, ~~since~~because not all landed whales and struck and lost ~~data~~whales are ~~not~~ consistently ~~provided~~reported.

Year	**Reported total number landed**
~~2011~~	~~22~~
~~2012~~	~~29~~
~~2013~~	~~29~~
2014	26
2015*	~~18~~22
2016	19
2017	10
2018	11
Mean annual number landed	~~25~~18

*The number of beluga whales landed in 2015 was changed from 18 to 22 whales based on updated harvest information from the ABWC (ABWC, unpubl. data, 2019).

Other Mortality

Mortality and serious injury may occasionally occur incidental to marine mammal research activities authorized under MMPA permits issued to a variety of government, academic, and other research organizations. In 2016 there was a report of one beluga whale mortality incidental to research on the Bristol Bay stock (Table 2; Young et al. in press), resulting in a mean annual mortality and serious injury rate of 0.2 beluga whales from this stock between 2014 and 2018.

Table 2. Summary of Bristol Bay beluga whale mortality and serious injury, by year and type, reported to the NMFS Office of Protected Resources between 2014 and 2018 (Young et al. in press). Beluga whales with non-serious injuries were excluded.

Cause of Injury	**2014**	**2015**	**2016**	**2017**	**2018**	**Mean annual mortality**
Incidental to MMPA-authorized research	0	0	1	0	0	0.2
Total incidental to MMPA-authorized research						0.2

STATUS OF STOCK

No fishery-related mortality or serious injury has been reported for the Bristol Bay beluga whale stock between 2014 to 2018; therefore, ~~A minimum estimate of~~ the mean annual mortality and serious injury rate incidental to U.S. commercial fisheries ~~is 0.2 beluga whales. However, it is unknown whether this level is~~can be considered insignificant and approaching a zero mortality and serious injury rate. ~~(i.e., less than 10% of PBR) because PBR is undetermined and a reliable estimate of the mortality and serious injury rate incidental to U.S. commercial fisheries is not available.~~ Bristol Bay beluga whales are not designated as depleted under the M~~arine~~ M~~ammal~~ ~~Protection~~ A~~ct~~ or listed as threatened or endangered under the Endangered Species Act. Because ~~the population size increased at a rate above~~ ~~R_{MAX}~~ ~~from 1993 to 2005, the sum of human impacts on the population was not a concern (Lowry et al. 2008). Therefore~~the minimum estimate of the mean annual human-caused mortality and serious injury rate (18 beluga whales) is less than the PBR (33), the Bristol Bay stock of beluga whales is not classified as a strategic stock. However, as noted previously, the estimate of fisheries-related mortality and serious injury is likely ~~to be~~ underestimated.

There are key uncertainties in the assessment of the Bristol Bay stock of beluga whales. The abundance is based on count data that are corrected for the proportion of whales that are diving and the proportion of newborns and yearlings not observed because of their size and coloration; however, the counts are not corrected for whales which are at the surface but missed by the observers. Although~~,~~ the apparent population rate of increase was quite high from 1993 to 2005, which may indicate that the population was depleted and reduced human-related mortality and serious injury allowed an increase, most coastal commercial fisheries that overlap with this stock have never been observed. Therefore, the mortality and serious injury of Bristol Bay beluga whales in commercial fisheries could be underestimated. Coastal subsistence fisheries for ~~fish~~salmon will occasionally cause incidental mortality or serious injury of a beluga whale; these incidental takes used for subsistence purposes may not always be reported to the ABWC ~~and included~~for inclusion in the subsistence harvest estimates for this stock.

HABITAT CONCERNS

Evidence indicates that ~~C~~climate is changing significantly in the Bristol Bay region. One result of the change is a reduction in the extent and duration of sea ice in the winter (ACIA 2004, Johannessen et al. 2004). These changes are likely to affect marine mammal species in Bristol Bay. Ice-associated animals, such as the beluga whale, are sensitive to changes in weather, sea-surface temperatures, and sea-ice extent, and the concomitant effect on prey availability. Decreases in seasonal sea ice may also increase the risk of killer whale predation (O'Corry-Crowe et al. 2016). There are insufficient data to make reliable predictions of the effects of climate change on beluga whales; however, Laidre et al. (2008) and Heide-Jørgensen et al. (2010) concluded that on a worldwide basis beluga whales were likely to be less sensitive to climate change in general than other arctic cetaceans because of their wide distribution and flexible behavior. However, local changes in distribution and seasonal behavior are likely to occur (Hauser et al. 2017). Increased human activity in the Bristol Bay region, including increased oil and gas exploration and development and increased nearshore development and mining activities near large tributaries, has the potential to impact habitat for beluga whales (Lowry et al. 2006, Norman et al. 2015). However, predicting the type and magnitude of these impacts is difficult.

In all cases, increased human activities in or near coastal areas of Bristol Bay will increase anthropogenic noise in the water, which has been shown to have negative impacts on cetacean feeding and communication (Norman et al. 2015, Small et al. 2017). Studies of beluga whales in Bristol Bay found that some individuals have "sensitive hearing that approaches the lower levels of noise within their habitat" (Mooney et al. 2018). This may be a result of living in an acoustically quiet environment, which allows for a large dynamic range of hearing. However, if the ambient noise were to increase due to increased anthropogenic activities, masking of calls may occur. This is a particular concern for cow/calf pairs because calves have been shown to vocalize at lower amplitudes than their mothers (Vergara 2019). If ambient or anthropogenic noise levels increase, cow/calf pairs may lose the ability to communicate effectively. Additionally, masking can reduce the range of acoustic detection of prey and communication in cooperative feeding.

CITATIONS

Arctic Climate Impact Assessment (ACIA). 2004. Impacts of a Warming Arctic: Arctic Climate Impact Assessment. Cambridge University Press, Cambridge, UK.

~~Breiwick, J. M. 2013. North Pacific marine mammal bycatch estimation methodology and results, 2007-2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-260, 40 p.~~

Brodie, P. F. 1971. A reconsideration of aspects of growth, reproduction, and behavior of the white whale with reference to the Cumberland Sound, Baffin Island, population. J. Fish. Res. Bd. Can. 28:1309-1318.

Citta, J. J., L. T. Quakenbush, K. J. Frost, L. Lowry, R. C. Hobbs, and H. Aderman. 2016. Movements of beluga whales (*Delphinapterus leucas*) in Bristol Bay, Alaska. Mar. Mammal Sci. 32:1272-1298. DOI: dx.doi.org/10.1111/mms.12337 .

Citta, J. J., P. Richard, L. F. Lowry, G. O'Corry-Crowe, M. Marcoux, R. Suydam, L. T. Quakenbush, R. C. Hobbs, D. I. Litovka, K. J. Frost, T. Gray, J. Orr, B. Tinker, H. Aderman, and M. L. Druckenmiller. 2017. Satellite telemetry reveals population specific winter ranges of beluga whales in the Bering Sea. Mar. Mammal Sci. 33:236-250. DOI: dx.doi.org/10.1111/mms.12357 .

Citta, J. J., G. O'Corry-Crowe, L. T. Quakenbush, A. L. Bryan, T. Ferrer, M. J. Olson, R. C. Hobbs, and B. Potgieter. 2018. Assessing the abundance of Bristol Bay belugas with genetic mark-recapture methods. Mar. Mammal Sci. 34(3):666-686.

Citta, J. J., K. J. Frost, and L. Quakenbush. 2019. Aerial surveys of Bristol Bay beluga whales, *Delphinapterus leucas*, in 2016. Mar. Fish. Rev. 81(3-4):98-104.

~~DeMaster, D. P. 1997. Minutes from the fifth meeting of the Alaska Scientific Review Group, 7-9 May 1997, Seattle, Washington. 21 p. + appendices. Available from Alaska Fisheries Science Center, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.~~

Dizon, A. E., C. Lockyer, W. F. Perrin, D. P. DeMaster, and J. Sisson. 1992. Rethinking the stock concept: a phylogeographic approach. Conserv. Biol. 6:24-36.

Frost, K. J., and L. F. Lowry. 1990. Distribution, abundance, and movements of beluga whales, *Delphinapterus leucas*, in coastal waters of western Alaska, p. 39-57. *In* T. G. Smith, D. J. St. Aubin, and J. R. Geraci (eds.), Advances in research on the beluga whale, *Delphinapterus leucas*. Can. Bull. Fish. Aquat. Sci. 224.

Frost, K. J., and L. F. Lowry. 1995. Radio tag based correction factors for use in beluga whale population estimates. Working paper for Alaska Beluga Whale Committee Scientific Workshop, Anchorage, AK, 5-7 April 1995. 12 p.

Frost, K. J., L. F. Lowry, and R. R. Nelson. 1984. Belukha whale studies in Bristol Bay, Alaska, p. 187-200. *In* Proceedings of the workshop on biological interactions among marine mammals and commercial fisheries in the southeastern Bering Sea, October 18-21, 1983, Anchorage AK. Alaska Sea Grant Report 84-1.

Goetz, K. T., P. W. Robinson, R. C. Hobbs, K. L. Laidre, L. A. Huckstadt, and K. E. W. Shelden. 2012. Movement and dive behavior of beluga whales in Cook Inlet, Alaska. AFSC Processed Rep. 2012-03, 40 p. Alaska Fisheries Science Center, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Gurevich, V. S. 1980. Worldwide distribution and migration patterns of the white whale (beluga), *Delphinapterus leucas*. Rep. Int. Whal. Comm. 30:465-480.

Hauser, D. D. W., K. L. Laidre, R. S. Suydam, and P. R. Richard. 2014. Population-specific home ranges and migration timing of Pacific Arctic beluga whales (*Delphinapterus leucas*). Polar Biol. 37:1171-1183. DOI: dx.doi.org/10.1007/s00300-014-1510-1 .

Hauser, D. D. W., K. L. Laidre, K. M. Stafford, H. L. Stern, R. S. Suydam, and P. R. Richard. 2017. Decadal shifts in autumn migration timing by Pacific Arctic beluga whales are related to delayed annual sea ice formation. Glob. Change Biol. 23:2206-2217. DOI: dx.doi.org/10.1111/gcb.13564 .

Hazard, K. 1988. Beluga whale, *Delphinapterus leucas*, p. 195-235. *In* J. W. Lentfer (ed.), Selected Marine Mammals of Alaska. Species Accounts with Research and Management Recommendations. Marine Mammal Commission, Washington, DC.

Heide-Jørgensen, M., K. Laidre, D. Borchers, T. Marques, H. Stern, and M. Simon. 2010. The effect of sea-ice loss on beluga whales (*Delphinapterus leucas*) in West Greenland. Polar Res. 29:198-208. DOI: dx.doi.org/10.1111/j.1751-8369.2009.00142.x .

Helker, V. T., M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. 2017. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2011-2015. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-354, 112 p.

Hobbs, R. C., K. L. Laidre, D. J. Vos, B. A. Mahoney, and M. Eagleton. 2005. Movements and area use of belugas, *Delphinapterus leucas*, in a subarctic Alaskan estuary. Arctic 58(4):331-340.

Johannessen, O. M., L. Bengtson, M. W. Miles, S. I. Kuzmina, V. A. Semenov, G. V. Alexseev, A. P. Nagurnyi, V. F. Zakharov, L. P. Bobylev, L. H. Pettersson, K. Hasselmann, and H. P. Cattle. 2004. Arctic climate change: observed and modeled temperature and sea-ice variability. Tellus 56A:328-341.

Laidre, K. L., I. Stirling, L. Lowry, Ø. Wiig, M. P. Heide-Jørgensen, and S. Ferguson. 2008. Quantifying the sensitivity of arctic marine mammals to climate-induced habitat change. Ecol. Appl. 18(2):S97-S125.

Lowry, L. F. 1985. The belukha whale (*Delphinapterus leucas*), p. 3-13. *In* J. J. Burns, K. J. Frost, and L. F. Lowry (eds.), Marine mammals species accounts. Alaska Department of Fish and Game, Game Tech. Bull. 7.

Lowry, L. F., and K. J. Frost. 1998. Alaska Beluga Whale Committee surveys of beluga whales in Bristol Bay, Alaska, 1993-1994. Alaska Beluga Whale Committee Report 98-3. 13 p.

Lowry, L., G. O'Corry-Crowe, and D. Goodman. 2006. *Delphinapterus leucas* (Cook Inlet population). *In*:- IUCN 2006. 2006 IUCN Red List of Threatened Species.

Lowry, L. F., K. J. Frost, A. Zerbini, D. DeMaster, and R. R. Reeves. 2008. Trend in aerial counts of beluga or white whales (*Delphinapterus leucas*) in Bristol Bay, Alaska, 1993-2005. J. Cetacean Res. Manage. 10(3):201-207.

Lowry, L. F., J. J. Citta, G. O'Corry-Crowe, L. T. Quakenbush, K. J. Frost, R. Suydam, R. C. Hobbs, and T. Gray. 2019. Distribution, abundance, harvest, and status of western Alaska beluga whale, *Delphinapterus leucas*, stocks. Mar. Fish. Rev. 81(3-4):54-71.

Mooney, T. A., M. Castellote, I. T. Jones, L. Quakenbush, R. Hobbs, E. Gaglione, and C. Goertz. 2018. Local acoustic habitat relative to hearing sensitivities in beluga whales (*Delphinapterus leucas*). J. Ecoacoustics 2:#QZD9Z5.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed June 2018August 2020.

Norman, S. A., R. C. Hobbs, C. E. C. Goertz, K. A. Burek-Huntington, K. E. W. Shelden, W. A. Smith, and L. A. Beckett. 2015. Potential natural and anthropogenic impediments to the conservation and recovery of Cook Inlet beluga whales, *Delphinapterus leucas*. Mar. Fish. Rev. 77(2):89-105. DOI: dx.doi.org/10.7755/MFR.77.2.5 .

O'Corry-Crowe, G. M., R. S. Suydam, A. Rosenberg, K. J. Frost, and A. E. Dizon. 1997. Phylogeography, population structure and dispersal patterns of the beluga whale *Delphinapterus leucas* in the western Nearctic revealed by mitochondrial DNA. Mol. Ecol. 6:955-970.

O'Corry-Crowe, G., A. R. Mahoney, R. Suydam, L. Quakenbush, A. Whiting, L. Lowry, and L. Harwood. 2016. Genetic profiling links changing sea-ice to shifting beluga whale migration patterns. Biol. Lett. 12:20160404. DOI: dx.doi.org/10.1098/rsbl.2016.0404 .

O'Corry-Crowe, G., R. Suydam, L. Quakenbush, B. Potgieter, L. Harwood, D. Litovka, T. Ferrer, J. Citta, V. Burkanov, K. Frost, and B. Mahoney. 2018. Migratory culture, population structure and stock identity in North Pacific beluga whales (*Delphinapterus leucas*). PLoS ONE 13(3):e0194201.

Quakenbush, L. 2003. Summer movements of beluga whales captured in the Kvichak River in May 2002 and 2003. Alaska Beluga Whale Committee Report 03-03. 15 p.

Quakenbush, L., and J. Citta. 2006. Fall movements of beluga whales captured in the Nushagak River, in September 2006. Alaska Beluga Whale Committee Report. 9 p.

Seaman, G. A., K. J. Frost, and L. F. Lowry. 1985. Investigations of belukha whales in coastal waters of western and northern Alaska. Part I. Distribution, abundance and movements. U.S. Dep. Commer., NOAA, OCSEAP Final Report 56:153-220. Available from NOAA-OMA-OAD, Alaska Office, 701 C. Street, P.O. Box 56, Anchorage, AK 99513.

Shelden, K. E. W., K. T. Goetz, D. J. Rugh, D. G. Calkins, B. A. Mahoney, and R. C. Hobbs. 2015. Spatio-temporal changes in beluga whale, *Delphinapterus leucas*, distribution: results from aerial surveys (1977-2014), opportunistic sightings (1975-2014), and satellite tagging (1999-2003) in Cook Inlet, Alaska. Mar. Fish. Rev. 77(2):1-31 + appendices. DOI: dx.doi.org/10.7755/MFR.77.2.1 .

Shelden, K. E. W., K. T. Goetz, R. C. Hobbs, L. K. Hoberecht, K. L. Laidre, B. A. Mahoney, T. L. McGuire, S. A. Norman, G. O'Corry-Crowe, D. J. Vos, G. M. Ylitalo, S. A. Mizroch, S. Atkinson, K. A. Burek-Huntington, and C. Garner. 2018. Beluga whale, *Delphinapterus leucas*, satellite-tagging and health assessments in Cook Inlet, Alaska, 1999 to 2002. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-369, 227 p.

Small, R. J., B. Brost, M. Hooten, M. Castellote, and J. Mondragon. 2017. Potential for spatial displacement of Cook Inlet beluga whales by anthropogenic noise in critical habitat. Endang. Species Res. 32:43-57. DOI: dx.doi.org/10.3354/esr00786 .

Suydam, R. S. 2009. Age, growth, reproduction, and movements of beluga whales (*Delphinapterus leucas*) from the eastern Chukchi Sea. Ph.D. Dissertation, University of Washington, School of Aquatic and Fishery Sciences, Seattle, WA.

Vergara, V., J. Wood, A. Ames, M. Mikus, V. Lesage, and R. Michaud. 2019. Mom, can you hear me? Impacts of underwater noise on mother-calf contact calls in endangered belugas (*Delphinapterus leucas*). Presented at the World Marine Mammal Conference, 9-12 December 2019, Barcelona, Spain.

~~Wade, P. R., and R. Angliss. 1997. Guidelines for assessing marine mammal stocks: report of the GAMMS Workshop April 3-5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12, 93 p.~~

Young, N. C., B. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX.

BELUGA WHALE (*Delphinapterus leucas*): Cook Inlet Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Beluga whales are distributed throughout seasonally ice-covered arctic and subarctic waters of the Northern Hemisphere (Gurevich 1980)~~ and~~. In ice-covered regions, they are closely associated with open leads and polynyas ~~in ice-covered regions~~ (Hazard 1988). In Alaska, depending on ~~the~~ season and region, beluga whales may occur in both offshore and coastal waters, with ~~genetically distinct~~ summer concentrations in upper Cook Inlet, Bristol Bay, ~~and the~~ eastern Bering Sea (i.e., Yukon River Delta, ~~and~~ Norton Sound), eastern Chukchi Sea, and ~~the~~ Beaufort Sea (Mackenzie River Delta) (Hazard 1988, O'Corry-Crowe et al. 2018) (Fig. 1). Seasonal distribution is affected by ice cover, tidal conditions, access to prey, temperature, and human interaction (Lowry 1985). Data from satellite transmitters attached to beluga whales from the Beaufort Sea, Eastern Chukchi Sea, ~~and~~ Eastern Bering Sea, and Bristol Bay stocks ~~show~~identify ~~month to month~~ ranges that ~~include~~are relatively distinct month to month for these stocks' summering areas and autumn migratory routes ~~that are relatively distinct for each population~~ (e.g., Hauser et al. 2014, Citta et al. 2017, Lowry et al. 2019). Transmitters that lasted through the winter showed that beluga whales from these summering areas overwinter in the Bering Sea; these stocks are not known to overlap in space and time in the Bering Sea (Suydam 2009, Citta et al. 2017, Lowry et al. 2019).

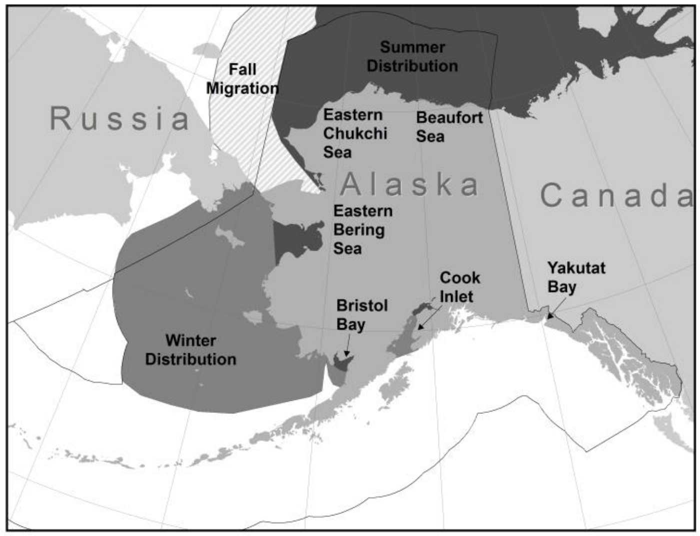

Figure 1. Approximate distribution for all five beluga whale stocks. Summering areas are dark gray, wintering areas are lighter gray, and the hashed area is a region used by the Eastern Chukchi Sea and Beaufort Sea stocks for autumn migration. The U.S. Exclusive Economic Zone is delineated by a black line.

The Beaufort Sea and Eastern Chukchi Sea stocks of beluga whales migrate between the Bering and Beaufort seas. Beaufort Sea beluga whales depart the Bering Sea in early spring, migrate through the Chukchi Sea and into the Canadian waters of the Beaufort Sea where they remain in the summer and fall, returning to the Bering Sea in late fall. Eastern Chukchi Sea beluga whales depart the Bering Sea in late spring and early summer, migrate through the Chukchi Sea and into the western Beaufort Sea where they remain in the summer, returning to the Bering Sea in the fall. The Eastern Bering Sea beluga whale stock remains in the Bering Sea but migrates south near Bristol Bay in winter and returns north to Norton Sound and the mouth of the Yukon River in summer (Suydam 2009, Hauser et al. 2014, Citta et al. 2017, Lowry et al. 2019). ~~Tag data for b~~Beluga whales ~~found~~tagged in Bristol Bay (Quakenbush 2003; Citta et al. 2016, 2017) and Cook Inlet (~~Hobbs et al. 2005;~~ Goetz et al. 2012a; Shelden et al. 2015~~a~~, 2018; Lowry et al. 2019) ~~show tagged whales~~ remain~~ed~~ in those areas throughout the year, showing only small seasonal shifts in distribution.

The following information was considered in classifying ~~B~~beluga whale stock structure ~~is~~ based on the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: geographic distribution discontinuous in summer (Frost and Lowry 1990); 2) Population response data: ~~possible extirpation of local populations,~~ distinct population trends among regions occupied in summering areas (O'Corry-Crowe et al. 2018); 3) Phenotypic data: unknown; and 4) Genotypic data: mitochondrial DNA analyses indicate distinct differences among ~~populations in~~ the five summering areas (O'Corry-Crowe et al. ~~2002~~2018). Based on this information, five beluga whale stocks are recognized within U.S. waters ~~(Fig. 1)~~: 1) Cook Inlet (Fig. 1), 2) Bristol Bay, 3) Eastern Bering Sea, 4) Eastern Chukchi Sea, and 5) Beaufort Sea.

During ice-free months, Cook Inlet beluga whales are often concentrated near river mouths (Shelden et al. 2015~~a~~). The fall-winter-spring distribution of this stock is not fully ~~determined~~understood; however, there is evidence that most whales in this population inhabit upper Cook Inlet year-round (Lammers et al. 2013, Castellote et al. 2015, Shelden et al. 2015~~a~~). From 1999 to 2002, satellite tags were attached to a total of 18 Cook Inlet beluga whales to determine their movement patterns (Goetz et al. 2012a; Shelden et al. 2015~~a~~, 2018). All tagged beluga whales remained in Cook Inlet, primarily in the upper inlet north of ~~the~~ East and West Forelands, with brief trips to the lower inlet (Shelden et al. 2015~~a~~, 2018).

A review of all marine mammal surveys and anecdotal sightings in the northern Gulf of Alaska between 1936 and 2000 found only 28 beluga whale sightings, indicating that very few beluga whales occurred in the Gulf of Alaska outside Cook Inlet (Laidre et al. 2000). Yakutat Bay is the only area in the Gulf of Alaska outside of Cook Inlet where multiple beluga whale sightings have occurred (Laidre et al. 2000, Lucey et al. 2015, O'Corry-Crowe et al. 2015). Based on genetic analyses, traditional ecological knowledge ~~(TEK)~~, and observations by fishermen and others, the Yakutat Bay beluga whales likely represent a small, resident group (fewer than 20 whales) that has been observed year round and is reproductively separated from Cook Inlet (Lucey et al. 2015, O'Corry-Crowe et al. 2015). Furthermore, this group in Yakutat Bay appears to be showing signs of inbreeding and low diversity due to their isolation and small numbers (O'Corry-Crowe et al. 2015). Although the beluga whales in Yakutat Bay are not included in the Cook Inlet Distinct Population Segment (DPS) of beluga whales under the Endangered Species Act (ESA), they are considered part of the depleted Cook Inlet stock under the Marine Mammal Protection Act (MMPA) (50 CFR 216.15; 75 FR 12498, 16 March 2010) because insufficient information was available to identify Yakutat Bay beluga whales as a separate population when Cook Inlet beluga whales were designated as depleted under the MMPA. Thus, Yakutat Bay beluga whales remain part of the Cook Inlet stock, are designated as depleted, and are provided the same protections as the Cook Inlet stock, including ~~limitations on~~ hunting regulations/restrictions.

POPULATION SIZE

Aerial surveys during June documented the distribution and abundance of Cook Inlet beluga whales and were conducted by NMFS each year from 1994 to 2012 (Rugh et al. 2000, 2005; Shelden et al. 2013), after which NMFS began biennial surveys in 2014 (Shelden et al. ~~2015b~~2019) (Fig. 2). NMFS changed to a biennial survey schedule after analysis showed there would be little reduction in the ability to detect a trend given the current growth rate of the population (Hobbs 2013).

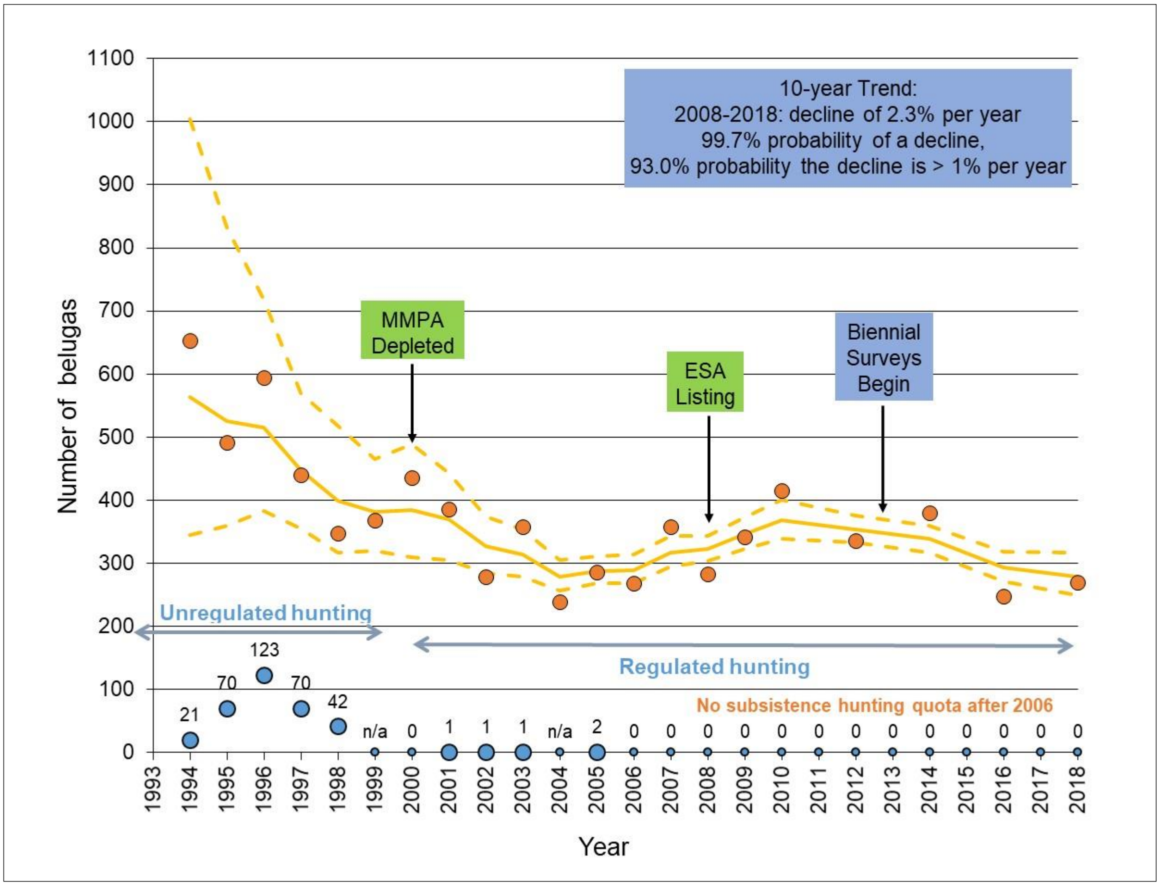

Figure 2. Annual abundance estimates (orange circles) of beluga whales in Cook Inlet, Alaska, 1994-2018 (Hobbs et al. 2015a, Wade et al. 2019). Blue circles show reported removals (landed plus struck and lost) during the Alaska Native subsistence harvest. A struck and lost average was calculated by the Cook Inlet Marine Mammal Council (CIMMC) for 1996, 1997, and 1998. The solid line is a weighted moving average of the abundance estimates that represents the smoothed trend of the population through time. Dashed lines above and below the solid line are 95% probability intervals around the smoothed trend line.

The survey covers all coastal areas and all river mouths and deltas in Cook Inlet in early June. The surveys are designed with the intention of detecting all substantially-sized beluga whale groups in the upper inlet. When beluga whale groups are detected, the group sizes are estimated by visual counts by observers or from video data recorded of the groups. The group-size estimates are summed across all detected groups to calculate an abundance estimate from each day's survey. Daily estimates from all survey days considered acceptable are combined to form an annual estimate of abundance for the population.

The method used for estimating group size from video data requires estimating multiple correction factors for visibility bias (Hobbs et al. 2000, 2015a). Following the June 2016 abundance survey, a major revision was made to the methods used to estimate group sizes from the survey data (Boyd et al. 2019). A new method was developed using a Bayesian statistical approach to group-size estimation; this new method was then applied to the 2004-2016 time series (Boyd et al. 2019). Wade et al. (2019) applied the same methodology to the 2018 survey data to estimate abundance for the 2018 survey. The new approach was designed to address the same four types of bias in the group-size estimation process as previous methods: 1) availability bias due to diving behavior; 2) proximity bias due to individuals concealed by another individual in the video data; 3) perception bias due to individuals not detected because of small image size in the video data; and 4) individual observer bias in visual estimates of group size (see Boyd et al. 2019 for a complete description of methods). The main advantages to the change in group-size estimation methods are as follows: (a) the Bayesian methods allow the variance in the parameter estimates to be fully propagated through the analysis (unlike the previous methods), and also allows for specification of distributions for some parameters, rather than just single values, to more completely consider uncertainty in the analyses; (b) for estimating the visibility bias correction factors (availability, proximity bias, and perception), the important assumption was added that the true group size was the same for all video passes of the same group (this assumption was not previously used in the analysis); (c) for availability bias, a prior distribution is specified for mean dive time for a beluga group; previously this was fixed at the single value of 24.1 seconds; and (d) for perception bias, the analysis now simultaneously estimates two distributions as part of the integrated analysis: 1) detection probability as a function of image size, and 2) the distribution of image sizes for all individuals; previously, this was done as a separate ad hoc analysis (Wade et al. 2019).

In addition to the new group-size estimation method, the revised abundance method controls for possible strong positive and negative outliers on single days (Wade et al. 2019). Strong negative outliers (days with very low abundance) can potentially happen when some groups are not seen. Strong positive outliers (days with very high abundance) can potentially happen when the whales occur in one or more very large groups, and the video group-size estimation process becomes difficult, with wide probability intervals. Previously (i.e., Hobbs et al. 2015a), the annual estimate of abundance was calculated as the average of three or more days, excluding a day's estimate if it was less than approximately 60% of the highest day. Now, the annual abundance is calculated as the median of all the daily abundance estimates, using all days with an acceptable survey day, defined objectively by weather/sighting conditions and spatial coverage. Using the median lessens the influence of strong positive and negative outliers.

The point estimate of abundance for 2018, based on the median of all acceptable daily estimates in 2018, is 269 beluga whales (coefficient of variation (CV) = 0.103, 95% probability interval (PI): 227 to 333). The best estimate of current abundance is based on a weighted average from the last three annual abundance estimates (2014, 2016, and 2018), giving more weight to the more recent estimates. From that weighted average, the best estimate of abundance for the Cook Inlet beluga population in 2018 is 279 (CV = 0.061, 95% PI: 250 to 317) (Wade et al. 2019).

~~The abundance estimate for Cook Inlet beluga whales is based on counts by aerial observers and video analysis of whale groups. Paired, independent observers count each whale group while video is collected during each counting pass. Each count is corrected for subsurface animals (availability correction) and animals at the surface that were missed (sightability correction) based on an analysis of the video tapes (Hobbs et al. 2000). When video counts are not available, observers' counts are corrected for availability and sightability using a regression of counts and an interaction term with an encounter rate against the video count estimates (Hobbs et al. 2000). The estimate of the abundance equation variance was revised using the squared standard error of the average for the abundance estimates in place of the abundance estimate variance and the measurement error (Hobbs et al. 2015a). This reduced all coefficients of variation (CVs) by almost half (Hobbs et al. 2015a). Annual abundance estimates based on aerial surveys of Cook Inlet beluga whales during the most recent 3-survey period were 312 (2012), 340 (2014), and 328 (2016), resulting in an average abundance estimate for this stock of 327 beluga whales (CV = 0.06). An abundance survey was conducted in June 2018 and results are undergoing analysis.~~

Minimum Population Estimate

The minimum population estimate (N_{MIN}) is calculated as the 20th percentile of the best abundance estimate, according to ~~Equation 1 from~~ the potential biological removal (PBR) guidelines (NMFS 2016a). ~~Thus~~In this case, N_{MIN} ~~$= N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$~~is calculated as the 20th percentile of the posterior distribution of the best estimate of abundance in 2018, which is 267 (Wade et al. 2019). ~~Using the 3-survey average population estimate (N) of 327 whales and an associated CV(N) of 0.06~~Therefore, N_{MIN} for the Cook Inlet beluga whale stock is ~~311~~267 beluga whales.

Current Population Trend

The ~~corrected~~ annual abundance estimates for 1994 to ~~2016~~2018 are shown in Figure 2, along with a weighted moving average to show the smoothed trend over time. ~~The population was declining at the end of the period of unregulated harvest, with the relatively steep decline ending in 1999, coincident with harvest removals dropping from an estimated 42 in 1998 to just 0 to 2 whales per year in 2000 to 2006 (and with no removals after 2006). From 1999 to 2016, the rate of decline of the population was estimated to be 0.4% (SE = 0.6%) per year, with a 73% probability of a population decline. While from 2006 to 2016, the most recent 10-year period, the rate of decline was estimated to be 0.5% per year, with a 70% probability of a population decline (Shelden et al. 2017).~~The population declined substantially during the period of unregulated hunting, with the peak hunting mortality reported in 1996 (123 whales) and the last year of substantial hunting mortality in 1998 (42 whales). Although only five whales were reported killed from hunting from 1999 to 2005, the population continued to decline until about 2004. The population showed an increase from 2005 to 2010 but has apparently declined since 2010. During the most recent 10-year time period (2008-2018), the estimated exponential trend in the abundance estimates is a decline of 2.3% per year (95% PI: -4.1% to -0.6%), with a 99.7% probability of a decline, and a 93.0% probability of a decline that is more than 1% per year (Wade et al. 2019).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is not available for the Cook Inlet beluga whale stock. Until additional data become available, the default cetacean maximum theoretical net productivity rate of 4% will be used for this stock (NMFS 2016a).

POTENTIAL BIOLOGICAL REMOVAL

PBR is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.1, the value for cetacean stocks that are listed as endangered (NMFS 2016a). Using the N_{MIN} of ~~311~~267 beluga whales, the calculated PBR for this stock is ~~0.62~~0.53 beluga whales (~~311~~267 × 0.02 × 0.1).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals between ~~2013~~2014 and ~~2017~~2018 is listed, by marine mammal stock, in ~~Delean et al. (2020)~~Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. No human-caused mortality or serious injury of Cook Inlet beluga whales was confirmed between ~~2013~~2014 and ~~2017~~2018. There are no observers in Cook Inlet fisheries, so the mean annual mortality and serious injury in commercial fisheries is unknown, although likely low, given that an observer program conducted in Cook Inlet in 1999-2000 did not observe mortality or serious injury of beluga whales (Manly 2006). Other potential threats most likely to result in direct human-caused mortality or serious injury of this stock include ship strikes.

Fisheries Information

Information ~~(including observer programs, observer coverage, and observed incidental takes of marine mammals)~~ for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is ~~presented~~available in Appendi~~ces~~x 3~~-6~~ of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

~~The minimum estimated average annual mortality and serious injury rate incidental to U.S. commercial fisheries for this stock is unknown, although probably low, given that an observer program directed at the Cook Inlet commercial set and drift gillnet fisheries in 1999-2000 did not observe mortality or serious injury of beluga whales (Manly 2006).~~

Alaska Native Subsistence/Harvest Information

Subsistence harvest of Cook Inlet beluga whales is important to the Native Village of Tyonek and the Alaska Native subsistence hunter community in Anchorage. Between 1993 and 1998, the annual subsistence take ranged from 17 to more than 123 beluga whales (Fig. 2), including struck and lost whales (NMFS 2016b).

Following a significant decline in Cook Inlet beluga whale abundance estimates between 1994 and 1998, the Cook Inlet hunters voluntarily stopped hunting in 1999 and the Federal government took actions to conserve, protect, and prevent further declines in the abundance of these whales. Public Laws 106-31 (1999) and 106-553 (2000) established a moratorium on Cook Inlet beluga whale harvests unless such taking occurs pursuant to a cooperative agreement between NMFS and affected Alaska Native organizations. A cooperative agreement, also referred to as a co-management agreement, was not signed in 1999 and 2004. In December 2000, an administrative hearing was held to create interim harvest regulations for 2001 through 2004 (69 FR 17973, 6 April 2004). Three Cook Inlet beluga whales were ~~harvested~~killed under this interim harvest plan (2001-2004). In August 2004, an administrative hearing was held to create a long-term harvest plan, which allowed up to eight whales to be harvested between 2005 and 2009 (NMFS 2008). Two whales were harvested in 2005 and no whales were harvested in 2006. The long-term harvest plan was signed in 2008 and established a harvest level for a 5-year period, based on the average abundance in the previous 5-year period and the growth rate during the previous 10-year period (NMFS 2008). A harvest is not allowed if the previous 5-year average abundance is less than 350 beluga whales. Under the long-term harvest plan, the 5-year average abundance during the first review period (2003-2007) was 336 whales and, therefore, a harvest was not allowed during the subsequent 5-year period (2008-2012) (73 FR 60976, 15 October 2008). The average abundance of Cook Inlet beluga whales remained below 350 whales during the second review period (2008-2012); therefore, a harvest was not allowed for the subsequent 5-year period (2013-2017). NMFS changed to a biennial survey schedule after 2012, therefore, the 5-year average abundance is now based on either two or three surveys in a 5-year period. Hobbs (2013) showed that biennial rather than annual surveys may lead to higher variation in allowable harvest levels, but it is not expected to change the probability of recovery while using the algorithm that determines the allowable harvest level. The average abundance for a third review period (2013-2017), using the 2014 and 2016 estimates, is still below 350 whales (Wade et al. 2019), so a harvest is not allowed for the subsequent 5-year period (2018-2022).

Other Mortality

Reports from the NMFS Alaska Region marine mammal stranding network provide additional information on beluga whale mortality. Mortality related to live stranding events, where a beluga whale group strands as the tide recedes, has been regularly observed in upper Cook Inlet (Table 1). Improved reports include the number of live stranded beluga whales, as well as floating and beachcast carcasses (NMFS 2016b; ~~https://www.fisheries.noaa.gov/resource/document/2017-alaska-region-stranding-summary~~https://www.fisheries.noaa.gov/resource/document/alaska-region-marine-mammal-stranding-summary, accessed ~~December 2019~~August 2020). Most whales involved in live stranding events survive, although some associated deaths may not be observed if whales die later from live-stranding-related injuries (Vos and Shelden 2005, Burek-Huntington et al. 2015). Between ~~2013~~2014 and ~~2017~~2018, there were reports of approximately ~~78~~79 beluga whales involved in ~~two~~three known live stranding events plus one suspected live stranding event with two associated deaths (Table 1; NMFS 2016b; NMFS, unpubl. data). A beluga whale calf that stranded alive in 2017 was sent to the Alaska SeaLife Center for rehabilitation and then transferred to SeaWorld in San Antonio, Texas, in 2018. In 2014, necropsy results from two whales found in Turnagain Arm suggested that a live stranding event contributed to their deaths as both had aspirated mud and water. No live stranding events were reported prior to the discovery of these dead whales, suggesting that not all live stranding events are observed (Table 1). Most live strandings occur in Knik Arm and Turnagain Arm, which are shallow~~,~~ and have ~~big tides~~large tidal ranges (Turnagain Arm has the largest tidal range in the U.S., with a mean of 30 ft), strong currents, and ~~have~~ extensive mudflats~~ and strong currents~~.

Table 1. Cook Inlet beluga whale strandings investigated by NMFS between ~~2013~~2014 and ~~2017~~2018 (NMFS 2016b; NMFS, unpubl. data).

Year	Floating and beachcast carcasses	Number of beluga whales per live stranding event (number of associated known or suspected resulting deaths)
~~2013~~	~~5~~	~~0~~
2014	~~10~~11	unknown~~*~~[a] (2), 76+ (0)
2015	3	2 (0)
2016	8	0
2017	12	~~0~~1[b]
2018	7	0
Total	~~38~~41	~~78~~79+ (2)

~~*~~[a]A live stranding was not observed but was suspected based on necropsy results from two beluga whales found in Turnagain Arm (NMFS 2016b).

[b]A beluga whale calf that stranded alive in 2017 was sent to the Alaska SeaLife Center for rehabilitation and then transferred to SeaWorld in San Antonio, Texas, in 2018.

Another source of beluga whale mortality in Cook Inlet is predation by transient-type (mammal-eating) killer whales. Killer whale sightings were not well documented and were likely rare in the upper inlet prior to the mid-1980s. From 1982 through ~~2017~~2018, NMFS received 31 reports of killer whale sightings in upper Cook Inlet (north of ~~the~~ East and West Forelands). Up to 12 beluga whale deaths, inlet-wide, were suspected to be a direct result of killer whale predation (NMFS 2016b). The last confirmed killer whale predation of a Cook Inlet beluga whale occurred in 2008 in Turnagain Arm. From ~~2013~~2014 through ~~2017~~2018, NMFS received two separate killer whale sighting reports (both in 2015) in upper Cook Inlet, but there were no reports of predation attempts. Transient killer whale vocalizations have been detected on acoustic moorings in upper Cook Inlet (Castellote et al. 2016a) but only once in a 5-year period (Castellote et al. 2016b).

Between 1998 and 2013, 38 necropsies were performed on beluga whale carcasses (23% of the 164 known stranded carcasses) (Burek-Huntington et al. 2015). The sample included adults (n = 25), juveniles (n = 6), calves (n = 3), and aborted fetuses (n = 4). When possible, a primary cause of death was noted along with contributing factors. Cause of death was unknown for 29% of the necropsied carcasses. Other causes of death were attributed to various types of trauma (18%), ~~—~~caused by confirmed and suspected killer whale predation, blunt force, choking on a starry flounder, and entanglement in a setnet (although this individual was in poor health and it could not be determined if it died before or after entanglement); perinatal mortality (13%); mass stranding (13%); single stranding (11%); malnutrition (8%); or disease (8%). Several animals had mild to moderate pneumonia, kidney disease, and/or stomach ulcers that likely contributed to their deaths.

A photo-identification study (Kaplan et al. 2009) did not find any instances where Cook Inlet beluga whales appeared to have been entangled in, or to have otherwise interacted with, fishing gear. However, in 2010, a beluga whale with a rope entangled around its girth was observed and photographed from May through August. Based on how frequently this whale was seen between 2010 and 2013, and the abrupt cessation of sightings post-2013, it is assumed this whale died. It is also possible that it lost the rope and was no longer recognized in subsequent sightings; however, natural marks (i.e., marks other than the rope) were quite distinct on this whale, and it seems likely that it would still have been recognizable if it had been photographed without the rope (McGuire et al. 2018).

STATUS OF STOCK

The Cook Inlet beluga whale stock was designated as depleted under the MMPA in 2000 (65 FR 34590, 21 May 2000) and listed as endangered under the ESA in 2008 (73 FR 62919, 22 October 2008). Therefore, the Cook Inlet beluga whale stock is considered a strategic stock.

There are key uncertainties in the assessment of the Cook Inlet stock of beluga whales. The stock decline is well documented. While the early decline was likely due to unrestricted subsistence harvesting, it is unknown what has prevented recovery of this stock, because subsistence harvest has not been allowed since ~~2006~~2007, and the mortality and serious injury in commercial fisheries is likely low. PBR is designed to allow stocks to recover to, or remain above, the maximum net productivity level (Wade 1998). An underlying assumption in the application of the PBR equation is that marine mammal stocks exhibit certain dynamics. Specifically, it is assumed that a depleted stock will naturally grow toward Optimum Sustainable Population and that some surplus growth could be removed while still allowing recovery. However, the Cook Inlet beluga whale population is far below historical levels and yet, for unknown reasons, is not increasing. If the Cook Inlet beluga whale population was increasing at an expected rate of approximately 2 to 4%, it would currently be adding, on average, about 7 to 13 whales per year to the population. Although there is currently no known direct human-caused mortality (e.g., from fisheries bycatch, harvest, ship strikes, or other sources), even if the PBR level (~one whale every 2 years) was taken, it is clear this would have little consequence on the overall population trend given the unexplained lack of increase by 7 to 13 whales per year. Stranding data from Cook Inlet have shown that an average of approximately 10 beluga whales died per year between 1998 and 2013 (Burek-Huntington et al. 2015) due to non-human-related or unknown causes, but total mortality in the population is unknown without information on the carcass recovery rate. Individuals die from natural causes even in a growing population; for example, if the average survival rate was a relatively high 0.95, there would still be approximately ~~16~~14 (0.05 × ~~327~~279) deaths expected each year; therefore, it is hard to conclude anything definitive from an average of 10 observed deaths per year.

HABITAT CONCERNS

Critical habitat designated for the Cook Inlet DPS of beluga whales under the ESA includes two geographic areas of marine habitat in Cook Inlet that comprise 7,800 km^2 (3,013 mi^2), excluding waters of the Port of ~~Anchorage~~Alaska (76 FR 20180, 11 April 2011). Based on available information, beluga whales remain within the inlet year-round. Review of beluga whale presence data from aerial surveys, satellite tagging, protected species observers, citizen scientists, and opportunistic sightings collected in Cook Inlet from the late 1970s to ~~2014~~2018 shows their range has contracted remarkably since the 1970s (Shelden et al. ~~2015a~~2019). Almost the entire population is found in northern Cook Inlet from late spring through the summer and into the fall. This differs markedly from surveys in the 1970s when beluga whales were found in, or would disperse to, lower Cook Inlet by midsummer. Since 2008, on average, 83% of the total population occupied the Susitna Delta (Beluga to Little Susitna rivers) in early June during the aerial survey period, compared to roughly 50% in the past (1978-1979, 1993-1997, 1998-2008). The 2009 to 2014 distribution was estimated to be only 25% of the range observed in 1978 and 1979 (Shelden et al. 2015~~a~~). Rugh et al. (2000) first noted that whales had not dispersed to the lower inlet in July during surveys in the mid-1990s. This was also evident during aerial surveys conducted in July 2001 (Rugh et al.

2004). Whales transmitting locations from satellite tags during July in 1999 and 2002 also remained in the northern reaches of the upper inlet (Shelden et al. 2015~~a~~). During surveys in the 1970s, large numbers of whales were scattered throughout the lower inlet in August (Shelden et al. 2015~~a~~). This was not the case in 2001, when counts in the upper inlet in August were similar to those reported in June and July (Rugh et al. 2004). In August, only 2 of 10 tagged whales spent time in offshore waters and the lower inlet (Shelden et al. 2015~~a~~). The number of whales observed in the upper inlet during the August calf index surveys, conducted from 2005 to 2012, was similar to the June surveys (Hobbs et al. 2015a~~, Shelden et al. 2015a~~), suggesting the contraction in range continued ~~into late~~through the summer. While surveys were not conducted in September during the 1970s and 1980s, aerial surveys in 1993 showed some dispersal into lower inlet waters by late September (Shelden et al. 2015~~a~~). However, surveys in September and October of 2001 resulted in counts that were similar to June (Rugh et al. 2004). With the exception of three whales that spent brief periods of time in the lower inlet during September and/or October, most whales transmitting locations in 1999, 2000, 2001, and 2002 remained in the upper inlet north of ~~the~~ East and West Forelands (Shelden et al. 2015~~a~~, 2018). Counts during aerial surveys in September 2008 were also similar to June (Shelden et al. 2015~~a~~).

Goetz et al. (2012b) modeled habitat preferences using NMFS' 1994-2008 June abundance survey data. In large areas, such as the Susitna Delta and Knik Arm, there was a high probability that beluga whales were in larger group sizes. Beluga whale presence also increased closer to rivers with Chinook salmon (*Oncorhynchus tshawytscha*) runs, such as the Susitna River. Chinook salmon runs have been decreasing in many Alaska Rivers since 2007, including the Susitna River (https://www.adfg.alaska.gov/index.cfm?adfg=chinookinitiative.main, accessed August 2020). The Susitna Delta also supports two major spawning migrations of a small, schooling eulachon (*Thaleichthys pacificus*) in May and June (Goetz et al. 2012b).

The population appears to be consolidated into habitat in the upper-most reaches of Cook Inlet for much longer periods of time, in habitat that is most likely to be noisy (e.g., Moore et al. 2000, Lowry et al. 2006, Hobbs et al. 2015b, Kendall and Cornick 2015, Norman et al. 2015). An assessment of noise sources in Cook Inlet (Castellote et al. 2019) indicates that anthropogenic noise occurring in some of the most important habitat (i.e., Area 1 critical habitat: 76 FR 20180, 11 April 2011) has the potential to mask beluga communication and hearing, and the potential reduction of communication and echolocation range is considerable. Whether this contracted distribution is a result of changing habitat (Moore et al. 2000), prey concentration, or predator avoidance (Shelden et al. 2003) or can simply be explained as the contraction of a reduced population into small areas of preferred habitat (Goetz et al. 2007, 2012b) is unknown. ~~Goetz et al. (2012b) modeled habitat preferences using NMFS' 1994-2008 June abundance survey data. In large areas, such as the Susitna Delta (Beluga to Little Susitna rivers) and Knik Arm, there was a high probability that beluga whales were in larger group sizes. Beluga whale presence also increased closer to rivers with Chinook salmon (*Oncorhynchus tshawytscha*) runs, such as the Susitna River. Chinook salmon runs have been decreasing in many Alaska Rivers since 2007, including the Susitna River (https://www.adfg.alaska.gov/index.cfm?adfg=chinookinitiative.main, accessed December 2019). The Susitna Delta also supports two major spawning migrations of a small, schooling eulachon (*Thaleichthys pacificus*) in May and June (Goetz et al. 2012b).~~

~~Identified in t~~The Cook Inlet Beluga Recovery Plan (NMFS 2016b) ~~are~~identifies potential threats~~ of~~: 1) high concern: catastrophic events (e.g., natural disasters, spills, mass strandings), cumulative effects of multiple stressors, and noise; 2) medium concern: disease agents (e.g., pathogens, parasites, and harmful algal blooms), habitat loss or degradation, reduction in prey, and unauthorized take; and 3) low concern: pollution, predation, and subsistence harvest. The recovery plan did not treat climate change as a distinct threat but rather as a consideration in the threats of high and medium concern.

CITATIONS

Boyd, C., R. C. Hobbs, A. E. Punt, K. E. W. Shelden, C. L. Sims, and P. R. Wade. 2019. Bayesian estimation of group sizes for a coastal cetacean using aerial survey data. Mar. Mammal Sci. 35(4):1322-1346. DOI: dx.doi.org/10.1111/mms.12592 .

Burek-Huntington, K. A., J. Dushane, C. E. C. Goertz, L. Measures, C. Romero, and S. Raverty. 2015. Morbidity and mortality in stranded Cook Inlet beluga whales (*Delphinapterus leucas*). Dis. Aquat. Organ. 114(1):45-60. DOI: dx.doi.org/10.3354/dao02839 .

Castellote, M., R. J. Small, J. Mondragon, J. Jenniges, and J. Skinner. 2015. Seasonal distribution and foraging behavior of Cook Inlet belugas based on acoustic monitoring. ADF&G Final Report to Department of Defense.

Castellote, M., R. J. Small, M. O. Lammers, J. J. Jenniges, J. Mondragon, and S. Atkinson. 2016a. Dual instrument passive acoustic monitoring of belugas in Cook Inlet, Alaska. J. Acoust. Soc. Am. 139:2697. DOI: dx.doi.org/10.1121/1.4947427 .

Castellote, M., R. J. Small, J. Mondragon, J. Jenniges, and J. Skinner. 2016b. Seasonal distribution and foraging behavior of Cook Inlet belugas based on acoustic monitoring. Alaska Department of Fish and Game, Final Wildlife Research Report, ADF&G/DWS/WRR-2016-3, Juneau, AK.

Castellote, M., B. Thayre, M. Mahoney, J. Mondragon, M. O. Lammers, and R. J. Small. 2019. Anthropogenic noise and the endangered Cook Inlet beluga whale, *Delphinapterus leucas*: acoustic considerations for management. Mar. Fish. Rev. 80(3):63-88. DOI: dx.doi.org/10.7755/MFR.80.3.3 .

Citta, J. J., L. T. Quakenbush, K. J. Frost, L. Lowry, R. C. Hobbs, and H. Aderman. 2016. Movements of beluga whales (*Delphinapterus leucas*) in Bristol Bay, Alaska. Mar. Mammal Sci. 32:1272-1298. DOI: dx.doi.org/10.1111/mms.12337 .

Citta, J. J., P. Richard, L. F. Lowry, G. O'Corry-Crowe, M. Marcoux, R. Suydam, L. T. Quakenbush, R. C. Hobbs, D. I. Litovka, K. J. Frost, T. Gray, J. Orr, B. Tinker, H. Aderman, and M. L. Druckenmiller. 2017. Satellite telemetry reveals population specific winter ranges of beluga whales in the Bering Sea. Mar. Mammal Sci. 33:236-250. DOI: dx.doi.org/10.1111/mms.12357 .

~~Delean, B. J., V. T. Helker, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, J. Jannot, and N. C. Young. 2020. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2013-2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-401, 86 p.~~

Dizon, A. E., C. Lockyer, W. F. Perrin, D. P. DeMaster, and J. Sisson. 1992. Rethinking the stock concept: a phylogeographic approach. Conserv. Biol. 6:24-36.

Frost, K. J., and L. F. Lowry. 1990. Distribution, abundance, and movements of beluga whales, *Delphinapterus leucas*, in coastal waters of western Alaska, p. 39-57. *In* T. G. Smith, D. J. St. Aubin, and J. R. Geraci (eds.), Advances in research on the beluga whale, *Delphinapterus leucas*. Can. Bull. Fish. Aquat. Sci. 224.

Goetz, K. T., D. J. Rugh, A. J. Read, and R. C. Hobbs. 2007. Summer habitat preferences of beluga whales (*Delphinapterus leucas*) in Cook Inlet, Alaska. Mar. Ecol. Prog. Ser. 330:247-256.

Goetz, K. T., P. W. Robinson, R. C. Hobbs, K. L. Laidre, L. A. Huckstadt, and K. E. W. Shelden. 2012a. Movement and dive behavior of beluga whales in Cook Inlet, Alaska. AFSC Processed Rep. 2012-03, 40 p. Alaska Fisheries Science Center, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Goetz, K. T., R. A. Montgomery, J. M. Ver Hoef, R. C. Hobbs, and D. S. Johnson. 2012b. Identifying essential summer habitat of the endangered beluga whale *Delphinapterus leucas* in Cook Inlet, Alaska. Endang. Species Res. 16:135-147.

Gurevich, V. S. 1980. Worldwide distribution and migration patterns of the white whale (beluga), *Delphinapterus leucas*. Rep. Int. Whal. Comm. 30:465-480.

Hauser, D. D. W., K. L. Laidre, R. S. Suydam, and P. R. Richard. 2014. Population-specific home ranges and migration timing of Pacific Arctic beluga whales (*Delphinapterus leucas*). Polar Biol. 37(8):1171-1183. DOI: dx.doi.org/10.1007/s00300-014-1510-1 .

Hazard, K. 1988. Beluga whale, *Delphinapterus leucas*, p. 195-235. *In* J. W. Lentfer (ed.), Selected Marine Mammals of Alaska: Species Accounts with Research and Management Recommendations. Marine Mammal Commission, Washington, DC.

Hobbs, R. C. 2013. Detecting changes in population trends for Cook Inlet beluga whales (*Delphinapterus leucas*) using alternative schedules for aerial surveys. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-252, 25 p.

Hobbs, R. C., J. M. Waite, and D. J. Rugh. 2000. Beluga, *Delphinapterus leucas*, group sizes in Cook Inlet, Alaska, based on observer counts and aerial video. Mar. Fish. Rev. 62(3):46-59.

~~Hobbs, R. C., K. L. Laidre, D. J. Vos, B. A. Mahoney, and M. Eagleton. 2005. Movements and area use of belugas, *Delphinapterus leucas*, in a subarctic Alaskan estuary. Arctic 58(4):331-340.~~

Hobbs, R. C., K. E. W. Shelden, D. J. Rugh, C. L. Sims, and J. M. Waite. 2015a. Estimated abundance and trend in aerial counts of beluga whales, *Delphinapterus leucas*, in Cook Inlet, Alaska, 1994-2012. Mar. Fish. Rev. 77(1):11-31. DOI: dx.doi.org/10.7755/MFR.77.1.2 .

Hobbs, R. C., P. R. Wade, and K. E. W. Shelden. 2015b. Viability of a small, geographically-isolated population of beluga whales, *Delphinapterus leucas*: effects of hunting, predation, and mortality events in Cook Inlet, Alaska. Mar. Fish. Rev. 77(2):59-88. DOI: dx.doi.org/10.7755/MFR.77.2.4 .

Kaplan, C. C., T. L. McGuire, M. K. Blees, and S. W. Raborn. 2009. Longevity and causes of marks seen on Cook Inlet beluga whales, Chapter 1. *In* Photo-identification of beluga whales in Upper Cook Inlet, Alaska: mark analysis, mark-resight estimates, and color analysis from photographs taken in 2008. Report prepared by LGL Alaska Research Associates, Inc., Anchorage, AK, for National Fish and Wildlife Foundation, Chevron, and ConocoPhillips Alaska, Inc. 32 p.

Kendall, L. S., and L. A. Cornick. 2015. Behavior and distribution of Cook Inlet beluga whales, *Delphinapterus leucas*, before and during pile driving activity. Mar. Fish. Rev. 77(2):106-114. DOI: dx.doi.org/10.7755/MFR.77.2.6 .

Laidre, K. L., K. E. W. Shelden, D. J. Rugh, and B. Mahoney. 2000. Beluga, *Delphinapterus leucas*, distribution and survey effort in the Gulf of Alaska. Mar. Fish. Rev. 62(3):27-36.

Lammers, M. O., M. Castellote, R. J. Small, S. Atkinson, J. Jenniges, A. Rosinski, J. N. Oswald, and C. Garner. 2013. Passive acoustic monitoring of Cook Inlet beluga whales (*Delphinapterus leucas*). J. Acoust. Soc. Am. 134:2497-2504. DOI: dx.doi.org/10.1121/1.4816575 .

Lowry, L. F. 1985. The belukha whale (*Delphinapterus leucas*), p. 3-13. *In* J. J. Burns, K. J. Frost, and L. F. Lowry (eds.), Marine mammals species accounts. Alaska Department of Fish and Game, Game Tech. Bull. 7.

Lowry, L., G. O'Corry-Crowe, and D. Goodman. 2006. *Delphinapterus leucas* (Cook Inlet population). *In* IUCN 2006. 2006 IUCN Red List of Threatened Species.

Lowry, L. F., J. J. Citta, G. O'Corry-Crowe, L. T. Quakenbush, K. J. Frost, R. Suydam, R. C. Hobbs, and T. Gray. 2019. Distribution, abundance, harvest, and status of western Alaska beluga whale, *Delphinapterus leucas*, stocks. Mar. Fish. Rev. 81(3-4):54-71.

Lucey, W., H. E. Abraham, G. O'Corry-Crowe, K. M. Stafford, and M. Castellote. 2015. Traditional knowledge and historical and opportunistic sightings of beluga whales, *Delphinapterus leucas*, in Yakutat Bay, Alaska. Mar. Fish. Rev. 77(1):41-46. DOI: dx.doi.org/10.7755/MFR.77.1.4 .

Manly, B. F. J. 2006. Incidental catch and interactions of marine mammals and birds in the Cook Inlet salmon driftnet and setnet fisheries, 1999-2000. Final Report to NMFS Alaska Region. 98 p.

McGuire, T., A. Stephens, and J. McClung. 2018. Photo-identification of beluga whales in upper Cook Inlet, Alaska. Summary of field activities and whales identified in 2017. Report prepared by the Cook Inlet Beluga Whale Photo-ID Project for the National Marine Fisheries Service, Alaska Region. 90 p.

Moore, S. E., K. E. W. Shelden, L. K. Litzky, B. A. Mahoney, and D. J. Rugh. 2000. Beluga, *Delphinapterus leucas*, habitat associations in Cook Inlet, Alaska. Mar. Fish. Rev. 62(3):60-80.

National Marine Fisheries Service (NMFS). 2008. Cook Inlet beluga whale subsistence harvest: Final Supplemental Environmental Impact Statement. U.S. Dep. Commer., NOAA, NMFS, Alaska Region, Office of Protected Resources, Juneau, AK. Available online: https://repository.library.noaa.gov/view/noaa/4948 . Accessed ~~December 2019~~August 2020.

National Marine Fisheries Service (NMFS). 2016a. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed ~~December 2019~~August 2020.

National Marine Fisheries Service (NMFS). 2016b. Recovery plan for the Cook Inlet beluga whale (*Delphinapterus leucas*). National Marine Fisheries Service, Alaska Region, Protected Resources Division, Juneau, AK.

Norman, S. A., R. C. Hobbs, C. E. C. Goertz, K. A. Burek-Huntington, K. E. W. Shelden, W. A. Smith, and L. A. Beckett. 2015. Potential natural and anthropogenic impediments to the conservation and recovery of Cook Inlet beluga whales, *Delphinapterus leucas*. Mar. Fish. Rev. 77(2):89-105. DOI: dx.doi.org/10.7755/MFR.77.2.5 .

~~O'Corry-Crowe, G. M., A. E. Dizon, R. S. Suydam, and L. F. Lowry. 2002. Molecular genetic studies of population structure and movement patterns in a migratory species: the beluga whale, *Delphinapterus leucas*, in the western Nearctic, p. 53-64. *In* C. J. Pfeiffer (ed.), Molecular and Cell Biology of Marine Mammals. Krieger Publishing Company, Malabar, FL.~~

O'Corry-Crowe, G., W. Lucey, F. I. Archer, and B. Mahoney. 2015. The genetic ecology and population origins of the beluga whales, *Delphinapterus leucas*, of Yakutat Bay. Mar. Fish. Rev. 77(1):47-58. DOI: dx.doi.org/10.7755/MFR.77.1.5 .

O'Corry-Crowe, G., R. Suydam, L. Quakenbush, B. Potgieter, L. Harwood, D. Litovka, T. Ferrer, J. Citta, V. Burkanov, K. Frost, and B. Mahoney 2018. Migratory culture, population structure and stock identity in North Pacific beluga whales (*Delphinapterus leucas*). PLoS ONE 13(3):e0194201. DOI: dx,doi.org/10.1371/journal.pone.0194201 .

Quakenbush, L. 2003. Summer movements of beluga whales captured in the Kvichak River in May 2002 and 2003. Alaska Beluga Whale Committee Report 03-03. 15 p.

Rugh, D. J., K. E. W. Shelden, and B. Mahoney. 2000. Distribution of beluga whales in Cook Inlet, Alaska, during June/July, 1993 to 1999. Mar. Fish. Rev. 62(3):6-21.

Rugh, D. J., B. A. Mahoney, and B. K. Smith. 2004. Aerial surveys of beluga whales in Cook Inlet, Alaska, between June 2001 and June 2002. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-145, 26 p.

Rugh, D. J., K. E. W. Shelden, C. L. Sims, B. A. Mahoney, B. K. Smith, L. K. Litzky, and R. C. Hobbs. 2005. Aerial surveys of belugas in Cook Inlet, Alaska, June 2001, 2002, 2003, and 2004. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-149, 71 p.

Shelden, K. E. W., D. J. Rugh, B. A. Mahoney, and M. E. Dahlheim. 2003. Killer whale predation on belugas in Cook Inlet, Alaska: implications for a depleted population. Mar. Mammal Sci. 19(3):529-544.

Shelden, K. E. W., D. J. Rugh, K. T. Goetz, C. L. Sims, L. Vate Brattström, J. A. Mocklin, B. A. Mahoney, B. K. Smith, and R. C. Hobbs. 2013. Aerial surveys of beluga whales, *Delphinapterus leucas*, in Cook Inlet, Alaska, June 2005 to 2012. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-263, 122 p.

Shelden, K. E. W., K. T. Goetz, D. J. Rugh, D. G. Calkins, B. A. Mahoney, and R. C. Hobbs. 2015a. Spatio-temporal changes in beluga whale, *Delphinapterus leucas*, distribution: results from aerial surveys (1977-2014), opportunistic sightings (1975-2014), and satellite tagging (1999-2003) in Cook Inlet, Alaska. Mar. Fish. Rev. 77(2):1-31 + appendices. DOI: dx.doi.org/10.7755/MFR.77.2.1 .

~~Shelden, K. E. W., C. L. Sims, L. Vate Brattström, K. T. Goetz, and R. C. Hobbs. 2015b. Aerial surveys of beluga whales (*Delphinapterus leucas*) in Cook Inlet, Alaska, June 2014. AFSC Processed Rep. 2015-03, 55 p.~~

~~Shelden, K. E. W., R. C. Hobbs, C. L. Sims, L. Vate Brattström, J. A. Mocklin, C. Boyd, and B. A. Mahoney. 2017. Aerial surveys, abundance, and distribution of beluga whales (*Delphinapterus leucas*) in Cook Inlet, Alaska, June 2016. AFSC Processed Rep. 2017-09, 62 p.~~

Shelden, K. E. W., K. T. Goetz, R. C. Hobbs, L. K. Hoberecht, K. L. Laidre, B. A. Mahoney, T. L. McGuire, S. A. Norman, G. O'Corry-Crowe, D. J. Vos, G. M. Ylitalo, S. A. Mizroch, S. Atkinson, K. A. Burek-Huntington, and C. Garner. 2018. Beluga whale, *Delphinapterus leucas*, satellite-tagging and health assessments in Cook Inlet, Alaska, 1999 to 2002. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-369, 227 p.

Shelden, K. E. W., C. Boyd, C. L. Sims, V. A. Gill, and B. A. Mahoney. 2019. Chapter 1: Field report for the June 2018 Cook Inlet beluga aerial abundance and distribution survey. *In* K. E. W. Shelden and P. R. Wade (eds.), Aerial surveys, distribution, abundance, and trend of belugas (*Delphinapterus leucas*) in Cook Inlet, Alaska, June 2018. AFSC Processed Rep. 2019-09, 93 p. Alaska Fisheries Science Center, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Suydam, R. S. 2009. Age, growth, reproduction, and movements of beluga whales (*Delphinapterus leucas*) from the eastern Chukchi Sea. Ph.D. Dissertation, University of Washington, School of Aquatic and Fishery Sciences, Seattle, WA.

Vos, D. J., and K. E. W. Shelden. 2005. Unusual mortality in the depleted Cook Inlet beluga population. Northwest. Nat. 86(2):59-65.

Wade, P. R. 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. Mar. Mammal Sci. 14:1-37. DOI: dx.doi.org/10.1111/j.1748-7692.1998.tb00688.x .

Wade, P. R., C. Boyd, K. E. W. Shelden, and C. L. Sims. 2019. Chapter 2: Group size estimates and revised abundance estimates and trend for the Cook Inlet beluga population. *In* K. E. W. Shelden and P. R. Wade (eds.), Aerial surveys, distribution, abundance, and trend of belugas (*Delphinapterus leucas*) in Cook Inlet, Alaska, June 2018. AFSC Processed Rep. 2019-09, 93 p. Alaska Fisheries Science Center, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX.

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KILLER WHALE (*Orcinus orca*): Eastern North Pacific Gulf of Alaska, Aleutian Islands, and Bering Sea Transient Stock

NOTE – NMFS has preliminary genetic information on killer whales in Alaska which indicates that the current stock structure of killer whales in Alaska needs to be reassessed. NMFS is evaluating the new genetic information. In the interim, new information on killer whale mortality levels is provided within this report. A complete revision of the killer whale stock assessments will be postponed until the stock structure evaluation is completed and any new stocks are identified.

STOCK DEFINITION AND GEOGRAPHIC RANGE

Killer whales have been observed in all oceans and seas of the world (Leatherwood and Dahlheim 1978). Although reported from tropical and offshore waters, killer whales occur at higher densities in colder and more productive waters of both hemispheres, with the greatest densities found at high latitudes (Mitchell 1975, Leatherwood and Dahlheim 1978, Forney and Wade 2006). Killer whales are found throughout the North Pacific Ocean. Along the west coast of North America, seasonal and year-round occurrence of killer whales ~~occur~~has been noted along the entire Alaska coast (Braham and Dahlheim 1982), in British Columbia and Washington inland waterways (Bigg et al. 1990), and along the outer coasts of Washington, Oregon, and California (Green et al. 1992; Barlow 1995, 1997; Forney et al. 1995). ~~Seasonal and year-round occurrence has been noted for killer whales throughout Alaska (Braham and Dahlheim 1982) and in the intracoastal waterways of British Columbia and Washington State, where whales~~Killer whales from these areas have been labeled as "resident," "transient," and "offshore" type killer whales (Bigg et al. 1990, Ford et al. 2000, Dahlheim et al. 2008) based on aspects of morphology, ecology, genetics, and behavior (Ford and Fisher 1982; Baird and Stacey 1988; Baird et al. 1992; Hoelzel et al. 1998, 2002; Barrett-Lennard 2000; Dahlheim et al. 2008). Through examination of photographs of recognizable individuals and pods, movements of whales between geographical areas have been documented. For example, whales identified in Prince William Sound have been observed near Kodiak Island (Matkin et al. 1999) and whales identified in Southeast Alaska have been observed in Prince William Sound, British Columbia, and Puget Sound (Leatherwood et al. 1990, Dahlheim et al. 1997). Movements of killer whales between the waters of Southeast Alaska and central California have also been documented (Goley and Straley 1994, Black et al. 1997, Dahlheim and White 2010).

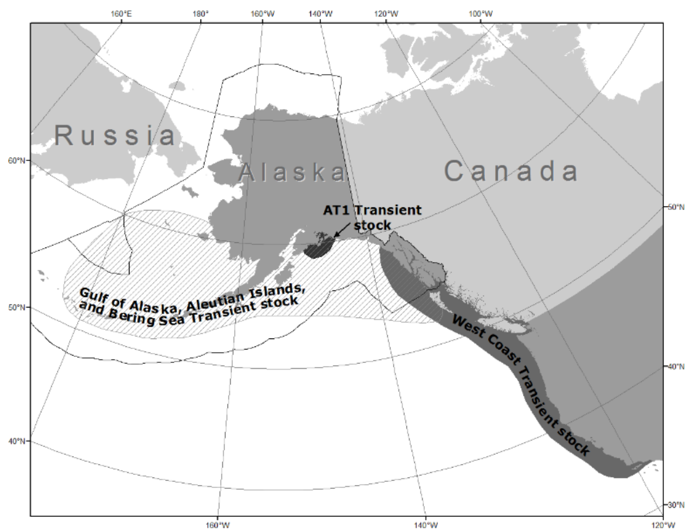

Figure 1. Approximate distribution of transient killer whales in the eastern North Pacific (shaded areas). The distribution of resident and transient killer whale stocks in the eastern North Pacific largely overlap (see text). The U.S. Exclusive Economic Zone is delineated by a black line.

Several studies provide evidence that the resident, offshore, and transient ecotypes are genetically distinct in both mtDNA and nuclear DNA (Hoelzel and Dover 1991; Hoelzel et al. 1998, 2002; Barrett-Lennard 2000). Genetic differences have also been found between populations within the transient and resident ecotypes (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000). A ~~recent~~ global genetic study of killer whales using the entire mitochondrial genome found that some killer whale ecotypes represent deeply divergent evolutionary lineages and warrant elevation to species or subspecies status (Morin et al. 2010). In particular, estimates from mitogenome sequence data indicate that transient killer whales diverged from all other killer whale lineages ~~~~approximately 700,000 years ago. In light of these differences, the Society for Marine Mammalogy's Committee on Taxonomy currently recognizes the resident and transient North Pacific ecotypes as un-named *Orcinus orca* subspecies (Committee on Taxonomy ~~2012~~2019). In recognition of its status as an un-named subspecies or species, some researchers now refer to transient-type killer whales as Bigg's killer whales (e.g., Ford 2011, Riesch et al. 2012), in tribute to the late Dr. Michael Bigg.

~~Until recently,~~The first studies of transient killer whales in Alaska ~~had only been studied intensively~~were conducted in Southeast Alaska and in the Gulf of Alaska (from Prince William Sound, through the Kenai Fjords, and around Kodiak Island). In the Gulf of Alaska, Matkin et al. (1999) described two genetically distinct populations of transients which were never found in association with one another, the so-called "Gulf of Alaska" transients and "AT1" transients. In the past, neither of these populations were known to associate with the population of transient killer whales that ranged from California to Southeast Alaska, which are described as the West Coast Transient stock. Gulf of Alaska transients are documented throughout the Gulf of Alaska, including occasional sightings in Prince William Sound. AT1 transients ~~are primarily~~have been seen only in Prince William Sound and in the Kenai Fjords region, and are therefore partially sympatric with Gulf of Alaska transients. ~~Recently, on one occasion, members of the Gulf of Alaska transient population were seen in association with the transient killer whales that range from California to southeastern Alaska, the West Coast Transients, which are identified by a unique mtDNA haplotype (Matkin et al. 2012). Photographs have identified~~ In addition, 14 out of 217 ~~whales considered~~ "transients on the outer coast~~"~~ ~~transients in~~of Southeast Alaska and British Columbia ~~that were also photographed in Alaska waters and considered~~were identified as Gulf of Alaska transients and in one encounter they were observed mixing with West Coast transients (Matkin et al. 2012, Ford et al. 2013). Transients ~~that are~~ within the Gulf of Alaska population have been found to have two mtDNA haplotypes, neither of which is found in the West Coast or AT1 populations. Members of the AT1 population share a single mtDNA haplotype. Transient killer whales from the West Coast ~~stock~~population have been found to share a single mtDNA haplotype that is not found in the other ~~stocks~~populations. Additionally, all three populations have been found to have significant differences in nuclear (microsatellite) DNA (Barrett-Lennard 2000). Acoustic differences have been found ~~between these stocks by Saulitis (1993) and~~as well; Saulitis et al. (2005) described acoustic differences between Gulf of Alaska transients and AT1 transients. For these reasons, the Gulf of Alaska transients are considered part of a population that is discrete from the AT1 population, and both of these ~~communities~~populations are considered discrete from the West Coast ~~T~~transients.

Transient-type killer whales from the Aleutian Islands and Bering Sea are currently considered to be part of a single population that includes Gulf of Alaska transients; however, recent genetic analyses suggest substructure within the region. Biopsy samples from the eastern Aleutians and the south side of the west end of the Alaska Peninsula have produced the same haplotypes as killer whales in the northern Gulf of Alaska; however, nuclear DNA analysis strongly suggests they belong to a separate population (Parsons et al. 2013). ~~Samples~~The geographic distribution of mtDNA haplotypes revealed samples from the central Aleutian Islands and Bering Sea ~~have identified mtDNA~~with haplotypes not found in Gulf of Alaska transients, suggesting additional population structure in western Alaska. ~~At this time transient-type killer whales from the Aleutian Islands and Bering Sea are considered to be part of a single population that includes Gulf of Alaska transients.~~ Killer whales ~~are~~ observed in the northern Bering Sea and north and east to the western Beaufort Sea ~~that~~ have ~~the physical~~ characteristics of transient-type whales, but little is known about these whales (Braham and Dahlheim 1982, George and Suydam 1998). AT1 haplotype whales are also present west of the Aleutian Islands and into the Bering Sea; however, nuclear DNA analysis indicates these animals are not part of the AT1 transient population in the Gulf of Alaska (Parsons et al. 2013).

In summary, within the transient ecotype, association data (Ford et al. 1994, Ford and Ellis 1999, Matkin et al. 1999), acoustic data (~~Saulitis 1993,~~ Ford and Ellis 1999, Saulitis et al. 2005), and genetic data (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000) confirm that at least three communities of transient whales exist and represent three discrete populations: 1) Gulf of Alaska, Aleutian Islands, and Bering Sea ~~T~~transients, 2) AT1 ~~T~~transients, and 3) West Coast ~~T~~transients ~~(Fig. 1)~~.

Based on data regarding association patterns, acoustics, movements, and genetic differences, eight killer whale stocks are now recognized within the Pacific U.S. Exclusive Economic Zone: 1) the Alaska Resident stock - occurring from ~~s~~Southeast~~ern~~ Alaska to the Aleutian Islands and Bering Sea, 2) the Northern Resident stock - occurring from Washington State through part of ~~s~~Southeast~~ern~~ Alaska, 3) the Southern Resident stock - occurring mainly within the inland waters of Washington State and southern British Columbia, but also in coastal waters from ~~southeastern~~Southeast Alaska through California, 4) the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock - occurring mainly from Prince William Sound through the Aleutian Islands and Bering Sea (Fig. 1), 5) the AT1 Transient stock - occurring in Alaska from Prince William Sound through the Kenai Fjords, 6) the West Coast Transient stock - occurring from California through ~~southeastern~~Southeast Alaska, 7) the Offshore stock - occurring from California through Alaska, and 8) the Hawaiian stock. Transient killer whales in Canadian waters are considered part of the West Coast Transient stock. The Hawaiian and Offshore stocks are reported in the Stock

Assessment Reports for the ~~Alaska~~U.S. Pacific Region~~ contain information concerning all the killer whale stocks except the Hawaiian and Offshore stocks~~.

~~In recent years, a small number of the Gulf of Alaska transients (identified by genetics and association) have been seen in southeastern Alaska; previously only West Coast Transients had been seen in southeastern Alaska. Therefore, the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock occupies a range that includes all of the U.S. EEZ in Alaska, though few individuals from this population have been seen in southeastern Alaska.~~

POPULATION SIZE

In January 2004, the North Gulf Oceanic Society (NGOS) and the Marine Mammal Laboratory (MML) held a joint workshop to match identification photographs of transient killer whales from this population. That analysis of photographic data resulted in the following minimum counts for transient killer whales belonging to the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock. In the Gulf of Alaska (east of the Shumagin Islands), 82 whales were identified by NGOS, including whales from Matkin et al. (1999) as well as whales identified in subsequent years (but not including whales identified as part of the AT1 population). MML identified 43 whales and 11 matches were found between the NGOS and MML catalogues. Since that time an additional 22 whales have been added to the NGOS catalogue (Matkin et al. in prep.). Therefore, a total of 136 transients (104 + 43 - 11) have been identified in the Gulf of Alaska. In the Aleutian Islands (west of and including the Shumagin Islands) and Bering Sea, the combined NGOS/MML catalogue (NGOS/MML 2012) now contains 451 individually identifiable whales (not counting unmarked calves and not counting two Gulf of Alaska transient whales that have been photographed in that region).~~ All have been photographed in the past ten years.~~ Combining the Aleutian Islands and Bering Sea count (451) with the Gulf of Alaska count (136), a total count of 587 individual whales have been identified in catalogues of this stock.

MML conducted killer whale line-transect surveys for 3 years in July and August in 2001-2003. These surveys covered an area from approximately Resurrection Bay in the Kenai Fjords to the central Aleutians. The surveys covered an area from shore to 30-45 nautical miles offshore, with randomly located transects in a zigzag pattern. Estimated transient killer whale abundance from these surveys, using post-encounter estimates of group size, was 249 (CV = 0.50), with a 95% confidence interval of 99-628 (Zerbini et al. 2007).

Mark-recapture methods were used to estimate the number of ~~mammal-eating~~ transient killer whales using the coastal waters from the central Gulf of Alaska to the central Aleutian Islands, using photographs collected during the three line-transect surveys (Zerbini et al. 2007), along with photographs collected from a variety of additional surveys during the same time period (Durban et al. 2010). A total of 154 individuals were identified from 6,489 photographs collected between July 2001 and August 2003. A Bayesian mixture model estimated seven distinct clusters (95% Probability Interval = 7-10) of individuals that were differentially covered by 14 boat-based surveys exhibiting varying degrees of association in space and time, leading to a total estimate of 345 whales (95% Probability Interval = 255-487). This estimate is higher than the line-transect estimate for at least two reasons. First, the line-transect estimate provides an “instantaneous” (across ~40 days) estimate of the average number of transient killer whales in the survey area, whereas the mark-recapture methods provide an estimate of the total number of whales to use the survey area over the ~~three~~3 years, which is known to be greater due to the long distance movements documented by satellite tags (J. Durban, Southwest Fisheries Science Center, pers. comm.). Second, the mark-recapture estimate included photographic data from a broader seasonal time period~~,~~ and, therefore, includes transient killer whales documented in the False Pass/Unimak Island area in spring where they aggregate to prey on gray whales on migration (Matkin et al. 2007). Many of these whales have not been seen in that region in the summer. However, mark recapture estimates do not include most of the Bering Sea and Pribilof Islands.

It should be noted that the photographic catalogue encompasses a larger area, including some data from areas such as the Bering Sea and Pribilof Islands that were outside the line-transect survey area. The photo catalogue also encompasses a much longer time period (through 2012). Additionally, the number of whales in the photographic catalogue is a documentation of all whales seen in the area over the time period of the catalogue; movements of some individual whales have been documented between the line-transect survey area and locations outside the survey area. Accordingly, a larger number of transient killer whales may use the line-transect survey area at some point over the 3 years than would necessarily be found at one time in the survey area in July and August in a particular year.

Minimum Population Estimate

~~The 20th percentile of the line transect survey estimate is 167. The 20th percentile of the mark-recapture estimates of 345 is ~303.~~ A total count of 587 individual whales have been identified in the photograph catalogues from the Gulf of Alaska (Matkin et al. in prep.) and from western Alaska (NGOS/MML 2012). The photograph catalogue estimate of transient killer whales is a direct count of individually identifiable animals. However, the number of catalogued whales does not necessarily represent the number of live animals. Some animals may have died, but whales cannot be presumed dead if not resighted because long periods of time between sightings are common for some transient animals. The catalogue for the western area used data only from 2001-2012, decreasing the potential bias from using whales that may have died prior to the end of the time period. However, given that researchers continue to identify new whales and the entire range has not been surveyed, the estimate of abundance based on the number of uniquely identified individuals catalogued is likely conservative.~~ The catalogue count is slightly higher than the 20 th percentile of the mark-recapture estimates, in part because it included data from areas such as Prince William Sound and the Bering Sea that were outside the survey area.~~

Thus, the minimum population estimate (N_{MIN}) for the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock of killer whales is 587 animals based on the count of individuals using photo-identification.

Current Population Trend

~~Recently~~ Matkin et al. (2012) analyzed photographic data collected since 1984 and determined Gulf of Alaska transients in the northern Gulf of Alaska have had stable numbers. At present, reliable data on trends in population abundance for the Aleutian Islands and Bering Sea portion of this stock of killer whales are not ~~un~~available.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is ~~currently~~not ~~un~~available for ~~this~~the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock of killer whales.~~ Studies of resident killer whale pods in the Pacific Northwest resulted in estimated population growth rates of 2.92% and 2.54% over the period from 1973 to 1987 (Olesiuk et al. 1990, Brault and Caswell 1993).~~ Between 2012 and 2018, Towers et al. (2019) observed a mean annual growth rate of 4.1% for a population subset of transient killer whales in Canadian coastal waters, which was higher than the mean annual growth rate of 2.7% documented by Ford et al. (2013) between 2006 and 2011 for a sub-population of inner-coast transient killer whales that contained most of the same individuals. However, ~~U~~until ~~stock-specific~~additional data become available for the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock of killer whales, ~~it is recommended that~~ the default cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% will be ~~employed~~used for this stock (~~Wade and Angliss 1997~~NMFS 2016).

POTENTIAL BIOLOGICAL REMOVAL

~~Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the p~~Potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR ~~=~~is $N_{MIN} \times 0.5R_{Max} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for cetacean stocks with unknown population status~~ with a mortality rate CV ≥ 0.80~~ (~~Wade and Angliss 1997~~NMFS 2016). Thus, for the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient killer whale stock, PBR ~~=~~is ~~5.87~~5.9 animals (587 × 0.02 × 0.5). Although only a few individuals have been observed in Canadian waters, the proportion of time that this trans-boundary stock spends in Canadian waters cannot be determined (G. Ellis, Pacific Biological Station, Canada, pers. comm.).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals between 2014 and 2018 is listed, by marine mammal stock, in Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. The minimum estimated mean annual level of human-caused mortality and serious injury for Gulf of Alaska, Aleutian Islands, and Bering Sea Transient killer whales between 2014 and 2018 is 0.8 killer whales in U.S. commercial fisheries. Potential threats most likely to result in direct human-caused mortality or serious injury of this stock include oil spills, vessel strikes, and interactions with fisheries.

Fisheries Information

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals between 2014 and 2018 is listed, by marine mammal stock, in Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports.

~~Detailed i~~Information ~~on~~for federally-managed and state-managed U.S. commercial fisheries in Alaska waters ~~(including observer programs, observer coverage, and observed incidental takes of marine mammals)~~ is

~~presented~~available in Appendi~~ces~~x 3~~-6~~ of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

~~Three~~Two of the federally-regulated U.S. commercial fisheries, monitored for incidental mortality and serious injury of marine mammals by fishery observers, incurred serious injury and mortality of killer whales ~~(~~of unknown stock~~)~~ ~~in 2010-2014~~between 2014 and 2018: the Bering Sea/Aleutian Islands flatfish trawl~~, Bering Sea/Aleutian Islands rockfish trawl,~~ and Bering Sea/Aleutian Islands ~~Pacific cod~~Greenland turbot longline fisheries (Table 1; Breiwick 2013; MML, unpubl. data).

Fishery observers have collected tissue samples from many of the killer whales that were killed incidental to U.S. commercial fisheries. Genetic analyses of samples from seven killer whales collected between 1999 and 2004 have confirmed that Alaska Resident killer whale mortality occurred incidental to the Bering Sea/Aleutian Islands flatfish trawl (n = 3) and Bering Sea/Aleutian Islands Pacific cod longline fisheries (n = 1) and that Gulf of Alaska, Aleutian Islands, and Bering Sea Transient killer whale mortality occurred incidental to the Bering Sea/Aleutian Islands pollock trawl fishery (n = 3) (M. Dahlheim, NMFS-AFSC-MML (retired), pers. comm., 20 February 2013). Given the overlap in the range of transient and resident stocks in Alaska waters, unless genetic samples can be collected from animals injured or killed by gear or the ship's propeller, these events are assigned to both the transient and resident stock occurring in that area. Thus, the estimated mean annual mortality and serious injury rate of ~~one~~0.6 killer whales ~~in 2010-2014~~between 2014 and 2018 will be assigned to both the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient and ~~the~~ Alaska Resident stocks of killer whales (Table 1).

Typically, if mortality or serious injury occurs incidental to U.S. commercial fishing, it is due to interactions with the fishing gear. However, reports indicate that observed killer whale mortality incidental to Bering Sea/Aleutian Islands trawl fisheries often occurs due to contact with the ship's propeller (e.g., the ~~2010~~2016 mortality in the Bering Sea/Aleutian Islands ~~rockfish~~flatfish trawl fishery).

Table 1. Summary of incidental mortality and serious injury of Gulf of Alaska, Aleutian Islands, and Bering Sea Transient killer whales due to U.S. commercial fisheries ~~in 2010-2014~~between 2014 and 2018 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix ~~6~~3 of the Alaska Stock Assessment Reports. N/A indicates that data are not available.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality (CV)	Mean estimated annual mortality
Bering Sea/Aleutian Is. flatfish trawl[a]	~~2010~~ ~~2011~~ ~~2012~~ ~~2013~~ 2014 2015 2016 2017 2018	obs data	~~99~~ ~~100~~ ~~99~~ ~~99~~ ~~99~~100 100 99 100 100	~~0~~ ~~0~~ ~~0 (+1)[a]~~ ~~2~~ 0 0 1 0 1	~~0~~ ~~0~~ ~~0 (+1)[b]~~ ~~2~~ 0 0 1 (0.05) 0 1 (0.05)	0.4 ~~(+0.2)[c]~~ (CV = 0.03)
Bering Sea/Aleutian Is. Greenland turbot longline[a]	2014 2015 2016 2017 2018	obs data	56 52 60 56 62	0 0 (+1)[b] 0 0 0	0 0 (+1)[c] 0 0 0	0 (+0.2)[d] (CV = N/A)
~~Bering Sea/Aleutian Is. rockfish trawl~~	~~2010~~ ~~2011~~ ~~2012~~ ~~2013~~ ~~2014~~	~~obs data~~	~~99~~ ~~99~~ ~~100~~ ~~99~~ ~~99~~	~~1~~ ~~0~~ ~~0~~ ~~0~~ ~~0~~	~~1~~ ~~0~~ ~~0~~ ~~0~~ ~~0~~	~~0.2~~ ~~(CV = 0)~~

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality (CV)	Mean estimated annual mortality
~~Bering Sea/Aleutian Is. Pacific cod longline~~	~~2010~~ ~~2011~~ ~~2012~~ ~~2013~~ ~~2014~~	~~obs data~~	~~64~~ ~~57~~ ~~51~~ ~~66~~ ~~64~~	~~0~~ ~~0~~ ~~0 (+1)[d]~~ ~~0~~ ~~0~~	~~0~~ ~~0~~ ~~0 (+1)[e]~~ ~~0~~ ~~0~~	~~0 (+0.2)[f]~~ ~~(CV = N/A)~~
Minimum total estimated annual mortality						~~1~~0.6 (CV = 0.03)

[a]Mortality and serious injury in this fishery was assigned to both the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient and Alaska Resident stocks of killer whales, since stock is unknown and the two stocks occur within the area of operation of the fishery.
[~~a~~b]Total mortality and serious injury observed in ~~2012~~2015: 0 whales in sampled hauls + 1 whale in an unsampled haul.
[~~b~~c]Total estimate of mortality and serious injury in ~~2012~~2015: 0 whales (extrapolated estimate from 0 whales observed in sampled hauls) + 1 whale (1 whale observed in an unsampled haul).
[~~c~~d]Mean annual mortality and serious injury for fishery: ~~0.4~~0 whales (mean of extrapolated estimates from sampled hauls) + 0.2 whales (mean of number observed in unsampled hauls).
~~[d]Total mortality and serious injury observed in 2012: 0 whales in sampled hauls + 1 whale in an unsampled haul.~~
~~[e]Total estimate of mortality and serious injury in 2012: 0 whales (extrapolated estimate from 0 whales observed in sampled hauls) + 1 whale (1 whale observed in an unsampled haul).~~
~~[f]Mean annual mortality and serious injury for fishery: 0 whales (mean of extrapolated estimates from sampled hauls) + 0.2 whales (mean of number observed in unsampled hauls).~~

Reports to NMFS Region marine mammal stranding networks of killer whales entangled in fishing gear or with injuries caused by interactions with gear are another source of mortality and serious injury data. A killer whale mortality in commercial California Dungeness crab pot gear in 2015 reported to the NMFS West Coast Region stranding network was genetically identified as a transient ecotype. Because the whale could not be assigned to a specific stock, the mean annual mortality and serious injury rate of 0.2 killer whales in this fishery between 2014 and 2018 was assigned to the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient and West Coast Transient killer whale stocks; it was not assigned to the AT1 Transient killer whale stock because none of the whales in this population are missing (Table 2; Young et al. in press).

Table 2. Summary of mortality and serious injury of Gulf of Alaska, Aleutian Islands, and Bering Sea Transient killer whales, by year and type, reported to the NMFS West Coast Region marine mammal stranding network between 2014 and 2018 (Young et al. in press).

Cause of Injury	**2014**	**2015**	**2016**	**2017**	**2018**	**Mean annual mortality**
Entangled in commercial CA Dungeness crab pot gear	0	1[a]	0	0	0	0.2
Total in commercial fisheries						0.2

[a]This whale was genetically identified as a transient ecotype but could not be assigned to a specific stock; therefore, the mortality was assigned to the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient and West Coast Transient killer whale stocks.

A minimum estimate of the mean annual mortality and serious injury rate incidental to U.S. commercial fisheries ~~in 2010-2014~~between 2014 and 2018 is ~~one~~0.8 Gulf of Alaska, Aleutian Islands, and Bering Sea Transient killer whales, based on observer data (0.6) and stranding data (0.2) (Tables 1 and 2).

Alaska Subsistence/Native Harvest Information

~~There~~Killer whales are not ~~reports of a~~harvested for subsistence ~~harvest of killer whales~~ in Alaska ~~or Canada~~.

Other Mortality

Collisions with ~~boats~~vessels ~~may be~~are an occasional source of mortality or serious injury of killer whales. For example, a killer whale struck the propeller of a vessel in the Bering Sea/Aleutian Islands ~~rockfish~~flatfish trawl fishery in ~~2010~~2016 (Table 1; Young et al. in press).

Other Issues

Killer whales are known to depredate longline catches in the Bering Sea (Dahlheim 1988; Yano and Dahlheim 1995; Perez 2003, 2006; Sigler et al. 2003) and in the Gulf of Alaska (Sigler et al. 2003, Perez 2006). In addition, there have been many reports of killer whales consuming the processing waste of Bering Sea groundfish trawl fishing vessels (Perez 2006). More recently, Peterson and Hanselman (2017) estimated that killer whales reduce commercial sablefish fishery catch rates by approximately 45% to 70%. However, resident killer whales are most likely to be involved in such fishery interactions since these whales are known to be fish eaters.

STATUS OF STOCK

The Eastern North Pacific Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock of killer whales is not designated as depleted under the MMPA or listed as threatened or endangered under the Endangered Species Act. Based on currently available data, a minimum estimate of the mean annual mortality and serious injury rate due to U.S. commercial fisheries (10.8 whales) is greater than 10% of the PBR (10% of PBR = 0.6) and, therefore, cannot be considered to be insignificant and approaching a zero mortality and serious injury rate. A minimum estimate of the total annual level of human-caused mortality and serious injury (10.8 whales) is less than the PBR (5.9). Therefore, the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock of killer whales is not classified as a strategic stock. Population trends and status of this stock relative to its Optimum Sustainable Population are currently unknown.

There are key uncertainties in the assessment of the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock of killer whales. The estimate of abundance, based on the number of uniquely identified individuals, is likely conservative because researchers continue to identify new whales and there has not been a comprehensive survey in recent years to allow an updated line-transect or mark-recapture estimate.

CITATIONS

Baird, R. W., and P. J. Stacey. 1988. Variation in saddle patch pigmentation in populations of killer whales (*Orcinus orca*) from British Columbia, Alaska, and Washington State. Can. J. Zool. 66 (11):2582-2585.

Baird, R. W., P. A. Abrams, and L. M. Dill. 1992. Possible indirect interactions between transient and resident killer whales: implications for the evolution of foraging specializations in the genus *Orcinus*. Oecologia 89:125-132.

Barlow, J. 1995. The abundance of cetaceans in California waters. Part I: Ship surveys in summer and fall of 1991. Fish. Bull., U.S. 93:1-14.

Barlow, J. 1997. Preliminary estimates of cetacean abundance off California, Oregon and Washington based on a 1996 ship survey and comparisons of passing and closing modes. Southwest Fisheries Science Center Administrative Report LJ-97-11, 25 p. Available from SWFSC, NMFS, 8901 La Jolla Shores Drive, La Jolla, CA 92037. 25 p.

Barrett-Lennard, L. G. 2000. Population structure and mating patterns of killer whales (*Orcinus orca*) as revealed by DNA analysis. Ph.D. Dissertation, University of British Columbia, Vancouver, BC, Canada. 97 p.

Bigg, M. A., P. F. Olesiuk, G. M. Ellis, J. K. B. Ford, and K. C. Balcomb III. 1990. Social organization and genealogy of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State, p. 386-406. *In* P. S. Hammond, S. A. Mizroch, and G. P. Donovan (eds.), Individual Recognition of Cetaceans: Use of Photo-identification and Other Techniques to Estimate Population Parameters. Rep. Int. Whal. Comm. Special Issue 12.

Black, N. A., A. Schulman-Janiger, R. L. Ternullo, and M. Guerrero-Ruiz. 1997. Killer whales of California and western Mexico: a catalog of photo-identified individuals. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-247, 174 p.

Braham, H. W., and M. E. Dahlheim. 1982. Killer whales in Alaska documented in the Platforms of Opportunity Program. Rep. Int. Whal. Comm. 32:643-646.

~~Brault, S., and H. Caswell. 1993. Pod-specific demography of killer whales (*Orcinus orca*). Ecology 74(5):1444-1454.~~

Breiwick, J. M. 2013. North Pacific marine mammal bycatch estimation methodology and results, 2007-2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-260, 40 p.

Committee on Taxonomy. 20122019. List of marine mammal species and subspecies. Society for Marine Mammalogy,. Available online: www.marinemammalscience.org ., consulted onAccessed 12 December 2012August 2020.

Dahlheim, M. E. 1988. Killer whale (*Orcinus orca*) depredation on longline catches of sablefish (*Anoplopoma fimbria*) in Alaskan waters. NWAFC Processed Rep. 88-14, 31 p. Available online: http://www.afsc.noaa.gov/Publications/ProcRpt/PR%2088-14.pdf . Accessed ~~December 2016~~August 2020.

Dahlheim, M. E., and P. A. White. 2010. Ecological aspects of transient killer whales (*Orcinus orca*) as predators in southeastern Alaska. Wildl. Biol. 16: 308-322.

Dahlheim, M. E., D. Ellifrit, and J. Swenson. 1997. Killer Whales of Southeast Alaska: A Catalogue of Photoidentified Individuals. Day Moon Press, Seattle, WA. 82 p. + appendices.

Dahlheim, M. E., A. Schulman-Janiger, N. Black, R. Ternullo, D. Ellifrit, and K. C. Balcomb. 2008. Eastern temperate North Pacific offshore killer whales (*Orcinus orca*): occurrence, movements, and insights into feeding ecology. Mar. Mammal Sci. 24:719-729.

Durban, J., D. Ellifrit, M. Dahlheim, J. Waite, C. Matkin, L. Barrett-Lennard, G. Ellis, R. Pitman, R. LeDuc, and P. R. Wade. 2010. Photographic mark-recapture analysis of clustered mammal-eating killer whales around the Aleutian Islands and Gulf of Alaska. Mar. Biol. 157:1591-1604.

Ford, J. K. B. 2011. Killer whales of the Pacific Northwest coast: from pest to paragon. Whalewatcher 40(1):15-23.

Ford, J. K. B., and G. M. Ellis. 1999. Transients: Mammal-Hunting Killer Whales of British Columbia, Washington, and Southeastern Alaska. University of British Columbia Press, Vancouver, BC. 96 p.

Ford, J. K. B., and H. D. Fisher. 1982. Killer whale (*Orcinus orca*) dialects as an indicator of stocks in British Columbia. Rep. Int. Whal. Comm. 32:671-679.

Ford, J. K. B., G. M. Ellis, and K. C. Balcomb. 1994. Killer Whales: The Natural History and Genealogy of *Orcinus orca* in British Columbia and Washington State. University of British Columbia Press, Vancouver, BC, and University of Washington Press, Seattle. 102 p.

Ford, J. K. B., G. M. Ellis, and K. C. Balcomb. 2000. Killer Whales: The Natural History and Genealogy of *Orcinus orca* in British Columbia and Washington State. Second edition. University of British Columbia Press, Vancouver, BC, Canada. 104 p.

Ford, J. K. B, E. H. Stredulinsky, J. R. Towers, and G. M. Ellis. 2013. Information in support of the identification of critical habitat for transient killer whales (*Orcinus orca*) off the west coast of Canada. DFO Canadian Science Advisory Secretariat Research Document 2012/nnn.

Forney, K. A., and P. R. Wade. 2006. World-wide abundance and density of killer whales, p. 145-162. *In* J. A. Estes, D. P. DeMaster, D. F. Doak, T. M. Williams, and R. L. Brownell, Jr. (eds.), Whales, Whaling, and Ocean Ecosystems. University of California Press.

Forney, K. A., J. Barlow, and J. V. Carretta. 1995. The abundance of cetaceans in California waters. Part II: Aerial surveys in winter and spring of 1991 and 1992. Fish. Bull., U.S. 93:15-26.

George, J. C., and R. Suydam. 1998. Observations of killer whale (*Orcinus orca*) predation in the northeastern Chukchi and western Beaufort seas. Mar. Mammal Sci. 14:330-332. DOI: dx.doi.org/10.1111/j.1748-7692.1998.tb00722.x .

Goley, P. D., and J. M. Straley. 1994. Attack on gray whales (*Eschrichtius robustus*) in Monterey Bay, California, by killer whales (*Orcinus orca*) previously identified in Glacier Bay, Alaska. Can. J. Zool. 72:1528-1530.

Green, G. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnell, and K. C. Balcomb. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990, p. 1-100. *In* J. J. Brueggeman (ed.), Oregon and Washington marine mammal and seabird surveys. Final Report OCS Study MMS 91-0093.

Hoelzel, A. R., and G. A. Dover. 1991. Genetic differentiation between sympatric killer whale populations. Heredity 66:191-195.

Hoelzel, A. R., M. E. Dahlheim, and S. J. Stern. 1998. Low genetic variation among killer whales (*Orcinus orca*) in the eastern North Pacific, and genetic differentiation between foraging specialists. J. Hered. 89:121-128.

Hoelzel, A. R., A. Natoli, M. Dahlheim, C. Olavarria, R. Baird, and N. Black. 2002. Low worldwide genetic diversity in the killer whale (*Orcinus orca*): implications for demographic history. Proc. R. Soc. Lond. 269:1467-1473.

Leatherwood, J. S., and M. E. Dahlheim. 1978. Worldwide distribution of pilot whales and killer whales. Naval Ocean Systems Center, Tech. Rep. 443:1-39.

Leatherwood, S., C. O. Matkin, J. D. Hall, and G. M. Ellis. 1990. Killer whales, *Orcinus orca*, photo-identified in Prince William Sound, Alaska 1976 to 1987. Can. Field Nat. 104:362-371.

Matkin, C., G. Ellis, E. Saulitis, L. Barrett-Lennard, and D. Matkin. 1999. Killer Whales of Southern Alaska. North Gulf Oceanic Society. 96 p.

Matkin, C. O., L. G. Barrett-Lennard, H. Yurk, D. Ellifrit, and A. W. Trites. 2007. Ecotypic variation and predatory behavior among killer whales (*Orcinus orca*) off the eastern Aleutian Islands, Alaska. Fish. Bull., U.S. 105:74-87.

Matkin, C. O., J. W. Durban, E. L. Saulitis, R. D. Andrews, J. M. Straley, D. R. Matkin, and G. M. Ellis. 2012. Contrasting abundance and residency patterns of two sympatric populations of transient killer whales (*Orcinus orca*) in the northern Gulf of Alaska. Fish. Bull., U.S. 110:143-155.

Matkin, C. O., G. M. Ellis, E. L. Saulitis, and R. D. Andrews. In prep. Monitoring, tagging, feeding habits, and restoration of killer whales in Prince William Sound/Kenai Fjords 2010-2012. Final Report to the EVOS Trustee Council, North Gulf Oceanic Society, Homer, Alaska.

Mitchell, E. D. 1975. Report on the meeting on small cetaceans, Montreal, April 1-11, 1974. J. Fish. Res. Board Can. 32:914-916.

Morin, P. A., F. I. Archer, A. D. Foote, J. Vilstrup, E. E. Allen, P. R. Wade, J. W. Durban, K. M. Parsons, R. Pitman, L. Li, P. Bouffard, S. C. Abel Nielsen, M. Rasmussen, E. Willerslev, M. T. P. Gilbert, and T. Harkins. 2010. Complete mitochondrial genome phylogeographic analysis of killer whales (*Orcinus orca*) indicates multiple species. Genome Res. 20:908-916.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed August 2020.

North Gulf Oceanic Society/Marine Mammal Laboratory (NGOS/MML). 2012. A working catalogue of western transients in Alaska. North Gulf Oceanic Society, Homer, Alaska, and Marine Mammal Laboratory/NOAA, Seattle, WA. Available electronically by request.

~~Olesiuk, P. F., M. A. Bigg, and G. M. Ellis. 1990. Life history and population dynamics of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Rep. Int. Whal. Comm. (Special Issue 12):209-242.~~

Parsons, K. M, J. W. Durban, A. M. Burdin, V. N. Burkanov, R. L. Pitman, J. Barlow, L. G. Barrett-Lennard, R. G. LeDuc, K. M. Robertson, C. O. Matkin, and P. R. Wade. 2013. Geographic patterns of genetic differentiation among killer whales in the northern North Pacific. J. Hered. 104:737-754.

Perez, M. A. 2003. Compilation of marine mammal-fisheries interaction data from the domestic and joint venture groundfish fisheries in the U.S. EEZ of the North Pacific, 1989-2001. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-138, 145 p.

Perez, M. A. 2006. Analysis of marine mammal bycatch data from the trawl, longline, and pot groundfish fisheries of Alaska, 1998-2004, defined by geographic area, gear type, and target groundfish catch species. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-167, 194 p.

Peterson, M. J., and D. Hanselman. 2017. Sablefish mortality associated with whale depredation in Alaska. ICES J. Mar. Sci. 74(5):1382-1394. DOI: dx.doi.org/10.1093/icesjms/fsw239 .

Riesch, R., L. G. Barrett-Lennard, G. M. Ellis, J. K. B. Ford, and V. B. Deecke. 2012. Cultural traditions and the evolution of reproductive isolation: ecological speciation in killer whales? Biol. J. Linn. Soc. 106:1-17.

~~Saulitis, E. L. 1993. The behavior and vocalizations of the "AT" group of killer whales (*Orcinus orca*) in Prince William Sound, Alaska. MS Thesis, University of Alaska, Fairbanks.~~

Saulitis, E., C. O. Matkin, and F. H. Fay. 2005. Vocal repertoire and acoustic behavior of the isolated AT1 killer whale subpopulation in southern Alaska. Can. J. Zool. 83:1015-1029.

Sigler, M. F., C. R. Lunsford, J. T. Fujioka, and S. A. Lowe. 2003. Alaska sablefish assessment for 2004. *In* Stock assessment and fishery evaluation report for the groundfish fisheries of the Bering Sea/Aleutian Islands regions. North Pacific Fishery Management Council, Anchorage, AK, Section 3:223-292.

Towers, J. R., G. J. Sutton, T. J. H. Shaw, M. Malleson, D. Matkin, B. Gisborne, J. Forde, D. Ellifrit, G. M. Ellis, J. K. B. Ford, and T. Doniol-Valcroze. 2019. Photo-identification catalogue, population status, and distribution of Bigg's killer whales known from coastal waters of British Columbia, Canada. Can. Tech. Rep. Fish. Aquat. Sci. 3311:vi + 299 p.

~~Wade, P. R., and R. Angliss. 1997. Guidelines for assessing marine mammal stocks: report of the GAMMS Workshop April 3-5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12, 93 p.~~

Yano, K., and M. E. Dahlheim. 1995. Killer whale, *Orcinus orca*, depredation on longline catches of bottomfish in the southeastern Bering Sea and adjacent waters. Fish. Bull., U.S. 93:355-372.

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX.

Zerbini, A. N., J. M. Waite, J. Durban, R. LeDuc, M. E. Dahlheim, and P. R. Wade. 2007. Estimating abundance of killer whales in the nearshore waters of the Gulf of Alaska and Aleutian Islands using line-transect sampling. Mar. Biol. 150(5):1033-1045.

KILLER WHALE (*Orcinus orca*): AT1 Transient Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Killer whales have been observed in all oceans and seas of the world (Leatherwood and Dahlheim 1978). Although reported from tropical and offshore waters, killer whales occur at higher densities in colder and more productive waters of both hemispheres, with the greatest densities found at high latitudes (Mitchell 1975, Leatherwood and Dahlheim 1978, Forney and Wade 2006). Killer whales are found throughout the North Pacific Ocean. Along the west coast of North America, seasonal and year-round occurrence of killer whales has been noted along the entire Alaska coast (Braham and Dahlheim 1982), in British Columbia and Washington inland waterways (Bigg et al. 1990), and along the outer coasts of Washington, Oregon, and California (Green et al. 1992; Barlow 1995, 1997; Forney et al. 1995). Killer whales from these areas have been labeled as "resident," "transient," and "offshore" type killer whales (Bigg et al. 1990, Ford et al. 2000, Dahlheim et al. 2008) based on aspects of morphology, ecology, genetics, and behavior (Ford and Fisher 1982; Baird and Stacey 1988; Baird et al. 1992; Hoelzel et al. 1998, 2002; Barrett-Lennard 2000; Dahlheim et al. 2008). Through examination of photographs of recognizable individuals and pods, movements of whales between geographical areas have been documented. For example, whales identified in Prince William Sound have been observed near Kodiak Island (Matkin et al. 1999) and whales identified in Southeast Alaska have been observed in Prince William Sound, British Columbia, and Puget Sound (Leatherwood et al. 1990, Dahlheim et al. 1997). Movements of killer whales between the waters of Southeast Alaska and central California have also been documented (Goley and Straley 1994, Black et al. 1997, Dahlheim and White 2010).

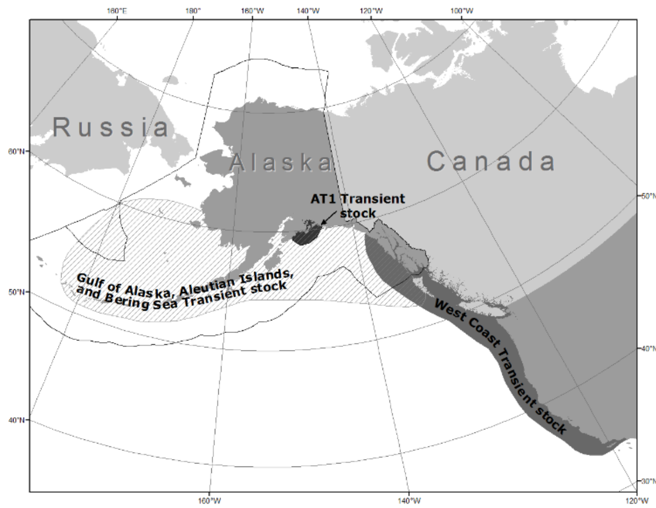

Figure 1. Approximate distribution of transient killer whales in the eastern North Pacific (shaded areas). The distribution of resident and transient killer whale stocks in the eastern North Pacific largely overlap (see text). The U.S. Exclusive Economic Zone is delineated by a black line.

Several studies provide evidence that the resident, offshore, and transient ecotypes are genetically distinct in both mtDNA and nuclear DNA (Hoelzel and Dover 1991; Hoelzel et al. 1998, 2002; Barrett-Lennard 2000). Genetic differences have also been found between populations within the transient and resident ecotypes (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000). A global genetic study of killer whales using the entire mitochondrial genome found that some killer whale ecotypes represent deeply divergent evolutionary lineages and warrant elevation to species or subspecies status (Morin et al. 2010). In particular, estimates from mitogenome sequence data indicate that transient killer whales diverged from all other killer whale lineages ~~~~~approximately 700,000 years ago. In light of these differences, the Society for Marine Mammalogy's Committee on Taxonomy currently recognizes the resident and transient North Pacific ecotypes as un-named *Orcinus orca* subspecies (Committee on Taxonomy ~~2018~~2019). In recognition of its status as an un-named subspecies or species, some researchers now refer to transient-type killer whales as Bigg's killer whales (e.g., Ford 2011, Riesch et al. 2012), in tribute to the late Dr. Michael Bigg.

The first studies of transient killer whales in Alaska were conducted in Southeast Alaska and in the Gulf of Alaska (from Prince William Sound, through the Kenai Fjords, and around Kodiak Island). In the Gulf of Alaska, Matkin et al. (1999) described two genetically distinct populations of transients which were never found in association with one another, the so-called "Gulf of Alaska" transients and "AT1" transients. In the past, neither of these populations were known to associate with the population of transient killer whales that ranged from California to Southeast Alaska, which are described as the West Coast Transient stock. Gulf of Alaska transients are documented throughout the Gulf of Alaska, including occasional sightings in Prince William Sound. AT1 transients have been seen only in Prince William Sound and in the Kenai Fjords region, and are therefore partially sympatric with Gulf of Alaska transients. In addition, 14 out of 217 transients on the outer coast of Southeast Alaska and British Columbia were identified as Gulf of Alaska transients and in one encounter they were observed mixing with West Coast ~~T~~transients (Matkin et al. 2012, Ford et al. 2013). Transients within the Gulf of Alaska population have been found to have two mtDNA haplotypes, neither of which is found in the West Coast or AT1 populations. Members of the AT1 population share a single mtDNA haplotype. Transient killer whales from the West Coast population have been found to share a single mtDNA haplotype that is not found in the other populations. Additionally, all three populations have been found to have significant differences in nuclear (microsatellite) DNA (Barrett-Lennard 2000). Acoustic differences have been found as well; Saulitis et al. (2005) described acoustic differences between Gulf of Alaska transients and AT1 transients. For these reasons, the Gulf of Alaska transients are considered part of a population that is discrete from the AT1 population, and both of these populations are considered discrete from the West Coast ~~T~~transients.

Transient-type killer whales from the Aleutian Islands and Bering Sea are currently considered to be part of a single population that includes Gulf of Alaska transients; however, recent genetic analyses suggest substructure within the region. Biopsy samples from the eastern Aleutians and the south side of the west end of the Alaska Peninsula have produced the same haplotypes as killer whales in the northern Gulf of Alaska; however, nuclear DNA analysis strongly suggests they belong to a separate population (Parsons et al. 2013). The geographic distribution of mtDNA haplotypes revealed samples from the central Aleutian Islands and Bering Sea with haplotypes not found in Gulf of Alaska transients, suggesting additional population structure in western Alaska. ~~Transient-type killer whales from the Aleutian Islands and Bering Sea are considered to be part of a single population that includes Gulf of Alaska transients.~~ Killer whales observed in the northern Bering Sea and north and east to the western Beaufort Sea have characteristics of transient-type whales, but little is known about these whales (Braham and Dahlheim 1982, George and Suydam 1998). AT1 haplotype whales are also present west of the Aleutian Islands and into the Bering Sea; however, nuclear DNA analysis indicates these animals are not part of the AT1 transient population in the Gulf of Alaska (Parsons et al. 2013).

In summary, within the transient ecotype, association data (Ford et al. 1994, Ford and Ellis 1999, Matkin et al. 1999), acoustic data (Ford and Ellis 1999, Saulitis et al. 2005), and genetic data (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000) confirm that at least three communities of transient whales exist and represent three discrete populations: 1) Gulf of Alaska, Aleutian Islands, and Bering Sea transients, 2) AT1 transients, and 3) West Coast transients.

Based on data regarding association patterns, acoustics, movements, and genetic differences, eight killer whale stocks are now recognized within the Pacific U.S. Exclusive Economic Zone: 1) the Alaska Resident stock - occurring from Southeast Alaska to the Aleutian Islands and Bering Sea, 2) the Northern Resident stock - occurring from Washington State through part of Southeast Alaska, 3) the Southern Resident stock - occurring mainly within the inland waters of Washington State and southern British Columbia, but also in coastal waters from Southeast Alaska through California, 4) the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock - occurring mainly from Prince William Sound through the Aleutian Islands and Bering Sea, 5) the AT1 Transient stock - occurring in Alaska from Prince William Sound through the Kenai Fjords (Fig. 1), 6) the West Coast Transient stock - occurring from California through Southeast Alaska, 7) the Offshore stock - occurring from California through Alaska, and 8) the Hawaiian stock. Transient killer whales in Canadian waters are considered part of the West Coast Transient stock. The Hawaiian and Offshore stocks are reported in the Stock Assessment Reports for the U.S. Pacific Region.

AT1 killer whales were first identified as a separate, cohesive group in 1984, when 22 transient-type whales were documented in Prince William Sound (Leatherwood et al. 1984, Heise et al. 1991), although individual whales from the group had been photographed as early as 1978 (von Ziegesar et al. 1986). Once the North Gulf Oceanic Society (NGOS) began consistent annual research effort in Prince William Sound, AT1 killer whales were resighted frequently. In fact, AT1 killer whales were found to be some of the most frequently sighted killer whales in Prince William Sound (Matkin et al. 1993, 1994, 1999). Gulf of Alaska transients are seen less frequently in Prince William Sound, with periods of several years or more between resightings.

AT1 killer whales have never been seen in association with sympatric resident killer whale pods or with Gulf of Alaska transients (Matkin et al. 1999, 2012) and appear to have a more limited range than other transients. Their approximately 200-mile known range includes only Prince William Sound and Kenai Fjords and adjacent offshore waters (Matkin et al. 1999, 2012).

POPULATION SIZE

Using photographic-identification, all 22 individuals in the AT1 Transient population were censused for the first time in 1984 (Leatherwood et al. 1984). All 22 AT1 killer whales were seen annually or biannually from 1984 to 1988 (Matkin et al. 1999, 2003). The *Exxon Valdez* oil spill occurred in spring of 1989. Nine individuals from the AT1 group have been missing since 1990 (last seen in 1989), and two have been missing since 1992 (last seen in 1990 and 1991). Three of the missing AT1 killer whales (AT5, AT7, and AT8) were seen near the leaking *Exxon Valdez* shortly after the spill (Matkin et al. 1993, 1994, 2008). Two whales were found dead, stranded in 1989 and 1990, both genetically assigned to the AT1 population and one visually recognized as AT19, one of the missing nine whales (Matkin et al. 1994, 2008; Heise et al. 2003). The second unidentified whale was most likely one of the other missing AT1 whales. Additional mortalities of four older males include whales AT1 found stranded in 2000, AT13 and AT17 missing in 2002 (one of which was thought to be the carcass from the AT1 population that was found in 2002), and AT14 missing in 2003. A stranded whale found in 2003, genetically assigned to the AT1 population, was probably AT14 but could also have been AT13 (Matkin et al. 2008). No births have occurred in this population since 1984 and none of the missing whales have been seen since 2003 and are presumed dead. There is an extremely small probability (0.4%) that AT1 killer whales that are missing for 3 years or more are still alive (Matkin et al. 2008). No AT1 killer whale missing for at least 4 years has ever been resighted, and all 15 missing whales are presumed dead (Matkin et al. 2008). In ~~2018~~2019, photographs of the seven remaining AT1 killer whales were confirmed by researchers from the NGOS (http://www.whalesalaska.org, accessed ~~June 2019~~August 2020); birth year is estimated for whales born before 1983, as described in Matkin et al. (1999): AT2 (female, born ≤1969), AT3 (male, born 1984), AT4 (female, born ≤1974), AT6 (male, born 1976), AT9 (female, born ≤1965), AT10 (male, born 1980), and AT18 (female, born ≤1974). Therefore, the population estimate as of the summer of ~~2018~~2019 remains at seven whales (NGOS; C. Matkin, NGOS, pers. comm., ~~30 October 2018~~17 October 2019). There has been no recruitment in this population since 1984 (Matkin et al. 2012).

Minimum Population Estimate

The abundance estimate of killer whales is a direct count of individually identifiable animals. Only 11 whales were seen between 1990 and 1999. Since then, four of those whales have not been seen for four or more consecutive years, so the minimum population estimate (N_{MIN}) is seven whales (Matkin et al. 2008; NGOS; C. Matkin, NGOS, pers. comm., ~~30 October 2018~~17 October 2019). Fourteen years of annual effort have failed to discover any whales that had not been seen previously, so there is no reason to believe there are additional whales in the population. Therefore, this N_{MIN} is the total population size.

Current Population Trend

The population counts have declined from a level of 22 whales in 1989 to the 7 whales that have been resighted since 2003, a decline of 68%. Most of the mortality apparently occurred in 1989 and 1990.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is not ~~un~~available for ~~this~~the AT1 Transient stock of killer whales.~~ Studies of resident killer whale pods in the Pacific Northwest resulted in estimated population growth rates of 2.9% and 2.5% over the period from 1973 to 1987 (Olesiuk et al. 1990, Brault and Caswell 1993).~~ Between 2012 and 2018, Towers et al. (2019) observed a mean annual growth rate of 4.1% for a population subset of transient killer whales in Canadian coastal waters, which was higher than the mean annual growth rate of 2.7% documented by Ford et al. (2013) between 2006 and 2011 for a subpopulation of inner-coast transient killer whales that contained most of the same individuals. The current net productivity rate for ~~this~~the AT1 Transient stock of killer whales is 0, given that there has been no recruitment into the stock since 1984. Until additional stock-specific data become available, the default cetacean maximum theoretical net productivity rate of 4% will be used for this stock (NMFS 2016).

POTENTIAL BIOLOGICAL REMOVAL

Potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.1, as the stock is considered depleted under the Marine Mammal Protection Act (MMPA) and there has been no recruitment into the stock since 1984. Thus, for the AT1 Transient killer whale stock, PBR ~~=~~is 0.01 whales (7 × 0.02 × 0.1).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals between ~~2013~~2014 and ~~2017~~2018 is listed, by marine mammal stock, in ~~Delean et al. (2020)~~Young et al. (in press); however, only the mortality and serious injury data are included in the Stock

Assessment Reports. No human-caused mortality or serious injury of AT1 Transient killer whales was reported between ~~2013~~2014 and ~~2017~~2018. Potential threats most likely to result in direct human-caused mortality or serious injury of this stock include ship strikes and oil spills (most of the mortality in this stock occurred in 1989 and 1990, following the *Exxon Valdez* oil spill).

Fisheries Information

Information ~~on~~for federally-managed and state-managed U.S. commercial fisheries in Alaska waters ~~(including observer programs, observer coverage, and observed incidental takes of marine mammals)~~ is ~~presented~~available in Appendi~~ces~~x 3~~-6~~ of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

The known range of the AT1 Transient stock is limited to waters of Prince William Sound and Kenai Fjords. There are no federally-managed commercial fisheries in this area. Incidental mortality or serious injury of AT1 killer whales has not been reported in state-managed commercial fisheries which operate within the range of this stock, such as the Prince William Sound salmon set and drift gillnet fisheries and various herring fisheries, or in several subsistence fisheries (salmon, halibut, non-salmon finfish, and shellfish) which also occur within this area; however, the state-managed fisheries are not observed or have not been observed in a long time. Transient killer whales have entangled in pot fishery gear in other areas (~~Delean et al. 2020~~Young et al. in press) and entanglement in this type of gear may be a risk for the AT1 Transient stock of killer whales.

Alaska Native Subsistence/Harvest Information

~~There are no reports of a~~Killer whales are not harvested for subsistence ~~harvest of killer whales~~ in Alaska ~~or Canada~~.

Other Mortality

Collisions with vessels ~~may be~~are an occasional source of mortality or serious injury of killer whales. For example, a killer whale struck the propeller of a vessel in the Bering Sea/Aleutian Islands ~~rockfish~~flatfish trawl fishery in ~~2010~~2016 (Young et al. in press); however, this mortality did not involve a whale from the AT1 Transient stock. There has been no known mortality or serious injury of AT1 killer whales due to ~~ship strikes~~vessel collisions. Most of the mortality occurred from 1989 to 1990 following the *Exxon Valdez* oil spill.

STATUS OF STOCK

The AT1 Transient stock of killer whales is below its Optimum Sustainable Population (OSP) and designated as depleted under the MMPA (69 FR 31321, 3 June 2004); therefore, it is classified as a strategic stock. The AT1 Transient stock is not listed as threatened or endangered under the Endangered Species Act. Based on currently available data, the minimum estimated mean annual mortality and serious injury rate due to U.S. commercial fisheries (0) does not exceed 10% of the PBR (10% of PBR = 0.001) and, therefore, can be considered insignificant and approaching a zero mortality and serious injury rate. At least 11 animals were alive in 1998, but it appears that only 7 individuals remain alive. The AT1 killer whale group has been reduced to 32% (7/22) of its 1984 level. Since no births have occurred in the past 30 years, it is unlikely that this stock will recover.

There are few uncertainties in the assessment of the AT1 Transient stock of killer whales. Individual whales can be counted annually and the stock has been declining slowly since a dramatic reduction in the stock occurred immediately after the *Exxon Valdez* oil spill. PBR is designed to allow stocks to recover to, or remain above, the maximum net productivity level (MNPL) (Wade 1998). An underlying assumption in the application of the PBR equation is that marine mammal stocks exhibit certain dynamics. Specifically, it is assumed that a depleted stock will naturally grow toward OSP and that some surplus growth could be removed while still allowing recovery. However, the AT1 Transient killer whale population is at a very small population size, and small populations can have different dynamics than larger populations from Allee effects and stochastic dynamics. Although there is currently no known direct human-caused mortality or serious injury, given the small number of animals in the population, any human-caused mortality or serious injury is likely to have a serious population-level impact.

CITATIONS

Baird, R. W., and P. J. Stacey. 1988. Variation in saddle patch pigmentation in populations of killer whales (*Orcinus orca*) from British Columbia, Alaska, and Washington State. Can. J. Zool. 66(11):2582-2585.

Baird, R. W., P. A. Abrams, and L. M. Dill. 1992. Possible indirect interactions between transient and resident killer whales: implications for the evolution of foraging specializations in the genus *Orcinus*. Oecologia 89:125-132.

Barlow, J. 1995. The abundance of cetaceans in California waters. Part I: Ship surveys in summer and fall of 1991. Fish. Bull., U.S. 93:1-14.

Barlow, J. 1997. Preliminary estimates of cetacean abundance off California, Oregon and Washington based on a 1996 ship survey and comparisons of passing and closing modes. Southwest Fisheries Science Center Administrative Report LJ-97-11,~~.~~ 25 p. Available from SWFSC, NMFS, 8901 La Jolla Shores Drive, La Jolla, CA 92037.

Barrett-Lennard, L. G. 2000. Population structure and mating patterns of killer whales as revealed by DNA analysis. Ph.D. Dissertation, University of British Columbia, Vancouver, BC, Canada. 97 p.

Bigg, M. A., P. F. Olesiuk, G. M. Ellis, J. K. B. Ford, and K. C. Balcomb III. 1990. Social organization and genealogy of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State, p. 386-406. *In* P. S. Hammond, S. A. Mizroch, and G. P. Donovan (eds.), Individual Recognition of Cetaceans: Use of Photo-identification and Other Techniques to Estimate Population Parameters. Rep. Int. Whal. Comm. Special Issue 12.

Black, N. A., A. Schulman-Janiger, R. L. Ternullo, and M. Guerrero-Ruiz. 1997. Killer whales of California and western Mexico: a catalog of photo-identified individuals. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-247, 174 p.

Braham, H. W., and M. E. Dahlheim. 1982. Killer whales in Alaska documented in the Platforms of Opportunity Program. Rep. Int. Whal. Comm. 32:643-646.

~~Brault, S., and H. Caswell. 1993. Pod-specific demography of killer whales (*Orcinus orca*). Ecology 74(5):1444-1454.~~

Committee on Taxonomy. ~~2018~~2019. List of marine mammal species and subspecies. Society for Marine Mammalogy. Available online: www.marinemammalscience.org . Accessed ~~December 2019~~August 2020.

Dahlheim, M. E., and P. A. White. 2010. Ecological aspects of transient killer whales (*Orcinus orca*) as predators in southeastern Alaska. Wildl. Biol. 16:308-322.

Dahlheim, M. E., D. Ellifrit, and J. Swenson. 1997. Killer Whales of Southeast Alaska: A Catalogue of Photoidentified Individuals. Day Moon Press, Seattle, WA. 82 p. + appendices.

Dahlheim, M. E., A. Schulman-Janiger, N. Black, R. Ternullo, D. Ellifrit, and K. C. Balcomb. 2008. Eastern temperate North Pacific offshore killer whales (*Orcinus orca*): occurrence, movements, and insights into feeding ecology. Mar. Mammal Sci. 24(3):719-729.

~~Delean, B. J., V. T. Helker, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, J. Jannot, and N. C. Young. 2020. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2013-2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-401, 86 p.~~

Ford, J. K. B. 2011. Killer whales of the Pacific Northwest coast: from pest to paragon. Whale Watcher 40(1):15-23.

Ford, J. K. B., and G. M. Ellis. 1999. Transients: Mammal-Hunting Killer Whales of British Columbia, Washington, and Southeastern Alaska. University of British Columbia Press, Vancouver, BC. 96 p.

Ford, J. K. B., and H. D. Fisher. 1982. Killer whale (*Orcinus orca*) dialects as an indicator of stocks in British Columbia. Rep. Int. Whal. Comm. 32:671-679.

Ford, J. K. B., G. M. Ellis, and K. C. Balcomb. 1994. Killer Whales: The Natural History and Genealogy of *Orcinus orca* in British Columbia and Washington State. University of British Columbia Press, Vancouver, BC, and University of Washington Press, Seattle. 102 p.

Ford, J. K. B., G. M. Ellis, and K. C. Balcomb. 2000. Killer Whales: The Natural History and Genealogy of *Orcinus orca* in British Columbia and Washington State. Second edition. University of British Columbia Press, Vancouver, BC, Canada. 104 p.

Ford, J. K. B., E. H. Stredulinsky, J. R. Towers, and G. M. Ellis. 2013. Information in support of the identification of critical habitat for transient killer whales (*Orcinus orca*) off the west coast of Canada. DFO Canadian Science Advisory Secretariat Research Document 2012/nnn.

Forney, K. A., and P. R. Wade. 2006. World-wide abundance and density of killer whales, p. 145-162. *In* J. A. Estes, D. P. DeMaster, D. F. Doak, T. M. Williams, and R. L. Brownell, Jr. (eds.), Whales, Whaling, and Ocean Ecosystems. University of California Press.

Forney, K. A., J. Barlow, and J. V. Carretta. 1995. The abundance of cetaceans in California waters. Part II: Aerial surveys in winter and spring of 1991 and 1992. Fish. Bull., U.S. 93:15-26.

George, J. C., and R. Suydam. 1998. Observations of killer whale (*Orcinus orca*) predation in the northeastern Chukchi and western Beaufort seas. Mar. Mammal Sci. 14:330-332. DOI: dx.doi.org/10.1111/j.1748-7692.1998.tb00722.x .

Goley, P. D., and J. M. Straley. 1994. Attack on gray whales (*Eschrichtius robustus*) in Monterey Bay, California, by killer whales (*Orcinus orca*) previously identified in Glacier Bay, Alaska. Can. J. Zool. 72:1528-1530.

Green, G. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnell, and K. C. Balcomb. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990, p. 1-100. *In* J. J. Brueggeman (ed.), Oregon and Washington marine mammal and seabird surveys. Final Report OCS Study MMS 91-0093.

Heise, K., G. Ellis, and C. Matkin. 1991. A Catalogue of Prince William Sound Killer Whales. North Gulf Oceanic Society, Homer, AK. 51 p.

Heise, K., L. G. Barrett-Lennard, E. Saulitis, C. Matkin, and D. Bain. 2003. Examining the evidence for killer whale predation on Steller sea lions in British Columbia and Alaska. Aquat. Mamm. 29(3):325-334.

Hoelzel, A. R., and G. A. Dover. 1991. Genetic differentiation between sympatric killer whale populations. Heredity 66:191-195.

Hoelzel, A. R., M. E. Dahlheim, and S. J. Stern. 1998. Low genetic variation among killer whales (*Orcinus orca*) in the eastern North Pacific, and genetic differentiation between foraging specialists. J. Hered. 89:121-128.

Hoelzel, A. R., A. Natoli, M. Dahlheim, C. Olavarria, R. Baird, and N. Black. 2002. Low worldwide genetic diversity in the killer whale (*Orcinus orca*): implications for demographic history. Proc. R. Soc. Lond. 269:1467-1473.

Leatherwood, J. S., and M. E. Dahlheim. 1978. Worldwide distribution of pilot whales and killer whales. Naval Ocean Systems Center, Tech. Rep. 443:1-39.

Leatherwood, S., A. E. Bowles, E. Krygier, J. D. Hall, and S. Ingell. 1984. Killer whales (*Orcinus orca*) in Southeast Alaska, Prince William Sound, and Shelikof Strait: a review of available information. Rep. Int. Whaling Comm. 34:521-530.

Leatherwood, S., C. O. Matkin, J. D. Hall, and G. M. Ellis. 1990. Killer whales, *Orcinus orca*, photo-identified in Prince William Sound, Alaska 1976 to 1987. Can. Field Nat. 104:362-371.

Matkin, C. O., M. E. Dahlheim, G. Ellis, and E. Saulitis. 1993. Vital rates and pod structure of resident killer whales following the *Exxon Valdez* oil spill, p. 303-307. *In Exxon Valdez* Oil Spill Trustee Council, *Exxon Valdez* oil spill symposium abstract book, February 2-5, 1993, Anchorage, Alaska.

Matkin, C. O., G. M. Ellis, M. E. Dahlheim, and J. Zeh. 1994. Status of killer whales in Prince William Sound, 1985-1992, p. 141-162. *In* T. R. Loughlin (ed.), Marine Mammals and the *Exxon Valdez*. Academic Press, San Diego, CA.

Matkin, C., G. Ellis, E. Saulitis, L. Barrett-Lennard, and D. Matkin. 1999. Killer Whales of Southern Alaska. North Gulf Oceanic Society, Homer, AK. 96 p.

Matkin, C. O., G. M. Ellis, L. G. Barrett-Lennard, H. Yurk, E. L. Saulitis, D. Scheel, P. Olesiuk, and G. Ylitalo. 2003. Photographic and acoustic monitoring of killer whales in Prince William and Kenai Fjords, *Exxon Valdez* Oil Spill Restoration Project Final Report, Restoration Project 03012, North Gulf Oceanic Society, Homer, AK. 118 p.

Matkin, C. O., E. L. Saulitis, G. M. Ellis, P. Olesiuk, and S. D. Rice. 2008. Ongoing population-level impacts on killer whales *Orcinus orca* following the ‘Exxon Valdez’ oil spill in Prince William Sound, Alaska. Mar. Ecol. Prog. Ser. 356:269-281.

Matkin, C. O., J. W. Durban, E. L. Saulitis, R. D. Andrews, J. M. Straley, D. R. Matkin, and G. M. Ellis. 2012. Contrasting abundance and residency patterns of two sympatric populations of transient killer whales (*Orcinus orca*) in the northern Gulf of Alaska. Fish. Bull., U.S. 110:143-155.

Mitchell, E. D. 1975. Report on the meeting on small cetaceans, Montreal, April 1-11, 1974. J. Fish. Res. Board Can. 32:914-916.

Morin, P. A., F. I. Archer, A. D. Foote, J. Vilstrup, E. E. Allen, P. Wade, J. Durban, K. Parsons, R. Pitman, L. Li, P. Bouffard, S. C. A~~.~~bel Nielsen, M. Rasmussen, E. Willerslev, M. T. P. Gilbert, and T. Harkins. 2010. Complete mitochondrial genome phylogeographic analysis of killer whales (*Orcinus orca*) indicates multiple species. Genome Res. 20:908-916.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed ~~December 2019~~August 2020.

Olesiuk, P. F., M. A. Bigg, and G. M. Ellis. 1990. Life history and population dynamics of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Rep. Int. Whal. Comm. (Special Issue 12):209-242.

Parsons, K. M., J. W. Durban, A. M. Burdin, V. N. Burkanov, R. L. Pitman, J. Barlow, L. G. Barrett-Lennard, R. G. LeDuc, K. M. Robertson, C. O. Matkin, and P. R. Wade. 2013. Geographic patterns of genetic differentiation among killer whales in the northern North Pacific. J. Hered. 104:737-754.

Riesch, R., L. G. Barrett-Lennard, G. M. Ellis, J. K. B. Ford, and V. B. Deecke. 2012. Cultural traditions and the evolution of reproductive isolation: ecological speciation in killer whales? Biol. J. Linn. Soc. 106:1-17.

Saulitis, E., C. O. Matkin, and F. H. Fay. 2005. Vocal repertoire and acoustic behavior of the isolated AT1 killer whale subpopulation in southern Alaska. Can. J. Zool. 83:1015-1029.

Towers, J. R., G. J. Sutton, T. J. H. Shaw, M. Malleson, D. Matkin, B. Gisborne, J. Forde, D. Ellifrit, G. M. Ellis, J. K. B. Ford, and T. Doniol-Valcroze. 2019. Photo-identification catalogue, population status, and distribution of Bigg's killer whales known from coastal waters of British Columbia, Canada. Can. Tech. Rep. Fish. Aquat. Sci. 3311:vi + 299 p.

von Ziegesar, O., G. M. Ellis, C. O. Matkin, and B. Goodwin. 1986. Repeated sightings of identifiable killer whales (*Orcinus orca*) in Prince William Sound, Alaska, 1977-1983. Cetus 6(2):9-13.

Wade, P. R. 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. Mar. Mammal Sci. 14:1-37. DOI: dx.doi.org/10.1111/j.1748-7692.1998.tb00688.x .

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX.

KILLER WHALE (*Orcinus orca*): West Coast Transient Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Killer whales have been observed in all oceans and seas of the world (Leatherwood and Dahlheim 1978). Although reported from tropical and offshore waters, killer whales occur at higher densities in colder and more productive waters of both hemispheres, with the greatest densities found at high latitudes (Mitchell 1975, Leatherwood and Dahlheim 1978, Forney and Wade~~,~~ 2006). Killer whales are found throughout the North Pacific Ocean. Along the west coast of North America, seasonal and year-round occurrence of killer whales ~~occur~~has been noted along the entire Alaska~~n~~ coast (Braham and Dahlheim 1982), in British Columbia and Washington inland waterways (Bigg et al. 1990), and along the outer coasts of Washington, Oregon, and California (Green et al. 1992; Barlow 1995, 1997; Forney et al. 1995). ~~Seasonal and year-round occurrence has been noted for killer whales throughout Alaska (Braham and Dahlheim 1982) and in the intracoastal waterways of British Columbia and Washington State, where~~Killer whales from these areas have been labeled as "resident," "transient," and "offshore" type killer whales (Bigg et al. 1990, Ford et al. 2000~~;~~, Dahlheim et al. 2008) based on aspects of morphology, ecology, genetics, and behavior (Ford and Fisher 1982; Baird and Stacey 1988; Baird et al. 1992; Hoelzel et al. 1998, 2002; Barrett-Lennard 2000; Dahlheim et al. 2008). Through examination of photographs of recognizable individuals and pods, movements of whales between geographical areas have been documented. For example, whales identified in Prince William Sound have been observed near Kodiak Island (Matkin et al. 1999) and whales identified in Southeast Alaska have been observed in Prince William Sound, British Columbia, and Puget Sound (Leatherwood et al. 1990, Dahlheim et al. 1997). Movements of killer whales between the waters of Southeast Alaska and central California have also been documented (Goley and Straley 1994~~;~~, Black et al. 1997~~;~~, Dahlheim and White 2010).

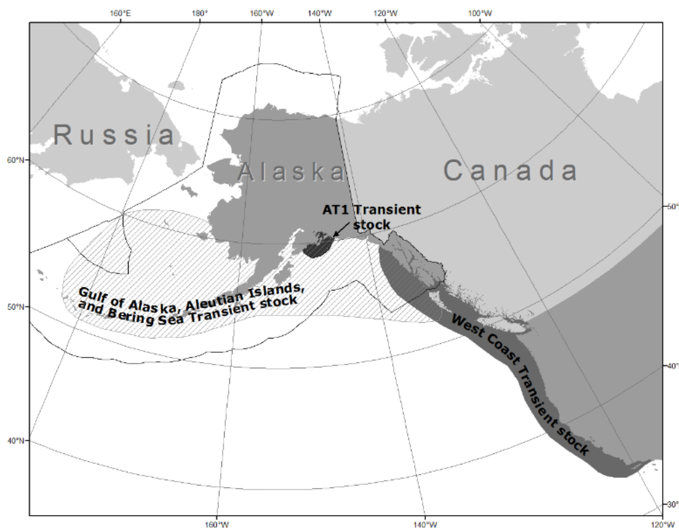

Figure 1. Approximate distribution of transient killer whales in the eastern North Pacific (shaded areas). The distribution of ~~the eastern North Pacific R~~resident and ~~T~~transient killer whale stocks ~~are~~in the eastern North Pacific largely overlap~~ping~~ (see text). The U.S. Exclusive Economic Zone is delineated by a black line.

Several studies provide evidence that the 'resident', 'offshore', and 'transient' ecotypes are genetically distinct in both mtDNA and nuclear DNA (Hoelzel and Dover 1991; Hoelzel et al. 1998, 2002; Barrett-Lennard 2000). Genetic differences have also been found between populations within the 'transient' and 'resident' ecotypes (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000). A ~~recent~~ global genetic study of killer whales using the entire mitochondrial genome found that some killer whale ecotypes represent deeply divergent evolutionary lineages and warrant elevation to species or subspecies status (Morin et al. 2010). In particular, estimates from mitogenome sequence data indicate that transient killer whales diverged from all other killer whale lineages ~~~~~approximately 700,000 years ago. In light of these differences, the Society for Marine Mammalogy's Committee on Taxonomy currently recognizes the resident and transient North Pacific ecotypes as un-named *Orcinus orca* subspecies (Committee on Taxonomy ~~2012~~2019). In recognition of its status as an un-named subspecies or species, some researchers now refer to transient-type killer whales as Bigg's killer whales (e.g., Ford 2011, Riesch et al. 2012), in tribute to the late Dr. Michael Bigg.

~~Based on data regarding association patterns, acoustics, movements, and genetic differences, eight killer whale stocks are now recognized within the Pacific U.S. EEZ: 1) the Alaska Resident stock – occurring from southeastern Alaska to the Aleutian Islands and Bering Sea, 2) the Northern Resident stock – occurring from~~

~~Washington State through part of southeastern Alaska, 3) the Southern Resident stock - occurring mainly within the inland waters of Washington State and southern British Columbia, but also in coastal waters from southeastern Alaska through California, 4) the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock - occurring mainly from Prince William Sound through the Aleutian Islands and Bering Sea, 5) the AT1 transient stock - occurring in Alaska from Prince William Sound through the Kenai Fjords, 6) the West Coast transient stock - occurring from California through southeastern Alaska, 7) the Offshore stock - occurring from California through Alaska, and 8) the Hawaiian stock. 'Transient' whales in Canadian waters are considered part of the West Coast Transient stock. The Stock Assessment Reports for the Alaska Region contain information concerning all the killer whale stocks except the Hawaiian and Offshore stocks.~~

~~Until recently, transient killer whales in Alaska had only been studied intensively~~The first studies of transient killer whales in Alaska were conducted in Southeast Alaska and in the Gulf of Alaska (from Prince William Sound, through the Kenai Fjords, and around Kodiak Island). In the Gulf of Alaska, Matkin et al. (1999) described two genetically distinct populations of transients which were never found in association with one another, the so-called "~~'~~Gulf of Alaska~~'~~" transients and "~~'~~AT1~~'~~" transients. In the past, neither of these populations were known to associate with the population of transient killer whales that ranged from California to Southeast Alaska, which are described as the West Coast Transient stock. Gulf of Alaska~~'~~ transients are documented throughout the Gulf of Alaska, including occasional sightings in Prince William Sound. AT1 transients ~~are primarily~~have been seen only in Prince William Sound and in the Kenai Fjords region, and are therefore partially sympatric with ~~'~~Gulf of Alaska~~'~~ transients. ~~Recently members of the Gulf of Alaska transient population have been seen in association with the transient killer whales that range from California to southeastern Alaska, the west coast transients, which are identified by a unique mtDNA haplotype. Recent data have identified~~In addition, 14 out of 217 ~~whales considered~~transients on the ~~'~~"outer coast~~'~~" ~~transients in~~of Southeast Alaska and British Columbia ~~as photographed in Alaskan waters and considered~~were identified as Gulf of Alaska transients and in one encounter they were observed mixing with West Coast transients (Matkin et al. 2012, Ford et al. 2013). Transients within the ~~'~~Gulf of Alaska~~'~~ population have been found to have two mtDNA haplotypes, neither of which is found in the ~~w~~West ~~c~~Coast or AT1 populations. Members of the AT1 population share a single mtDNA haplotype. Transient killer whales from the ~~'w~~West ~~c~~Coast~~'~~ ~~stock~~population have been found to share a single mtDNA haplotype that is not found in the other ~~communities~~populations. Additionally, all three populations have been found to have significant differences in nuclear (microsatellite) DNA (Barrett-Lennard 2000). Acoustic differences have been found~~,~~ as well~~, as Saulitis (1993) and~~; Saulitis et al. (2005) described acoustic differences between ~~'~~Gulf of Alaska~~'~~ transients and AT1 transients. For these reasons, the ~~'~~Gulf of Alaska~~'~~ transients are considered part of a population that is discrete from the AT1 population, and both of these ~~communities~~populations are considered discrete from the ~~'w~~West ~~c~~Coast~~'~~ transients.

Transient-type killer whales from the Aleutian Islands and Bering Sea are currently considered to be part of a single population that includes Gulf of Alaska transients; however, recent genetic analyses suggest substructure within the region. Biopsy samples from the eastern Aleutians and the south side of the west end of the Alaska Peninsula have produced the same haplotypes as killer whales in the northern Gulf of Alaska~~,~~; however, nuclear DNA analysis strongly suggests they belong to a separate population (Parsons et al. 2013). ~~Samples~~The geographic distribution of mtDNA haplotypes revealed samples from the central Aleutian Islands and Bering Sea ~~have identified mtDNA~~with haplotypes not found in Gulf of Alaska transients, suggesting additional population structure in western Alaska. ~~At this time, transient-type killer whales from the Aleutian Islands and Bering Sea are considered to be part of a single population that includes 'Gulf of Alaska' transients.~~ Killer whales ~~are~~ observed in the northern Bering Sea and north and east to the western Beaufort Sea ~~that~~ have ~~the physical~~ characteristics of transient-~~-~~type whales, but little is known about these whales (Braham and Dahlheim 1982, George and Suydam 1998). AT1 haplotype whales are also present west of the Aleutian Islands and into the Bering Sea; however, nuclear DNA analysis indicates these animals are not part of the AT1 transient population in the Gulf of Alaska (Parsons et al. 2013).

In summary, within the transient ecotype, association data (Ford et al. 1994, Ford and Ellis 1999, Matkin et al. 1999), acoustic data (~~Saulitis 1993,~~ Ford and Ellis 1999, Saulitis et al. 2005), and genetic data (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000~~, Parsons et al. 2013~~) confirm that at least three communities of transient whales exist and represent three discrete populations:~~-~~ 1) Gulf of Alaska, Aleutian Islands, and Bering Sea transients, 2) AT1 transients, and 3) West Coast transients.

Most of the transient killer whales photographed in the inland waters of Southeast Alaska share the ~~w~~West ~~c~~Coast ~~t~~Transient haplotype and have been seen in association with British Columbia/Washington State transients. Transients most often seen off California ~~have~~ also share the West Coast Transient (WCT) haplotype and have been observed in association with transients in Washington and British Columbia. The West Coast Transient ~~S~~stock is therefore considered to include transient killer whales from California through ~~southeastern~~Southeast Alaska. However, it should be noted that Fisheries and Oceans Canada ~~recently decided to exclude~~no longer includes whales from California ~~from~~in their assessment of the "West Coast Transient (WCT) Population" (~~DFO~~Fisheries and Oceans Canada 2007). They noted that 100 or so transient killer whales identified off the central coast of California (Black et al. 1997) were in the past considered to be an extension of this population because of acoustical similarities and occasional mixing with WCT individuals in BC waters (Ford and Ellis 1999), but that a recent reassessment indicated that the available evidence was insufficient to warrant inclusion of those whales in the WCT population (~~DFO~~Fisheries and Oceans Canada 2010). Canadian researchers have now identified 46 individual whales in British Columbia that are known from California (J. Ford, pers. comm., Department of Fisheries and Oceans, British Columbia, Canada, 30 January 2013). They also noted that the Gulf of Alaska transients are seen occasionally within the range of WCTs (in ~~southeastern~~Southeast Alaska and off British Columbia) but have only been observed to travel in association with WCTs on one occasion (~~DFO~~Fisheries and Oceans Canada 2007, Matkin et al. 2012). For the purposes of this stock assessment report, the West Coast Transient ~~S~~stock continues to include animals that occur in California, Oregon, Washington, British Columbia, and ~~southeastern~~Southeast Alaska. Based on data regarding association patterns, acoustics, movements, and genetic differences, eight killer whale stocks are now recognized within the Pacific U.S. Exclusive Economic Zone: 1) the Alaska Resident stock - occurring from Southeast Alaska to the Aleutian Islands and Bering Sea, 2) the Northern Resident stock - occurring from Washington State through part of Southeast Alaska, 3) the Southern Resident stock - occurring mainly within the inland waters of Washington State and southern British Columbia, but also in coastal waters from Southeast Alaska through California, 4) the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock - occurring mainly from Prince William Sound through the Aleutian Islands and Bering Sea, 5) the AT1 Transient stock - occurring in Alaska from Prince William Sound through the Kenai Fjords, 6) the West Coast Transient stock - occurring from California through Southeast Alaska (Fig. 1), 7) the Offshore stock - occurring from California through Alaska, and 8) the Hawaiian stock. Transient killer whales in Canadian waters are considered part of the West Coast Transient stock. The Hawaiian and Offshore stocks are reported in the Stock Assessment Reports for the U.S. Pacific Region.

POPULATION SIZE

The ~~w~~West ~~c~~Coast ~~t~~Transient stock is a trans-boundary stock, including killer whales from British Columbia. Preliminary analysis of photographic data resulted in the following minimum counts for ~~'~~transient~~'~~ killer whales belonging to the ~~w~~West ~~c~~Coast ~~t~~Transient stock. ~~Over the time series from 1975 to 2012, 521 individual transient killer whales have been identified. Of these, 217 are considered part of the poorly known "outer coast" subpopulation and 304 belong to the well-known "inner coast" population. However of the 304, the number of whales currently alive is not certain (see Ford et al. 2013). A recent mark-recapture estimate that does not include the "outer coast" subpopulation or whales from California for the west coast transient population resulted in an estimate of 243 (95% probability interval = 180-339) in 2006 (DFO 2009). This estimate applies to the population of west coast transient whales that occur in the inside waters of southeastern Alaska, British Columbia, and northern Washington.~~Towers et al. (2019) used a 61-year archive of photo-identification data (1958-2018) to assess the portion of the West Coast Transient stock that inhabits Canadian coastal waters and, therefore, was most likely to be impacted by human activity in Canada. Because there is evidence that this population may be composed of discrete population clusters (Parsons et al. 2013, Sharpe et al. 2017), they used a set of criteria to ensure that their analysis represented the animals that were the most regularly and recently documented in Canadian waters. Using only mature individuals, the criteria included the number of encounters, the cumulative number of years documented, and the time since the last encounter. Examination of these data produced a population subset of 349 individuals, including 206 mature individuals plus 143 individuals who were offspring and other inferred maternally related kin. Given that this number was limited to the population likely to be impacted by human activity in British Columbia, and that the California transient numbers have not been updated since the publication of the catalogue in 1997 (Black et al. 1997), the total number of transient killer whales reported above should be considered ~~as~~ a minimum count for the ~~w~~West ~~c~~Coast ~~t~~Transient stock.

Minimum Population Estimate

The abundance estimate of killer whales is an ~~direct count~~analysis of individually identifiable animals. However, the number of catalogued whales does not necessarily represent the number of live animals. Some ~~animals~~whales may have died, but ~~whales~~they can~~-~~not be presumed dead if not resighted because long periods of time between sightings are common for some ~~'~~transient~~'~~ ~~animals~~whales. The connection of the "outer coast" whales with the ~~w~~West ~~c~~Coast transient population of inshore waters is not well established, and the photographic catalogue from California has not been updated in 15 years. Estimates of the overall population size (i.e., N_{BEST}) and associated CV(N) that include the ~~“~~outer coast~~”~~ whales are not currently available. Thus, the minimum population estimate (N_{MIN}) of 349 whales for the West Coast Transient stock of killer whales is derived from the recent ~~mark-recapture analysis~~catalogue for West Coast transient population whales from the inside waters of ~~Alaska and~~ British Columbia~~ of 243 whales (95% probability interval = 180-339) in 2006~~ (~~DFO 2009~~Towers et al. 2019), which ~~includes~~focuses on ~~animals~~whales found in Canadian waters (see PBR Guidelines regarding the status of migratory trans-boundary stocks, ~~Wade and Angliss 1997~~NMFS 2016). Information on the percentage of time ~~animals~~whales typically encountered in Canadian waters spend in U.S. waters is unknown. However, as noted above, this minimum population estimate is considered conservative. This approach is consistent with previous recommendations of the Alaska Scientific Review Group (DeMaster 1996).

Current Population Trend

Recent analyses of the inshore ~~w~~West ~~c~~Coast ~~t~~Transient population indicate that this segment grew rapidly from the mid-1970s to mid-1990s as a result of a combination of high birth rate~~,~~ and survival, as well as greater immigration of animals into the nearshore study area (~~DFO~~Fisheries and Oceans Canada 2009). The rapid growth of the ~~w~~West ~~c~~Coast ~~t~~Transient population in the mid-1970s to mid-1990s coincided with a dramatic increase in the abundance of the whales' primary prey, harbor seals, in nearshore waters. Population growth began slowing in the mid-1990s ~~and has continued to slow~~but has increased in recent years (~~DFO~~Fisheries and Oceans Canada 2009, Towers et al. 2019). Given that population estimates are based on photo identification of individuals and considered minimum estimates, no reliable estimate of trend is available.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is ~~currently~~ not ~~un~~available for ~~this~~the West Coast Transient stock of killer whales. Analyses ~~in~~by ~~DFO~~Fisheries and Oceans Canada (2009) estimated a rate of increase of about 6% per year in this population from 1975 to 2006; however, ~~but~~ this included recruitment of non-calf whales into the population, at least in the first half of the time period, interpreted as either a movement of some whales into nearshore waters from elsewhere~~,~~ or ~~from~~a result of better spatial sampling coverage. The population increased at a rate of approximately 2% for the second half of the time period, when recruitment of new individuals was nearly exclusively from new-born individuals (~~DFO~~Fisheries and Oceans Canada 2009). Between 2012 and 2018, Towers et al. (2019) observed a mean annual growth rate of 4.1% for a population subset in Canadian coastal waters, which was higher than the mean annual growth rate of 2.7% documented by Ford et al. (2013) between 2006 and 2011 for a sub-population of inner-coast transient killer whales that contained most of the same individuals. This rate was also higher than Ford et al.'s (2007) mean annual growth rate of 2% estimated for the same population between 1991 and 2006.~~ Studies of ‘resident’ killer whale pods in the Pacific Northwest resulted in estimated population growth rates of 2.92% and 2.54% over the period from 1973 to 1987 (Olesiuk et al. 1990, Brault and Caswell 1993) and an observed growth rate of 3.1% was observed in northern resident killer whales and used in calculations of~~ ~~R_{MAX}~~ ~~for that stock.~~ However, until additional data become available for ~~this~~the West Coast Transient stock of ~~transient type~~ killer whales, ~~it is recommended that~~ the default cetacean maximum theoretical net productivity rate ~~(R_{MAX})~~ of 4% will be ~~employed~~used for this stock (~~Wade and Angliss 1997~~NMFS 2016).

POTENTIAL BIOLOGICAL REMOVAL

~~Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the p~~Potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for cetacean stocks with unknown population status ~~with a mortality rate CV = 0.80~~ (~~Wade and Angliss 1997~~NMFS 2016). Thus, for the West Coast Transient killer whale stock, PBR = is ~~2.4~~3.5 ~~animals~~whales (~~243~~349 × 0.02 × 0.5). The proportion of time that this trans-boundary stock spends in Canadian waters cannot be determined (G. Ellis, Pacific Biological Station, Canada, pers. comm.)

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals between 2014 and 2018 is listed, by marine mammal stock, in Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. The minimum estimated mean annual level of human-caused mortality and serious injury for the West Coast Transient stock of killer whales between 2014 and 2018 is 0.4 killer whales: 0.2 in U.S. commercial fisheries and 0.2 in unknown (commercial, recreational, or subsistence) fisheries. Potential threats most likely to result in direct human-caused mortality or serious injury of this stock include oil spills, vessel strikes, and interactions with fisheries.

~~New Serious Injury Guidelines~~

~~NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*." Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.~~

Fisheries Information

Information for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is available in Appendix 3 of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

NMFS observers monitored the California~~/Oregon~~ ~~thresher shark/~~swordfish drift gillnet fishery from ~~1994~~1990 to ~~2003~~2017 (~~Julian 1997, Julian and Beeson 1998, Cameron and Forney 1999, Carretta 2002, Carretta and Chivers 2003, Carretta and Chivers 2004~~Carretta et al. 2019). The one killer whale mortality observed ~~mortality~~ in this fishery, in 1995, was genetically identified as a transient ecotype~~whale as determined by genetic testing (S. Chivers, NMFS-SWFSC, pers. comm.)~~. ~~Overall entanglement rates in the California/Oregon thresher shark/swordfish drift gillnet fishery dropped considerably after the 1997 implementation of a Take Reduction Plan, which included skipper education workshops and required the use of pingers and minimum 6-fathom extenders (Barlow and Cameron 1999). Because the California/Oregon thresher shark/swordfish drift gillnet fishery is observed and has not incurred incidental serious injuries or mortalities of killer whales between 1999-2003, the estimate of fishery-related take for this fishery is zero. Thus, the~~Bycatch estimates for 2013-2017, based on a bycatch model, result in a minimum mean annual mortality and serious injury rate ~~for this stock is~~of zero killer whales for this stock (Carretta et al. 2019).~~ Additional fisheries that could interact with the Eastern North Pacific Transient stock of killer whales are listed in Appendix 3.~~

Reports to NMFS Region marine mammal stranding networks of killer whales entangled in fishing gear or with injuries caused by interactions with gear are another source of mortality and serious injury data. A killer whale mortality in commercial California Dungeness crab pot gear in 2015 reported to the NMFS West Coast Region marine mammal stranding network was genetically identified as a transient ecotype. Because the whale could not be assigned to a specific stock, the mean annual mortality and serious injury rate of 0.2 killer whales between 2014 and 2018 was assigned to the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient and the West Coast Transient killer whale stocks; it was not assigned to the AT1 Transient killer whale stock because none of the whales in this population are missing (Table 1; Young et al. in press). An additional whale, photographically identified as a member of the West Coast Transient stock of killer whales, entangled in and self-released from commercial California Dungeness crab pot gear in 2016; however, this was considered to be a non-serious injury (Young et al. in press). There was also a report to the NMFS Alaska Region marine mammal stranding network of a killer whale entangled in pot gear in Icy Strait in 2016, resulting in a mean annual mortality and serious injury rate of 0.2 killer whales in unknown (commercial, recreational, or subsistence) Southeast Alaska pot fishery gear between 2014 and 2018 (Table 1; Young et al. in press). Because the stock identification is unknown, this mortality and serious injury was assigned to the three killer whale stocks that occur in the area: the Alaska Resident, Northern Resident, and West Coast Transient stocks. These mortality and serious injury estimates result from an actual count of verified human-caused deaths and serious injuries and are minimums because not all entangled animals strand nor are all stranded animals found or reported.

The minimum estimated ~~minimum~~ mean annual mortality and serious injury rate incidental to ~~recently monitored~~fisheries between 2014 and 2018 is 0.4 killer whales: 0.2 in U.S. commercial fisheries ~~is~~and ~~zero~~0.2 ~~animals per year~~in unknown (commercial, recreational, or subsistence) fisheries.

Table 1. Summary of mortality and serious injury of West Coast Transient killer whales, by year and type, reported to the NMFS Alaska Region and NMFS West Coast Region marine mammal stranding networks between 2014 and 2018 (Young et al. in press).

Cause of Injury	**2014**	**2015**	**2016**	**2017**	**2018**	**Mean annual mortality**
Entangled in commercial CA Dungeness crab pot gear	0	1[a]	0	0	0	0.2
Entangled in Southeast Alaska pot gear*	0	0	1[b]	0	0	0.2
Total in commercial fisheries						0.2
*Total in unknown (commercial, recreational, or subsistence) fisheries						0.2

[a]This whale was genetically identified as a transient ecotype but could not be assigned to a specific stock; therefore, the mortality was assigned to the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient and the West Coast Transient killer whale stocks.
[b]The stock identification of this whale is unknown; therefore, this mortality was assigned to the three killer whale stocks in the area: the Alaska Resident, Northern Resident, and West Coast Transient killer whale stocks.

All Canadian ~~trawl and~~ longline fisheries (including halibut, rockfish, dogfish, sablefish, jig for lingcod, and troll for lingcod and Chinook salmon) are monitored by observers or video~~;~~. However, only groundfish trawl fisheries have observer or electronic monitoring in Canada, whereas, trawl fisheries for krill, scallop, and shrimp have no observer coverage and salmon net fisheries are not observed (~~J. Ford~~T. Doniol-Valcroze, pers. comm., Department of Fisheries and Oceans, ~~British Columbia~~, Canada, ~~30 January 2013~~14 May 2019). The interaction of Alaska Resident killer whales with the sablefish longline fishery accounts for a large proportion of the commercial fishing/killer whale interactions in Alaska waters. However, transient killer whales typically are not involved in these interactions. ~~Resident killer whales are well documented to interact with the longline fishery.~~ Such interactions have not been reported in Canadian waters where sablefish are taken via a pot fishery~~. Canada has a Marine Mammal Response Network to track human interaction incidents such as entanglements (J. Ford, pers. comm., Department of Fisheries and Oceans, British Columbia, Canada, 30 January 2013)~~; however, Northern Resident killer whale interactions with Pacific halibut longline and salmon troll fisheries in British Columbia~~. Since 1990, there~~ have been ~~no~~ reported (Ford 2014). Reports ~~fishery-related strandings~~ of killer whales interactions with gillnets in Canadian waters~~. In 1994,~~ include one killer whale ~~was reported to have~~that contacted a salmon gillnet~~,~~ in 1994 but ~~it~~ did not entangle (Guenther et al. 1995) and one killer whale (Northern Resident I103) that entangled in a gillnet in 2014 but was quickly released (Fisheries and Oceans Canada 2018).

Alaska Native Subsistence/~~Native~~ Harvest Information

~~There~~Killer whales are not ~~reports of a~~harvested for subsistence ~~harvest of killer whales~~ in Alaska ~~or Canada~~.

Other Mortality

The shooting of killer whales in Canadian waters has been a concern in the past. ~~However, in recent years there have been no reports of shooting incidents in Canadian waters.~~Since 1974, however, fresh bullet wounds are rarely, if ever, seen on whales in British Columbia and Washington (Ford et al. 2000, Fisheries and Oceans Canada 2018). In fact, the likelihood of shooting incidents involving ~~'~~transient~~'~~ killer whales is thought to be minimal since commercial fishermen are most likely to observe ~~'~~transients~~'~~ feeding on seals or sea lions instead of interacting with their fishing gear (G. Ellis, Pacific Biological Station, Canada, pers. comm.).

Collisions with ~~boats~~vessels are ~~another~~an occasional source of mortality or serious injury of killer whales. For example, a ~~K~~killer whale~~s interacting with trawl vessels are occasionally~~ struck ~~by~~ the propeller~~; there were 4 incidents of mortality and serious injury~~of a vessel in the Bering Sea/Aleutian Islands flatfish trawl ~~and Bering Sea/ Aleutian Islands rockfish trawl~~ fishery~~ies between 2007-2011~~in 2016. Stock identification ~~for~~of ~~these~~this ~~occurrences~~whale is unknown; however, this ~~area~~fishery is outside of the known range ~~for~~of ~~this~~the West Coast

Transient stock. There ~~have~~has been no ~~reported~~known mortaliti~~es~~y or serious injury of West Coast Transient killer whales ~~from this stock~~ due to vessel collisions.

STATUS OF STOCK

The West Coast ~~t~~Transient killer whale stock is not designated as "depleted" under the MMPA or listed as "threatened" or "endangered" under the Endangered Species Act. In 2001, the Committee on the Status of Endangered Wildlife in Canada designated ~~w~~West ~~c~~Coast ~~t~~Transient killer whales in British Columbia as "threatened" under the Species at Risk Act (SARA) for Canada. Human-caused mortality may have been underestimated, primarily due to a lack of information on Canadian fisheries, and ~~that~~ the minimum abundance estimate is considered conservative (because researchers continue to encounter new whales and provisionally classified whales from Southeast Alaska and off the coast of California were not included), resulting in a conservative PBR estimate. Based on currently available data, the minimum estimated mean annual U.–S. commercial fishery-related mortality and serious injury ~~level~~rate (0.2) does not exceed 10% of the PBR (10% of PBR = ~~0.2~~0.3) and, therefore, ~~can be~~is considered to be insignificant and approaching a zero mortality and serious injury rate. The minimum estimated mean annual level of human-caused mortality and serious injury (0.4 ~~animals per year~~) ~~does not~~is not known to exceed the PBR (~~2.4~~3.5). Therefore, the West Coast Transient stock of killer whales is not classified as a strategic stock. Population trends and status of this stock relative to its Optimum Sustainable Population ~~(OSP) level~~size are currently unknown.

There are key uncertainties in the assessment of the West Coast Transient stock of killer whales. The current population estimate is for a subset of whales that inhabits Canadian coastal waters and this subset has increased at an average rate of 4.1% per year from 2012 to 2018. However, an updated abundance estimate and growth rate is not available for the entire stock.

HABITAT CONCERNS

Analyses of blubber biopsies collected from mammal-eating transient killer whales and fish-eating resident killer whales in Canadian waters between 1993 and 1996 revealed that transient killer whales and Southern Resident killer whales had surprisingly high levels of persistent PCB contamination; the particularly high levels of contamination found in transient killer whales most likely reflected their higher trophic level (Ross et al. 2000). Due to these high levels of contamination, transient and Southern Resident killer whales in Canadian waters were considered to be at risk for toxic effects (Ross et al. 2000).

CITATIONS

~~Angliss, R. P., and D. P. DeMaster. 1998. Differentiating serious and non-serious injury of marine mammals taken incidental to commercial fishing operations. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-13, 48 p.~~

~~Andersen, M. S., K. A. Forney, T. V. N. Cole, T. Eagle, R. Angliss, K. Long, L. Barre, L. Van Atta, D. Borggaard, T. Rowles, B. Norberg, J. Whaley, and L. Engleby. 2008. Differentiating Serious and Non-Serious Injury of Marine Mammals: Report of the Serious Injury Technical Workshop, 10-13 September 2007, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-39, 94 p.~~

Baird, R. W., and P. J. Stacey. 1988. Variation in saddle patch pigmentation in populations of killer whales (*Orcinus orca*) from British Columbia, Alaska, and Washington State. Can. J. Zool. 66 (11):2582-2585.

Baird, R. W., P. A. Abrams, and L. M. Dill. 1992. Possible indirect interactions between transient and resident killer whales: implications for the evolution of foraging specializations in the genus *Orcinus*. Oecologia 89:125-132.

Barlow, J. 1995. The abundance of cetaceans in California waters. Part I: Ship surveys in summer and fall of 1991. Fish. Bull., U.S. 93:1-14.

Barlow, J. 1997. Preliminary estimates of cetacean abundance off California, Oregon and Washington based on a 1996 ship survey and comparisons of passing and closing modes. Southwest Fisheries Science Center Administrative Report LJ-97-11~~,~~. 25 p. Available from ~~Southwest Fisheries Science Center~~SWFSC, ~~National Marine Fisheries Service~~NMFS, ~~P.O. Box 271~~8901 La Jolla Shores Drive, La Jolla, CA ~~92038~~92037. 25 p~~p~~.

~~Barlow, J., and G. A. Cameron. 1999. Field experiments show that acoustic pingers reduce marine mammal bycatch in the California drift gillnet fishery. Paper SC/51/SM2 presented to the International Whaling Commission, May 1998 (unpublished). 20 pp.~~

Barrett-Lennard, L. G. 2000. Population structure and mating patterns of killer whales (*Orcinus orca*) as revealed by DNA analysis. Ph.D. ~~Thesis~~Dissertation, University of British Columbia, Vancouver, BC, Canada~~,~~. 97 p~~p~~.

Bigg, M. A., P. F. Olesiuk, G. M. Ellis, J. K. B. Ford, and K. C. Balcomb III. 1990. Social organization and genealogy of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State~~.~~, ~~P~~p. 386-406. *In* P. S. Hammond~~, P. S.~~, S. A. Mizroch, and G. P. Donovan (eds.), Individual Recognition of Cetaceans: Use of Photo-identification and Other Techniques to Estimate Population Parameters. Rep. Int. Whal. Comm. Special Issue 12.

Black, N. A., A. Schulman-Janiger, R. L. Ternullo, and M. Guerrero-Ruiz. 1997. Killer whales of California and western Mexico: a catalog of photo-identified individuals. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-247, 174 p~~p~~.

Braham, H. W., and M. E. Dahlheim. 1982. Killer whales in Alaska documented in the Platforms of Opportunity Program. Rep. Int. Whal. Comm. 32:643-646.

~~Brault, S., and H. Caswell. 1993. Pod-specific demography of killer whales (*Orcinus orca*). Ecology 74(5):1444-1454.~~

~~Cameron, G. A., and K. A. Forney. 1999. Preliminary estimates of cetacean mortality in the California gillnet fisheries for 1997 and 1998. Paper SC/51/O4 presented to the International Whaling Commission, May 1999 (unpublished). 14 pp.~~

~~Carretta, J. V. 2002. Preliminary estimates of cetacean mortality in California gillnet fisheries for 2001. Unpubl. doc. submitted to Int. Whal. Comm. (SC/54/SM12). 22 pp.~~

~~Carretta, J. V., and S. J. Chivers. 2003. Preliminary estimates of marine mammal mortality and biological sampling of cetaceans in California gillnet fisheries for 2002. Unpubl. doc. submitted to Int. Whal. Comm. (SC/55/SM3). 21 pp.~~

~~Carretta J. V., and S. J. Chivers. 2004. Preliminary estimates of marine mammal mortality and biological sampling of cetaceans in California gillnet fisheries for 2003. Unpubl. doc. submitted to Int. Whal. Comm. (SC/56/SM1). 20 pp.~~

Carretta, J. V., J. E. Moore, and K. A. Forney. 2019. Estimates of marine mammal, sea turtle, and seabird bycatch from the California large-mesh drift gillnet fishery: 1990-2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-619, 76 p.

Committee on Taxonomy. ~~2012~~2019. List of marine mammal species and subspecies. Society for Marine Mammalogy~~,~~. Available online: www.marinemammalscience.org~~,~~. ~~consulted on~~Accessed ~~12 December 2012~~August 2020.

Dahlheim, M. E., D. Ellifrit, and J. Swenson. 1997. Killer Whales of Southeast Alaska: A Catalogue of Photoidentified Individuals. Day Moon Press, Seattle, WA. 82 p~~p~~. + appendices.

Dahlheim, M. E., A. Schulman-Janiger, N. Black, R. Ternullo, D. Ellifrit, and K. C. Balcomb. 2008. Eastern temperate North Pacific offshore killer whales (*Orcinus orca*): occurrence, movements, and insights into feeding ecology. Mar. Mamm~~.~~al Sci. 24(3)~~:~~-719-729.

Dahlheim, M. E., and P. A. White. 2010. Ecological aspects of transient killer whales (*Orcinus orca*) as predators in southeastern Alaska. Wildlife Biology 16:-308-322.

DeMaster, D. P. 1996. Minutes from the 11-13 September 1996 meeting of the Alaska Scientific Review Group, Anchorage, AK. 20 p~~p~~ + appendices. Available upon request -from ~~National~~ Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Fisheries and Oceans Canada. 2007. Recovery strategy for the transient killer whale (*Orcinus orca*) in Canada. Species at Risk Act Recovery Strategy Series, Fisheries and Oceans Canada, Vancouver. 47 p.

~~Department of~~ Fisheries and Oceans ~~(DFO)~~ Canada. 2009. Recovery ~~P~~potential ~~A~~assessment for West Coast Transient ~~K~~killer ~~W~~Whales. DFO Can~~.~~adian Sci~~.~~ence Advis~~.~~ory Sec~~.~~retariat Sci~~.~~ence Advis~~.~~ory Rep~~.~~ort 2009/039.

~~Department of Fisheries and Oceans (DFO) Canada. 2007. Recovery Strategy for the Transient Killer Whale (*Orcinus orca*) in Canada. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Vancouver. 47 pp.~~

Fisheries and Oceans Canada. 2010. Population assessment Pacific harbour seal (*Phoca vitulina richardsi*). DFO Canadian Science Advisory Secretariat Science Advisory Report 2009/011.

Fisheries and Oceans Canada. 2018. Recovery strategy for the Northern and Southern Resident killer whales in Canada. Species at Risk Act Recovery Strategy Series, Fisheries and Oceans Canada, Ottawa. x + 84 p.

Ford, J. K. B. 2011. Killer whales of the Pacific Northwest coast: from pest to paragon. Whale Watcher 40(1):~~-~~15-23.

Ford, J. K. B. 2014. Marine Mammals of British Columbia. Royal BC Museum Handbook, Mammals of BC, Volume 6. Royal BC Museum, Victoria. 460 p.

Ford, J. K. B., and G. M. Ellis. 1999. Transients: Mammal-Hunting Killer Whales of British Columbia, Washington, and Southeastern Alaska. University of British Columbia Press, Vancouver, BC. 96 p~~p~~.

Ford, J. K. B., and H. D. Fisher. 1982. Killer whale (*Orcinus orca*) dialects as an indicator of stocks in British Columbia. Rep. Int. Whal. Comm. 32:671-679.

Ford, J. K. B., G. M. Ellis, and K. C. Balcomb. 1994. Killer Whales: The Natural History and Genealogy of *Orcinus orca* in British Columbia and Washington State. University of British Columbia Press, Vancouver, BC, and University of Washington Press, Seattle. 102 p~~p~~.

Ford, J. K. B., G. M. Ellis, and K. C. Balcomb. 2000. Killer Whales~~.~~: The Natural History and Genealogy of *Orcinus orca* in British Columbia and Washington State. Second edition. University of British Columbia Press, Vancouver, ~~Toronto~~BC, Canada~~; University of Washington Press, Seattle~~. 104 p.

Ford, J. K. B., G. M. Ellis, and J. W. Durban. 2007. An assessment of the potential for recovery of West Coast Transient killer whales using coastal waters of British Columbia. DFO Canadian Science Advisory Secretariat Research Document 2007/088.

Ford, J. K. B, E. H. Stredulinsky, J. R. Towers, and G. M. Ellis. 2013. Information in support of the identification of critical habitat for transient killer whales (*Orcinus orca*) off the west coast of Canada. DFO Can~~.~~adian Sci~~.~~ence Advis~~.~~ory Sec~~.~~retariat Res~~.~~earch Doc~~.~~ument 2012/nnn~~. vi + xx p.~~

Forney, K. A., J. Barlow, and J. V. Carretta. 1995. The abundance of cetaceans in California waters. Part II: Aerial surveys in winter and spring of 1991 and 1992. Fish. Bull., U.S. 93:15-26.

Forney, K. A., and P. R. Wade. 2006. World-wide abundance and density of killer whales~~.~~, ~~P~~p. 145-162. *In* J. A. Estes, D. P. DeMaster, D. F. Doak, T. M. Williams, and R. L. Brownell, Jr. (eds.), Whales, Whaling, and Ocean Ecosystems. University of California Press.

George, J. C., and R. Suydam. 1998. Observations of killer whale (*Orcinus orca*) predation in the northeastern Chukchi and western Beaufort seas. Mar. Mammal Sci. 14:330-332. DOI: dx.doi.org/10.1111/j.1748-7692.1998.tb00722.x .

Goley, P. D., and J. M. Straley. 1994. Attack on gray whales (*Eschrichtius robustus*) in Monterey Bay, California, by killer whales (*Orcinus orca*) previously identified in Glacier Bay, Alaska. Can. J. Zool. 72:1528-1530.

Green, G. A., J. J. Brueggeman, R. A. Grotefendt, C. E. Bowlby, M. L. Bonnell, and K. C. Balcomb. 1992. Cetacean distribution and abundance off Oregon and Washington, 1989-1990,~~. P~~p. 1-100. *In* J. J. Brueggeman~~, J. J.~~ (ed.), Oregon and Washington ~~M~~marine ~~M~~mammal and ~~S~~seabird ~~S~~surveys. Final Rep~~.~~ort OCS Study MMS 91-0093.

Guenther, T. J., R. W. Baird, R. L. Bates, P. M. Willis, R. L. Hahn, and S. G. Wischniowski. 1995. Strandings and fishing gear entanglements of cetaceans on the west coast of Canada in 1994. ~~Paper SC/47/O6 presented~~Unpubl. doc. submitted to ~~the~~ Int.~~ernational~~ Whal.~~ing~~ Comm.~~ission~~ Scientific Committee~~, May 1995 (unpublished)~~ (SC/47/O6). 7 p~~p~~.

Hoelzel, A. R., and G. A. Dover. 1991. Genetic differentiation between sympatric killer whale populations. Heredity 66:191-195.

Hoelzel, A. R., M. E. Dahlheim, and S. J. Stern. 1998. Low genetic variation among killer whales (*Orcinus orca*) in the ~~E~~eastern North Pacific, and genetic differentiation between foraging specialists. J. Hered.~~ity~~ 89:121-128.

Hoelzel, A. R., A. Natoli, M. Dahlheim, C. Olavarria, R. Baird, and N. Black. 2002. Low worldwide genetic diversity in the killer whale (*Orcinus orca*): implications for demographic history. Proc. R. Soc. Lond. 269:~~-~~1467-1473.

~~Julian, F. 1997. Cetacean mortality in California gill net fisheries: preliminary estimates for 1996. Paper SC/49/SM02 presented to the Int. Whal. Comm., September 1997 (unpublished). 13 pp.~~

~~Julian, F., and M. Beeson. 1998. Estimates of marine mammal, turtle, and seabird mortality for two California gillnet fisheries: 1990-1995. Fish. Bull., U.S. 96(2):271-284.~~

Leatherwood, J. S., and M. E. Dahlheim. 1978. Worldwide distribution of pilot whales and killer whales. Naval Ocean Systems Center, Tech. Rep. 443:1-39.

Leatherwood, S., C. O. Matkin, J. D. Hall, and G. M. Ellis. 1990. Killer whales, *Orcinus orca*, photo-identified in Prince William Sound, Alaska 1976 to 1987. Can. Field Nat. 104:362-371.

Matkin, C., G. Ellis, E. Saulitis, L. Barrett-Lennard, and D. Matkin. 1999. Killer Whales of Southern Alaska. North Gulf Oceanic Society, Homer, AK. 96 ~~pp~~p.

~~Mitchell, E. D. 1975. Report on the meeting on small cetaceans, Montreal, April 1-11, 1974. J. Fish. Res. Bd. Can. 32:914-916.~~

Matkin, C. O., J. W. Durban, E. L. Saulitis, R. D. Andrews, J. M. Straley, D. R. Matkin, and G. M. Ellis. 2012. Contrasting abundance and residency patterns of two sympatric populations of transient killer whales (*Orcinus orca*) in the northern Gulf of Alaska. Fish. Bull., U.S. 110:143~~–~~-155.

Mitchell, E. D. 1975. Report on the meeting on small cetaceans, Montreal, April 1-11, 1974. J. Fish. Res. Board Can. 32:914-916.

Morin, P. A., F. I. Archer~~ F. I.~~, A. D. Foote~~ A. D.~~, J. Vilstrup~~ J.~~, E. E. Allen~~ E. E.~~, P. Wade~~ P. R.~~, J. Durban~~ J. W.~~, K. Parsons~~ K. M.~~, R. Pitman~~ R.~~, L. Li~~ L.~~, P. Bouffard~~ P.~~, S. C. Abel Nielsen~~ S. C.~~, M. Rasmussen~~ M.~~, E. Willerslev~~ E.~~, M. T. P. Gilbert~~ M. T. P.~~, and T. Harkins~~ T.~~ 2010. Complete mitochondrial genome phylogeographic analysis of killer whales (*Orcinus orca*) indicates multiple species. Genome Res. 20:908-916.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed August 2020.

~~NOAA. 2012. Federal Register 77:3233. National Policy for Distinguishing Serious From Non-Serious Injuries of Marine Mammals. http://www.nmfs.noaa.gov/op/pds/documents/02/238/02-238-01.pdf.~~

~~Olesiuk, P. F., M. A. Bigg, and G. M. Ellis. 1990. Life history and population dynamics of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Rep. Int. Whal. Comm. Special Issue 12:209-242.~~

Parsons, K. M., J. W. Durban, A. M. Burdin, V. N. Burkanov, R. L. Pitman, J. Barlow, L. G. Barrett-Lennard, R. G. LeDuc, K. M. Robertson, C. O. Matkin, and P. R. Wade. 2013. Geographic ~~P~~patterns of ~~G~~genetic ~~D~~differentiation among ~~K~~killer ~~W~~whales in the ~~N~~northern North Pacific. J. Hered. 104:737-754.

Riesch, R., L. G. Barrett-Lennard, G. M. Ellis, J. K. B. Ford, and V. B. Deecke. 2012. Cultural traditions and the evolution of reproductive isolation: ecological speciation in killer whales? Biol.~~ogical~~ J.~~ournal of the~~ Linn.~~ean~~ Soc.~~iety,~~ 106:1-17.

Ross, P. S., G. M. Ellis, M. G. Ikonomou, L. G. Barrett-Lennard, and R. F. Addison. 2000. High PCB concentrations in free-ranging Pacific killer whales, *Orcinus orca*: effects of age, sex and dietary preference. Marine Pollution Bulletin 40(6):504-515.

~~Saulitis, E. L. 1993. The behavior and vocalizations of the "AT" group of killer whales (*Orcinus orca*) in Prince William Sound, Alaska. M.S. Thesis, University of Alaska Fairbanks, Fairbanks, AK, 193 pp.~~

Saulitis, E., C. O. Matkin, and F. H. Fay. 2005. Vocal repertoire and acoustic behavior of the isolated AT1 killer whale subpopulation in ~~S~~southern Alaska. Can. J. Zool. 83:1015-1029.

Sharpe, D. L., M. Castellote, P. R. Wade, and L. A. Cornick. 2017. Call types of Bigg's killer whales (*Orcinus orca*) in western Alaska: using vocal dialects to assess population structure. Bioacoustics 28(1):74-99. DOI: dx.doi.org/10.1080/09524622.2017.1396562 .

Towers, J. R., G. J. Sutton, T. J. H. Shaw, M. Malleson, D. Matkin, B. Gisborne, J. Forde, D. Ellifrit, G. M. Ellis, J. K. B. Ford, and T. Doniol-Valcroze. 2019. Photo-identification catalogue, population status, and distribution of Bigg's killer whales known from coastal waters of British Columbia, Canada. Can. Tech. Rep. Fish. Aquat. Sci. 3311: vi + 299 p.

~~Wade, P. R., and R. Angliss. 1997. Guidelines for assessing marine mammal stocks: report of the GAMMS workshop April 3-5, 1996, Seattle, Washington. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-OPR-12, 93 pp.~~

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX.

Revised ~~12/30/2019~~8/14/2020

HARBOR PORPOISE (*Phocoena phocoena*): Southeast Alaska Stock

NOTE – December 2015: In areas outside of Alaska, studies of harbor porpoise distribution have indicated that stock structure is likely more fine-scaled than is reflected in the Alaska Stock Assessment Reports. No data are available to define stock structure for harbor porpoise on a finer scale in Alaska. However, based on comparisons with other regions, it is likely that several regional and sub-regional populations exist. Should new information on harbor porpoise stocks become available, the harbor porpoise Stock Assessment Reports will be updated.

STOCK DEFINITION AND GEOGRAPHIC RANGE

In the eastern North Pacific Ocean, harbor porpoise range from Point Barrow and offshore areas of the Chukchi Sea, along the Alaska coast, and down the west coast of North America to Point Conception, California (Gaskin 1984, Christman and Aerts 2015). Harbor porpoise primarily frequent the coastal waters of the Gulf of Alaska and Southeast Alaska (Dahlheim et al. 2000, 2009), typically occurring in waters less than 100 m deep; however, occasionally they occur in deeper waters (Hobbs and Waite 2010). Within the inland waters of Southeast Alaska, harbor porpoise distribution is clumped with greatest densities observed in the Glacier Bay/Icy Strait region and near Zarembo and Wrangell Islands and the adjacent waters of Sumner Strait (Dahlheim et al. 2009, 2015). The average density of harbor porpoise in Alaska appears to be less than that reported off the west coast of the continental U.S., although areas of high densities do occur in Glacier Bay and the adjacent waters of Icy Strait, Yakutat Bay, the Copper River Delta, Sitkalidak Strait (Dahlheim et al. 2000, 2009, 2015; Hobbs and Waite 2010), and lower Cook Inlet (Shelden et al. 2014).

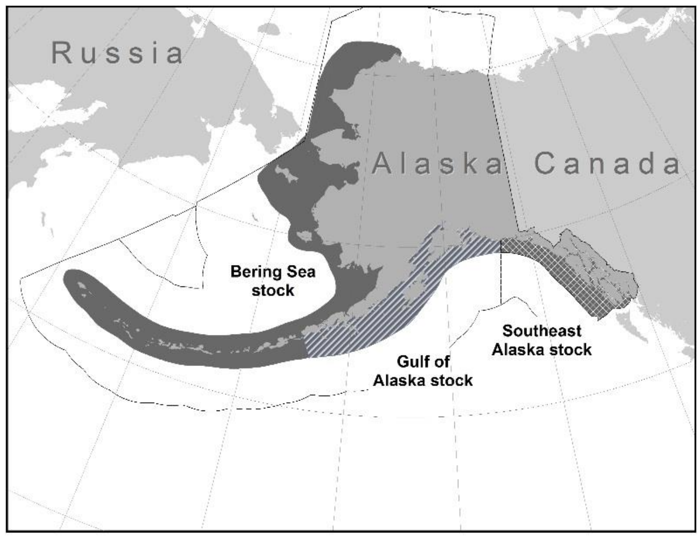

Figure 1. Approximate distribution of harbor porpoise in Alaska waters. The U.S. Exclusive Economic Zone is delineated by a black line.

Stock discreteness in the eastern North Pacific was analyzed using mitochondrial DNA from samples collected along the west coast (Rosel 1992), including one sample from Alaska. Two distinct mitochondrial DNA groupings or clades were found. One clade is present in California, Washington, British Columbia, and the single sample from Alaska (no samples were available from Oregon), while the other is found only in California and Washington. Although these two clades are not geographically distinct by latitude, the results may indicate a low mixing rate for harbor porpoise along the west coast of North America. Investigation of pollutant loads in harbor porpoise ranging from California to the Canadian border also suggests restricted harbor porpoise movements (Calambokidis and Barlow 1991); these results are reinforced by a similar study in the northwest Atlantic (Westgate and Tolley 1999). Further genetic testing of the same samples mentioned above, along with a few additional samples including eight more from Alaska, found differences between some of the four areas investigated, California, Washington, British Columbia, and Alaska, but inference was limited by small sample size (Rosel et al. 1995). Those results demonstrate that harbor porpoise along the west coast of North America are not panmictic and that movement is sufficiently restricted to result in genetic differences (Walton 1997). This is consistent with low movement suggested by genetic analysis of harbor porpoise specimens from the North Atlantic (Rosel et al. 1999). In a genetic analysis of small-scale population structure of eastern North Pacific harbor porpoise, Chivers et al. (2002) included 30 samples from Alaska, 16 of which were from the Copper River Delta, 5 from Barrow, 5 from Southeast Alaska, and 1 sample each from St. Paul, Adak, Kodiak, and Kenai. Unfortunately, no conclusions could be drawn about the genetic structure of harbor porpoise within Alaska because of the insufficient number of samples from each region. Accordingly, harbor porpoise stock structure in Alaska is defined by geographic areas.

Although it is difficult to determine the true stock structure of harbor porpoise populations in the northeast Pacific, from a management standpoint it is prudent to assume that regional populations exist and that they should be managed independently (Rosel et al. 1995, Taylor et al. 1996). Based on the above information, three harbor porpoise stocks in Alaska are currently specified, recognizing that the boundaries of these three stocks are identified primarily based upon geography or perceived areas of porpoise low density: 1) the Southeast Alaska stock - occurring from Dixon Entrance to Cape Suckling, ~~Alaska~~including inland waters (Fig. 1), 2) the Gulf of Alaska stock - occurring from Cape Suckling to Unimak Pass, and 3) the Bering Sea stock - occurring throughout the Aleutian Islands and all waters north of Unimak Pass ~~(Fig. 1)~~. There have been no analyses to assess the validity of these stock designations and research to assess substructure is ongoing only within a portion of the Southeast Alaska stock. Preliminary results from the analysis of environmental DNA (e-DNA) samples suggested significant genetic differentiation between porpoise concentrations found in Glacier Bay/Icy Strait and around Zarembo/Wrangell Islands (Parsons et al. 2018). Dahlheim et al. (2015) proposed that harbor porpoise in these regions potentially represent different subpopulations based on analogy with other west coast harbor porpoise populations, differences in trends in abundance of the two concentrations, and a possible hiatus in distribution between the two areas. Because e-DNA samples were obtained in only one area in the northern region and one area in the southern region, further sampling is needed to better understand substructure within Southeast Alaska, including the connectivity of subpopulations in inland waters and those in adjacent coastal waters. NMFS will consider whether concentrations of harbor porpoise in Glacier Bay/Icy Strait and around Zarembo/Wrangell Islands should be considered "prospective stocks" in a future Stock Assessment Report. Incidental takes from commercial fisheries within a small region (e.g., Wrangell and Zarembo Islands area) are of concern because of the potential impact on undefined localized stocks of harbor porpoise.

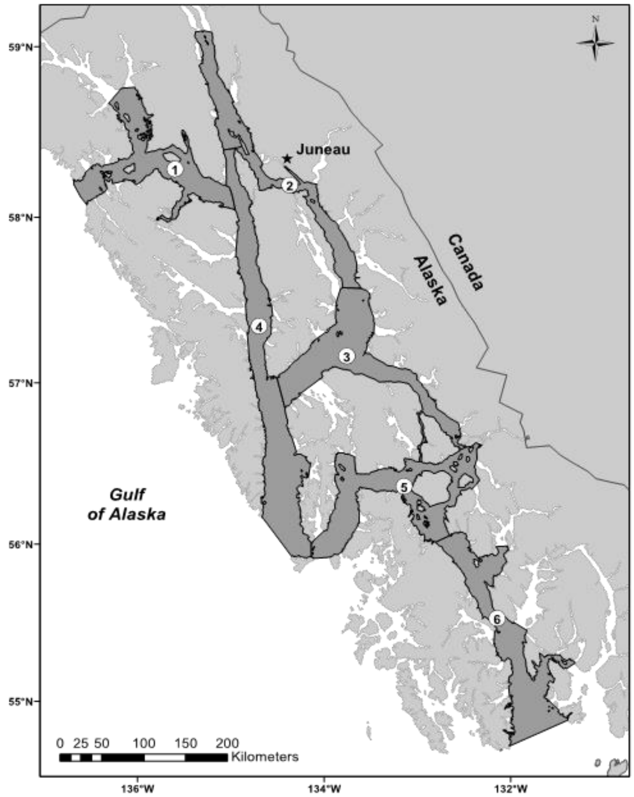

Figure 2. Survey strata defined for line-transect survey effort allocation in Southeast Alaska (as illustrated in Fig. 1 of Dahlheim et al. 2015). The northern region (Areas 1, 2, and 4) includes Cross Sound, Icy Strait, Glacier Bay, Lynn Canal, Stephens Passage, and Chatham Strait; the southern region (Areas 3, 5, and 6) includes Frederick Sound, Sumner Strait, Wrangell and Zarembo Islands, and Clarence Strait as far south as Ketchikan.

POPULATION SIZE

Information on harbor porpoise abundance and relative abundance has been collected for coastal and inside waters of Southeast Alaska by the Alaska Fisheries Science Center's Marine Mammal Laboratory (MML) using both aerial and shipboard surveys. Aerial surveys of this stock were conducted in June and July 1997 and resulted in an observed abundance estimate of 3,766 harbor porpoise (CV = 0.16) (Hobbs and Waite 2010); the surveys included a subset of smaller bays and inlets. Correction factors for observer perception bias and porpoise availability at the surface were used to develop an estimated corrected abundance of 11,146 harbor porpoise (3,766 × 2.96; CV = 0.24) in the coastal and inside waters of Southeast Alaska (Hobbs and Waite 2010).

~~In 1991, researchers initiated harbor porpoise studies aboard the NOAA ship *John N. Cobb* with broad survey coverage through the inland waters of Southeast Alaska. Between 1991 and 1993, line-transect methodology was used to 1) obtain population estimates of harbor porpoise, 2) establish a baseline for detecting trends in abundance, and 3) define overall distributional patterns and seasonality of harbor porpoise. The 1991 to 1993 vessel surveys were carried out each year in the spring, summer, and fall. Annual surveys were continued between 1994 and 2005; however, only two trips per year were conducted, one either in spring or summer and the other in fall.~~

~~These surveys were not designed to survey harbor porpoise habitat and standard line-transect methodology was not used; however, all cetaceans observed were recorded. During this 12-year period, observers reported fewer overall encounters with harbor porpoise. To fully assess abundance and population trends for harbor porpoise, line-transect methodology was used during the survey cruises in 2006 and 2007 (Dahlheim et al. 2009) and from 2010 to 2012 (Dahlheim et al. 2015). Previous studies reported no evidence of seasonal variation in the abundance of harbor porpoise occupying the inland waters of Southeast Alaska. Thus, only data collected during the summer were analyzed, given the broader spatial coverage and the greater number of surveys (i.e., a total of eight line-transect vessel surveys) completed during this season. Methods applied to the 2006 to 2012 surveys were comparable to those employed during the early 1990s; however, because these surveys only covered a portion of inland waters and not the entire range of this stock, they are not used to compute a stock-specific estimate of abundance.~~Relative abundance of harbor porpoise was computed from line-transect surveys carried out in the inland waters of Southeast Alaska in the summers of 1991-1993, 2005-2006, and 2010-2012 (Dahlheim et al 2015). Because these surveys only covered a portion of the inland waters and not the entire range of this stock, they were not used to compute stock-specific estimates of abundance. ~~The r~~Relative abundance ~~of harbor porpoise in inland waters of Southeast Alaska~~ was found to vary across the 22-year survey period~~s spanning the 22-year study (1991 to 2012)~~. Abundance estimated in 1991-1993 (N = 1,076; 95% CI = 910-1,272) was higher than the estimate obtained for 2006-2007 (N = 604; 95% CI = 468-780) but comparable to the estimate for 2010-2012 (N = 975; 95% CI = 857-1,109; Dahlheim et al. 2015). There is insufficient information to estimate the probability of detection (g(0)) from the ship surveys in Southeast Alaska; therefore, the abundance estimates above assume the probability of detection directly on the trackline to be unity (g(0) = 1). This assumption is typically violated in harbor porpoise surveys because observers tend to miss animals on the survey trackline. Therefore, the abundances provided by Dahlheim et al. (2015) were corrected using an estimate of g(0) from ship surveys for harbor porpoise off the U.S. east coast (g[0] = 0.72, CV = 0.083: Palka 1995) because the methods used in these surveys (e.g., size of vessels, number of observers) more closely resembled the methods employed in the Southeast Alaska surveys. Estimates corrected for g(0) are N(1991-1993) = 1,494 (95% CI = 1,130-1,974), N(2006-2007) = 839 (95% CI = 494-1,184), and N(2010-2012) = 1,354 (95% CI = 753-1,197).

Using the 2010 to 2012 survey data for the inland waters of Southeast Alaska, Dahlheim et al. (2015) calculated abundance estimates for the concentrations of harbor porpoise in the northern (Areas 1, 2, and 4) and southern (Areas 3, 5, and 6) regions of the inland waters (Fig. 2). The resulting g(0)-corrected abundance estimates are 553 harbor porpoise (CV = 0.13) in the northern inland waters (including Cross Sound, Icy Strait, Glacier Bay, Lynn Canal, Stephens Passage, and Chatham Strait) and 801 harbor porpoise (CV = 0.15) in the southern inland waters (including Frederick Sound, Sumner Strait, Wrangell and Zarembo Islands, and Clarence Strait as far south as Ketchikan).

A line-transect vessel survey was carried out in the inland waters of Southeast Alaska in July/August 2019 and data analysis is underway to compute new estimates of harbor porpoise abundance in this area.

Minimum Population Estimate

For the Southeast Alaska stock of harbor porpoise, the minimum population estimate (N_{MIN}) for the 2010-2012 shipboard surveys is 1,224 porpoise calculated using Equation 1 from the potential biological removal (PBR) guidelines (NMFS 2016): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$, where N = 1,354 (assumes g(0) = 0.72) and CV = 0.12. Since this abundance estimate represents some portion of the total number of animals in the stock, using this estimate to calculate N_{MIN} results in a negatively-biased N_{MIN} for the stock. Although harbor porpoise in the northern and southern regions of the inland waters of Southeast Alaska have not been determined to be subpopulations or stocks, PBR calculations for these areas may provide a frame of reference for comparison to harbor porpoise mortality and serious injury in the portion of the Southeast Alaska salmon drift gillnet fishery that was monitored in 2012 and 2013. The pooled 2010 to 2012 abundance estimates of 553 (CV = 0.13; assumes g(0) = 0.72) for the northern region and 801 (CV = 0.15; assumes g(0) = 0.72) for the southern region results in N_{MINs} of 496 and 707, respectively. Alaska Department of Fish and Game (ADF&G) Districts 6, 7, and 8, where the Southeast Alaska salmon drift gillnet fishery was observed in 2012 and 2013 (Manly 2015), partially overlap porpoise survey areas (Areas 5 and 6: Dahlheim et al. 2015) in the southern region of the inland waters.

Current Population Trend

An analysis of the line-transect vessel survey data collected throughout the inland waters of Southeast Alaska between 1991 and 2010 suggested high probabilities of a population decline ranging from 2 to 4% per year for the whole study area and highlighted a potentially important conservation issue (Zerbini et al. 2011). However, when data from 2011 and 2012 were added to this analysis, the population decline was no longer significant

(Dahlheim et al. 2015). It is unclear why a negative trend in harbor porpoise numbers was detected in inland waters of Southeast Alaska between 1991 and 2010 and reversed thereafter (Dahlheim et al. 2015). Regionally, abundance was relatively constant in the northern region of the inland waters of Southeast Alaska throughout the survey period, while declines and subsequent increases were documented in the southern region (Dahlheim et al. 2015).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is not available for the Southeast Alaska stock of harbor porpoise. Until additional data become available, the cetacean maximum theoretical net productivity rate of 4% will be used (NMFS 2016).

POTENTIAL BIOLOGICAL REMOVAL

PBR is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for cetacean stocks with unknown population status (NMFS 2016). Using the N_{MIN} of 1,224 (based on the 2010 to 2012 abundance estimate for harbor porpoise in the inland waters of Southeast Alaska), PBR is 12 harbor porpoise (1,224 × 0.02 × 0.5).

Computing N_{MINs} and PBRs for harbor porpoise in the northern and southern regions of the inland waters of Southeast Alaska may provide a frame of reference for the observed mortality and serious injury of harbor porpoise in the portion of the Southeast Alaska salmon drift gillnet fishery that was monitored in 2012 and 2013. Based on the pooled 2010 to 2012 abundance estimates and corresponding N_{MINs}, the PBR calculations for the northern and southern regions of the inland waters of Southeast Alaska are 5.0 (N = 553; CV = 0.13; N_{MIN} = 496) and 7.1 (N = 801; CV = 0.15; N_{MIN} = 707) harbor porpoise, respectively.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals between ~~2013~~2014 and ~~2017~~2018 is listed, by marine mammal stock, in ~~Delean et al. (2020)~~Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. The minimum estimated mean annual level of human-caused mortality and serious injury for Southeast Alaska harbor porpoise between ~~2013~~2014 and ~~2017~~2018 is 34 porpoise in U.S. commercial fisheries; however, this estimate is considered a minimum because not all of the salmon and herring fisheries operating within the range of this stock have been observed. Potential threats most likely to result in direct human-caused mortality or serious injury of this stock include entanglement in fishing gear.

Fisheries Information

Information ~~on~~for federally-managed and state-managed U.S. commercial fisheries in Alaska waters ~~(including observer programs, observer coverage, and observed incidental takes of marine mammals)~~ is ~~presented~~available in Appendi~~ces~~x 3~~-6~~ of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

No mortality or serious injury of harbor porpoise from the Southeast Alaska stock was observed incidental to federally-managed U.S. commercial fisheries in Alaska between ~~2013~~2014 and ~~2017~~2018.

In 2007 and 2008, the Alaska Marine Mammal Observer Program (AMMOP) placed observers in four regions where the state-managed Yakutat salmon set gillnet fishery operates (Manly 2009). These regions included the Alsek River area, the Situk area, the Yakutat Bay area, and the Kaliakh River and Tsiu River areas. Based on four mortalities and serious injuries observed during these 2 years, the estimated mean annual mortality and serious injury rate in the Yakutat salmon set gillnet fishery was 22 harbor porpoise (Table 1). Although these observer data are dated, they are considered the best available data on mortality and serious injury levels in these fisheries.

In 2012 and 2013, the AMMOP placed observers on independent vessels in the state-managed Southeast Alaska salmon drift gillnet fishery in ADF&G Management Districts 6, 7, and 8 to assess mortality and serious injury of marine mammals (Manly 2015). These Management Districts cover areas of Frederick Sound, Sumner Strait, Clarence Strait, and Anita Bay which include, but are not limited to, areas around and adjacent to Petersburg and Wrangell and Zarembo Islands. In 2013, four harbor porpoise were observed entangled and released: two were determined to be seriously injured and two were determined to be not seriously injured. Based on the two observed serious injuries, 23 serious injuries were estimated for Districts 6, 7, and 8 in 2013, resulting in an estimated mean annual mortality and serious injury rate of 12 harbor porpoise in 2012 and 2013 (Table 1). Since these three districts represent only a portion of the overall fishing effort in this fishery, this is a minimum estimate of mortality and serious injury for the fishery.

Table 1. Summary of incidental mortality and serious injury of Southeast Alaska harbor porpoise due to U.S. commercial fisheries between ~~2013~~2014 and ~~2017~~2018 (or the most recent data available) and calculation of the mean annual mortality and serious injury rate (Manly 2009, 2015). Methods for calculating percent observer coverage are described in Appendix ~~6~~3 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Yakutat salmon set gillnet	2007 2008	obs data	5.3 7.6	1 3	16.1 27.5	22 (CV = 0.54)
Southeast Alaska salmon drift gillnet (Districts 6, 7, and 8)	2012 2013	obs data	6.4 6.6	0 2	0 23	12 (CV = 1.0)
Minimum total estimated annual mortality						34 (CV = 0.77)

A complete estimate of the total mortality and serious injury incidental to U.S. commercial fisheries is not ~~un~~available for this stock because not all of the salmon and herring fisheries operating within the range of this stock have been observed. Based on observed mortality and serious injury in two commercial fisheries (Table 1), the minimum estimated mean annual mortality and serious injury rate incidental to U.S. commercial fisheries between ~~2013~~2014 and ~~2017~~2018 is 34 harbor porpoise.

Alaska Native Subsistence/Harvest Information

Subsistence hunters in Alaska have not been reported to take from this stock of harbor porpoise.

STATUS OF STOCK

Southeast Alaska harbor porpoise are not designated as depleted under the Marine Mammal Protection Act or listed as threatened or endangered under the Endangered Species Act. The minimum estimated mean annual level of human-caused mortality and serious injury for Southeast Alaska harbor porpoise (34 porpoise) exceeds the calculated PBR (12 porpoise), which means this stock is strategic. The minimum estimated mean annual U.S. commercial fishery-related mortality and serious injury rate (34 porpoise) is more than 10% of the calculated PBR (10% of PBR = 1.2 porpoise), so it is not considered insignificant and approaching a zero mortality and serious injury rate. However, the calculated PBR is likely biased low for the entire stock because it is based on estimates from the 2010 to 2012 surveys of only a portion (the inside waters of Southeast Alaska) of the range of this stock as currently designated. Population trends and status of this stock relative to its Optimum Sustainable Population are currently unknown.

There are key uncertainties in the assessment of the Southeast Alaska stock of harbor porpoise. This stock likely comprises multiple, smaller stocks based on analogy with harbor porpoise populations that have been the focus of specific studies on stock structure. Concentrations of harbor porpoise in the northern and southern regions of the inland waters of Southeast Alaska are identified, and N_{MINs} and PBR levels are calculated for these areas. The trend in abundance of harbor porpoise in these regions is unclear; an early decline appears to have reversed in recent years. Several commercial fisheries overlap with the range of this stock and are not observed or have not been observed in a long time; thus, the estimate of commercial fishery mortality and serious injury is expected to be a minimum estimate.~~ Estimates of human-caused mortality and serious injury from stranding data are underestimates because not all animals strand nor are all stranded animals found, reported, or have the cause of death determined.~~

HABITAT CONCERNS

Harbor porpoise are mostly found in nearshore areas and inland waters, including bays, tidal areas, and river mouths (Dahlheim et al. 2000, 2009, 2015; Hobbs and Waite 2010). As a result, harbor porpoise are vulnerable to physical modifications of nearshore habitats resulting from urban and industrial development (including waste management and nonpoint source runoff) and activities such as construction of docks and other over-water structures, filling of shallow areas, dredging, and noise (Linnenschmidt et al. 2013).

CITATIONS

Calambokidis, J., and J. Barlow. 1991. Chlorinated hydrocarbon concentrations and their use for describing population discreteness in harbor porpoises from Washington, Oregon, and California, p. 101-110. *In* J. E. Reynolds III and D. K. Odell (eds.), Proceedings of the Second Marine Mammal Stranding Workshop: 3-5 December 1987, Miami, Florida. U.S. Dep. Commer., NOAA Tech. Rep. NMFS-98.

Chivers, S. J., A. E. Dizon, P. J. Gearin, and K. M. Robertson. 2002. Small-scale population structure of eastern North Pacific harbor porpoise (*Phocoena phocoena*) indicated by molecular genetic analyses. J. Cetacean Res. Manage. 4(2):111-122.

Christman, C. L., and L. M. Aerts. 2015. Harbor porpoise (*Phocoena phocoena*) sightings from shipboard surveys in the Chukchi Sea during summer and fall, 2008-2014, p. 197. *In* Book of Abstracts, 2015 Alaska Marine Science Symposium, Anchorage, Alaska, January 19-23, 2015.

Dahlheim, M., A. York, R. Towell, J. Waite, and J. Breiwick. 2000. Harbor porpoise (*Phocoena phocoena*) abundance in Alaska: Bristol Bay to Southeast Alaska, 1991-1993. Mar. Mammal Sci. 16:28-45.

Dahlheim, M., P. A. White, and J. Waite. 2009. Cetaceans of Southeast Alaska: distribution and seasonal occurrence. J. Biogeogr. 36(3):410-426.

Dahlheim, M. E., A. N. Zerbini, J. M. Waite, and A. S. Kennedy. 2015. Temporal changes in abundance of harbor porpoise (*Phocoena phocoena*) inhabiting the inland waters of Southeast Alaska. Fish. Bull., U.S. 113(3):242-255.

~~Delean, B. J., V. T. Helker, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, J. Jannot, and N. C. Young. 2020. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2013-2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-401,86 p.~~

Gaskin, D. E. 1984. The harbor porpoise *Phocoena phocoena* (L.): regional populations, status, and information on direct and indirect catches. Rep. Int. Whal. Comm. 34:569-586.

Hobbs, R. C., and J. M. Waite. 2010. Abundance of harbor porpoise (*Phocoena phocoena*) in three Alaskan regions, corrected for observer errors due to perception bias and species misidentification, and corrected for animals submerged from view. Fish. Bull., U.S. 108(3):251-267.

Linnenschmidt, M., J. Teilmann, T. Akamatsu, R. Dietz, and L. A. Miller. 2013. Biosonar, dive, and foraging activity of satellite tracked harbor porpoises (*Phocoena phocoena*). Mar. Mammal Sci. 29(2):77-97.

Manly, B. F. J. 2009. Incidental catch of marine mammals and birds in the Yakutat salmon set gillnet fishery, 2007 and 2008. Final Report to NMFS Alaska Region. 96 p.

Manly, B. F. J. 2015. Incidental takes and interactions of marine mammals and birds in districts 6, 7, and 8 of the Southeast Alaska salmon drift gillnet fishery, 2012 and 2013. Final Report to NMFS Alaska Region. 52 p.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed ~~December 2019~~August 2020.

Palka, D. 1995. Abundance estimate of the Gulf of Maine harbor porpoise. Rep. Int. Whal. Comm. (Special Issue 16):27-50.

Parsons, K. M., M. Everett, M. Dahlheim, and L. Park. 2018. Water, water everywhere: environmental DNA can unlock population structure in elusive marine species. Royal Society Open Science 5:~~,~~180537. DOI: dx.doi.org/10.1098/rsos.180537 .

Rosel, P. E. 1992. Genetic population structure and systematic relationships of some small cetaceans inferred from mitochondrial DNA sequence variation. Ph.D. Dissertation, University of California San Diego. 191 p.

Rosel, P. E., A. E. Dizon, and M. G. Haygood. 1995. Variability of the mitochondrial control region in populations of the harbour porpoise, *Phocoena phocoena*, on inter-oceanic and regional scales. Can. J. Fish. Aquat. Sci. 52:1210-1219.

Rosel, P. E., R. Tiedemann, and M. Walton. 1999. Genetic evidence for limited trans-Atlantic movements of the harbor porpoise *Phocoena phocoena*. Mar. Biol. 133: 583-591.

Shelden, K. E. W., B. A. Agler, J. J. Brueggeman, L. A. Cornick, S. G. Speckman, and A. Prevel-Ramos. 2014. Harbor porpoise, *Phocoena phocoena vomerina*, in Cook Inlet, Alaska. Mar. Fish. Rev. 76(1-2):22-50.

Taylor, B. L., P. R. Wade, D. P. DeMaster, and J. Barlow. 1996. Models for management of marine mammals. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/48/SM50). 12 p.

Walton, M. J. 1997. Population structure of harbour porpoises *Phocoena phocoena* in the seas around the UK and adjacent waters. Proc. R. Soc. Lond. B 264:89-94.

Westgate, A. J., and K. A. Tolley. 1999. Geographical differences in organochlorine contaminants in harbour porpoises *Phocoena phocoena* from the western North Atlantic. Mar. Ecol. Prog. Ser. 177:255-268.

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX.

Zerbini, A. N., M. E. Dahlheim, J. M. Waite, A. S. Kennedy, P. R. Wade, and P. J. Clapham. 2011. Evaluation of population declines of harbor porpoise (*Phocoena phocoena*) in Southeastern Alaska inland waters, p. 23. *In* Book of Abstracts, 19th Biennial Conference on the Biology of Marine Mammals, Tampa, Florida, USA, 28 November-2 December 2011.

HARBOR PORPOISE (*Phocoena phocoena*): Gulf of Alaska Stock

NOTE – December 2015: In areas outside of Alaska, studies of harbor porpoise distribution have indicated that stock structure is likely more fine-scaled than is reflected in the Alaska Stock Assessment Reports. No data are available to define stock structure for harbor porpoise on a finer scale in Alaska. However, based on comparisons with other regions, it is likely that several regional and sub-regional populations exist. Should new information on harbor porpoise stocks become available, the harbor porpoise Stock Assessment Reports will be updated.

STOCK DEFINITION AND GEOGRAPHIC RANGE

In the eastern North Pacific Ocean, the harbor porpoise ranges from Point Barrow and offshore areas of the Chukchi Sea, along the Alaska coast, and down the west coast of North America to Point Conception, California (Gaskin 1984, Christman and Aerts 2015). Harbor porpoise primarily frequent the coastal waters of the Gulf of Alaska and Southeast Alaska (Dahlheim et al. 2000, 2009), typically occurring in waters less than 100 m deep; however, occasionally they occur in deeper waters (Hobbs and Waite 2010). The average density of harbor porpoise in Alaska appears to be less than that reported off the west coast of the continental U.S., although areas of high densities do occur in Glacier Bay and the adjacent waters of Icy Strait, Yakutat Bay, the Copper River Delta, Sitkalidak Strait (Dahlheim et al. 2000, 2009, 2015; Hobbs and Waite 2010), and lower Cook Inlet (Shelden et al. 2014).

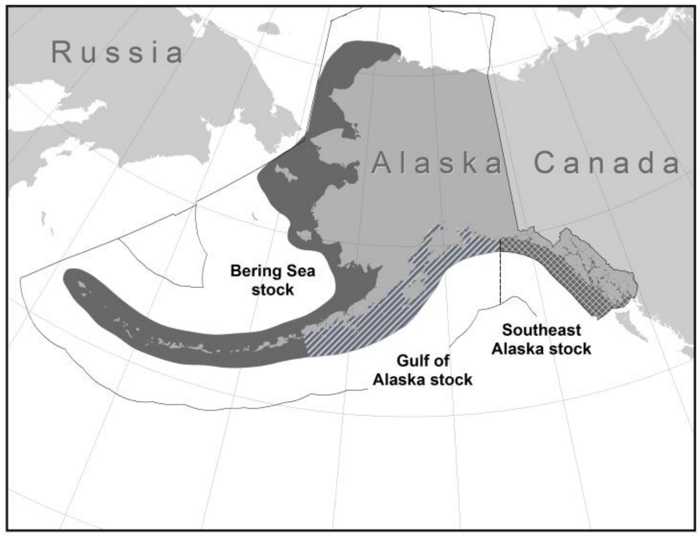

Figure 1. Approximate distribution of harbor porpoise in Alaska waters. The U.S. Exclusive Economic Zone is delineated by a black line.

Stock discreteness in the eastern North Pacific was analyzed using mitochondrial DNA from samples collected along the west coast (Rosel 1992), including one sample from Alaska. Two distinct mitochondrial DNA groupings or clades were found. One clade is present in California, Washington, British Columbia, and the single sample from Alaska (no samples were available from Oregon), while the other is found only in California and Washington. Although these two clades are not geographically distinct by latitude, the results may indicate a low mixing rate for harbor porpoise along the west coast of North America. Investigation of pollutant loads in harbor porpoise ranging from California to the Canadian border also suggests restricted harbor porpoise movements (Calambokidis and Barlow 1991); these results are reinforced by a similar study in the northwest Atlantic (Westgate and Tolley 1999). Further genetic testing of the same samples mentioned above, along with a few additional samples including eight more from Alaska, found differences between some of the four areas investigated, California, Washington, British Columbia, and Alaska, but inference was limited by small sample size (Rosel et al. 1995). Those results demonstrate that harbor porpoise along the west coast of North America are not panmictic and that movement is sufficiently restricted to result in genetic differences (Walton 1997). This is consistent with low movement suggested by genetic analysis of harbor porpoise specimens from the North Atlantic (Rosel et al. 1999). In a genetic analysis of small-scale population structure of eastern North Pacific harbor porpoise, Chivers et al. (2002) included 30 samples from Alaska, 16 of which were from the Copper River Delta, 5 from Barrow, 5 from Southeast Alaska, and 1 sample each from St. Paul, Adak, Kodiak, and Kenai. Unfortunately, no conclusions could be drawn about the genetic structure of harbor porpoise within Alaska because of the insufficient number of samples from each region. Accordingly, harbor porpoise stock structure in Alaska is defined by geographic areas.

Although it is difficult to determine the true stock structure of harbor porpoise populations in the northeast Pacific, from a management standpoint it is prudent to assume that regional populations exist and that they should be managed independently (Rosel et al. 1995, Taylor et al. 1996). Based on the above information, three harbor porpoise stocks in Alaska are currently specified, recognizing that the boundaries of these three stocks are inferred primarily based upon geography or perceived areas of low porpoise density: 1) the Southeast Alaska stock - occurring from Dixon Entrance to Cape Suckling, ~~Alaska~~including inland waters, 2) the Gulf of Alaska stock - occurring from Cape Suckling to Unimak Pass (Fig. 1), and 3) the Bering Sea stock - occurring throughout the Aleutian Islands and all waters north of Unimak Pass ~~(Fig. 1)~~. There have been no analyses to assess the validity of these stock designations and research to assess substructure is ongoing only within the Southeast Alaska stock (see the Southeast Alaska harbor porpoise Stock Assessment Report and Parsons et al. 2018).

POPULATION SIZE

In June and July of 1998 and 1999, an aerial survey covered the waters of the western Gulf of Alaska from Cape Suckling to Unimak Island, offshore to the 1,000 fathom depth contour. Two types of corrections were needed for these aerial surveys: one to correct for animals available but not counted because they were not detected by the observers (perception bias) and another to correct for porpoise that were submerged and not available at the surface (availability bias). The 1998 survey resulted in an abundance estimate for the Gulf of Alaska harbor porpoise stock of 10,489 porpoise (coefficient of variation (CV) = 0.12) (Hobbs and Waite 2010), which includes a correction factor (1.372; CV = 0.07) for perception bias. Laake et al. (1997) estimated the availability bias correction factor for aerial surveys of harbor porpoise in Puget Sound to be 2.96 (CV = 0.18); the use of this correction factor is preferred to other published correction factors (e.g., Barlow et al. 1988, Calambokidis et al. 1993) because it is an empirical estimate of availability bias. Hobbs and Waite (2010) applied the Laake et al. (1997) correction factor to the 1998 estimate, resulting in a corrected abundance of 31,046 porpoise (10,489 × 2.96 = 31,046; CV = 0.21) for the Gulf of Alaska stock.

This latest estimate of abundance (31,046) is considerably higher than the estimate reported in the 1999 stock assessment (8,271; CV = 0.31), which was based on surveys conducted in 1991-1993. This disparity largely stems from changes in the area covered by the two surveys and differences in harbor porpoise density encountered in areas added to, or dropped from, the 1998 survey relative to the 1991 to 1993 surveys. The survey area in 1998 (119,183 km^2) was greater than the area covered in the combined portions of the 1991, 1992, and 1993 surveys (106,600 km^2). The 1998 survey included selected bays, channels, and inlets in Prince William Sound, the outer Kenai Peninsula, the south side of the Alaska Peninsula, and the Kodiak Archipelago, whereas, the earlier survey included only open water areas. Several of the bays and inlets covered by the 1998 survey had higher harbor porpoise densities than ~~was~~were observed in the open waters. In addition, the 1998 estimate provided by Hobbs and Waite (2010) empirically estimates the perception bias and uses this in addition to the correction factor for availability bias. Finally, the 1998 estimate extrapolates available densities to estimate the number of porpoise which would likely be found in unsurveyed inlets within the study area. For these reasons, the 1998 survey result is probably more representative of the size of the Gulf of Alaska harbor porpoise stock.

Minimum Population Estimate

The minimum population estimate (N_{MIN}) for this stock is calculated using Equation 1 from the potential biological removal (PBR) guidelines (NMFS 2016): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{1/2})$. Using the population estimate (N) of 31,046 in 1998 and its associated ~~coefficient of variation (~~CV~~)~~ of 0.21, N_{MIN} for the Gulf of Alaska stock of harbor porpoise is 26,064. However, because the survey data are now more than 8 years old, N_{MIN} is considered unknown for this stock.

Current Population Trend

There is no reliable information on trends in abundance for the Gulf of Alaska stock of harbor porpoise ~~since~~because survey methods and results are not comparable.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is not available for the Gulf of Alaska stock of harbor porpoise. Until additional data become available, the cetacean maximum theoretical net productivity rate of 4% will be used (NMFS 2016).

POTENTIAL BIOLOGICAL REMOVAL

PBR is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for cetacean stocks with unknown population status (NMFS 2016). However, the 2016 guidelines for preparing Stock Assessment Reports (NMFS 2016) state that abundance estimates older than 8 years should not be used to calculate PBR due to a decline in confidence in the reliability of an aged abundance estimate. Therefore, the PBR for this stock is considered undetermined.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals between ~~2013~~2014 and ~~2017~~2018 is listed, by marine mammal stock, in ~~Delean et al. (2020)~~Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. The minimum estimated mean annual level of human-caused mortality and serious injury for Gulf of Alaska harbor porpoise between ~~2013~~2014 and ~~2017~~2018 is 72 porpoise: 72 in U.S. commercial fisheries and 0.2 in unknown (commercial, recreational, or subsistence) fisheries; however, this estimate is considered a minimum because of the absence of observer placements in all of the salmon and herring fisheries operating within the range of this stock. Potential threats most likely to result in direct human-caused mortality or serious injury of this stock include entanglement in fishing gear.

Fisheries Information

Information ~~on~~for federally-managed and state-managed U.S. commercial fisheries in Alaska waters ~~(including observer programs, observer coverage, and observed incidental takes of marine mammals)~~ is ~~presented~~available in Appendi~~ces~~x 3~~-6~~ of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

No incidental mortality or serious injury of Gulf of Alaska harbor porpoise was observed in U.S. federal commercial fisheries between ~~2013~~2014 and ~~2017~~2018. Alaska Marine Mammal Observer Program (AMMOP) observers monitoring the State of Alaska-managed Prince William Sound salmon drift gillnet fishery in 1990 and 1991 recorded 1 mortality in 1990 and 3 in 1991, which extrapolated to 8 (95% CI: 1-23) and 32 (95% CI: 3-103) for the entire fishery, resulting in a mean annual mortality and serious injury rate of 20 porpoise (CV = 0.60) when averaged over 1990 and 1991 (Table 1; Wynne et al. 1991, 1992). The Prince William Sound salmon drift gillnet fishery has not been observed since 1991 and no additional data are available for this fishery.

In 1999 and 2000, AMMOP observers were placed on state-managed Cook Inlet salmon set and drift gillnet vessels. One harbor porpoise mortality was observed in 2000 in the Cook Inlet salmon drift gillnet fishery (Manly 2006). This single mortality extrapolates to an estimated mortality and serious injury rate of 31 porpoise for that year and an average of 16 porpoise per year when averaged over the 2 years of observer data (Table 1).

In 2002 and 2005, AMMOP observers were placed on state-managed Kodiak Island set gillnet vessels. Harbor porpoise mortality observed in this fishery (two each in both 2002 and 2005) (Manly 2007) extrapolates to an estimated mean annual mortality and serious injury rate of 36 harbor porpoise (Table 1). Although these observer data are dated, they are considered the best available data on mortality and serious injury levels in these fisheries.

Table 1. Summary of incidental mortality and serious injury of Gulf of Alaska harbor porpoise due to state-managed fisheries from 1990 through 2005 and calculation of the mean annual mortality and serious injury rate (Wynne et al. 1991, 1992; Manly 2006, 2007). Methods for calculating percent observer coverage are described in Appendix ~~6~~3 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Prince William Sound salmon drift gillnet	1990 1991	obs data	4 5	1 3	8 32	20 (CV = 0.60)
Cook Inlet salmon drift gillnet	1999 2000	obs data	1.6 3.6	0 1	0 31	16 (CV = 1.00)
Cook Inlet salmon set gillnet	1999 2000	obs data	0.16-1.1 0.34-2.7	0 0	0 0	0

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Kodiak Island salmon set gillnet	2002 2005	obs data	6.0 4.9	2 2	32 39	36 (CV = 0.68)
Minimum total estimated annual mortality						72 (CV = 0.44)

Reports to the NMFS Alaska Region marine mammal stranding network of ~~Strandings of~~ marine mammals with fishing gear attached or with injuries caused by interactions with fishing gear are another source of mortality data. A harbor porpoise mortality, due to entanglement in unidentified fishing net near Homer, Alaska, was reported ~~to the NMFS Alaska Region stranding network~~ in 2014, resulting in a minimum mean annual mortality and serious injury rate of 0.2 harbor porpoise from this stock in unknown (commercial, recreational, or subsistence) fisheries between ~~2013~~2014 and ~~2017~~2018 (Table 2; ~~Delean et al. 2020~~Young et al. in press). This mortality and serious injury estimate results from an actual count of verified human-caused deaths and serious injuries and is a minimum because not all entangled animals strand nor are all stranded animals found, reported, or have the cause of death determined.

Table 2. Summary of incidental mortality and serious injury of Gulf of Alaska harbor porpoise, by year and type, reported to the NMFS Alaska Region marine mammal stranding network between ~~2013~~2014 and ~~2017~~2018 (~~Delean et al. 2020~~Young et al. in press).

Cause of Injury	~~2013~~	2014	2015	2016	2017	2018	Mean annual mortality
Entangled in unidentified net*	~~0~~	1	0	0	0	0	0.2
*Total in unknown (commercial, recreational, or subsistence) fisheries							0.2

A complete estimate of the total mortality and serious injury incidental to U.S. commercial fisheries is unavailable for this stock because of the absence of an observer program for all of the salmon and herring fisheries operating within the range of this stock. Based on observed mortality and serious injury in four commercial fisheries (Table 1) and a report to the NMFS Alaska Region stranding network (Table 2), the minimum estimated mean annual mortality and serious injury rate incidental to all fisheries between ~~2013~~2014 and ~~2017~~2018 is 72 harbor porpoise from this stock (72 in U.S. commercial fisheries + 0.2 in unknown fisheries).

Alaska Native Subsistence/Harvest Information

Porpoise in the Gulf of Alaska were hunted by prehistoric societies from Kodiak Island and areas around Cook Inlet and Prince William Sound (Shelden et al. 2014). Subsistence hunters have not been reported to harvest from this stock of harbor porpoise since the early 1900s (Shelden et al. 2014).

STATUS OF STOCK

Gulf of Alaska harbor porpoise are not designated as depleted under the Marine Mammal Protection Act or listed as threatened or endangered under the Endangered Species Act. The abundance estimate for this stock is unknown because the existing estimate is more than 8 years old and so the PBR level is considered undetermined. Because the PBR is undetermined and fisheries observer coverage is limited and aged, it is unknown if the minimum estimate of the mean annual mortality and serious injury rate (72 porpoise) in U.S. commercial fisheries can be considered insignificant and approaching a zero mortality and serious injury rate. NMFS considers this stock strategic because the level of mortality and serious injury would likely exceed the PBR level if we had accurate information on stock structure, a newer abundance estimate, and complete fisheries observer coverage. Population trends and status of this stock relative to its Optimum Sustainable Population are unknown.

There are key uncertainties in the assessment of the Gulf of Alaska stock of harbor porpoise. This stock likely comprises multiple, smaller stocks based on analogy with harbor porpoise populations that have been the focus of specific studies on stock structure. The most recent surveys were more than 8 years ago and, given the lack of information on population trend, the abundance estimates are not used to calculate an N_{MIN} and the PBR level is undetermined. Several commercial fisheries overlap with the range of this stock and are not observed or have not been observed in a long time; thus, the estimate of commercial fishery mortality and serious injury is expected to be a minimum estimate. Estimates of human-caused mortality and serious injury from stranding data and fisherman self-reports are underestimates because not all animals strand or are self-reported nor are all stranded animals found, reported, or have the cause of death determined.

HABITAT CONCERNS

Harbor porpoise are mostly found in nearshore areas, bays, tidal areas, and river mouths (Dahlheim et al. 2000, Hobbs and Waite 2010). As a result, harbor porpoise are vulnerable to physical modifications of nearshore habitats resulting from urban and industrial development (including waste management and nonpoint source runoff) and activities such as construction of docks and other over-water structures, filling of shallow areas, dredging, and noise (Linnenschmidt et al. 2013).

CITATIONS

Barlow, J., C. W. Oliver, T. D. Jackson, and B. L. Taylor. 1988. Harbor porpoise, *Phocoena phocoena*, abundance estimation for California, Oregon, and Washington: II. Aerial surveys. Fish. Bull., U.S. 86:433-444.

Calambokidis, J., and J. Barlow. 1991. Chlorinated hydrocarbon concentrations and their use for describing population discreteness in harbor porpoises from Washington, Oregon, and California, p. 101-110. *In* J. E. Reynolds III and D. K. Odell (eds.), Proceedings of the Second Marine Mammal Stranding Workshop: 3-5 December 1987, Miami, Florida. U.S. Dep. Commer., NOAA Tech. Rep. NMFS-98.

Calambokidis, J., J. R. Evenson, J. C. Cubbage, S. D. Osmek, D. Rugh, and J. L. Laake. 1993. Calibration of sighting rates of harbor porpoise from aerial surveys. Final Report to the National Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115. 55 p.

Chivers, S. J., A. E. Dizon, P. J. Gearin, and K. M. Robertson. 2002. Small-scale population structure of eastern North Pacific harbor porpoise (*Phocoena phocoena*) indicated by molecular genetic analyses. J. Cetacean Res. Manage. 4(2):111-122.

Christman, C. L., and L. M. Aerts. 2015. Harbor porpoise (*Phocoena phocoena*) sightings from shipboard surveys in the Chukchi Sea during summer and fall, 2008-2014, p. 197. *In* Book of Abstracts, 2015 Alaska Marine Science Symposium, Anchorage, Alaska, January 19-23, 2015.

Dahlheim, M., A. York, R. Towell, J. Waite, and J. Breiwick. 2000. Harbor porpoise (*Phocoena phocoena*) abundance in Alaska: Bristol Bay to Southeast Alaska, 1991-1993. Mar. Mammal Sci. 16:28-45.

Dahlheim, M., P. A. White, and J. Waite. 2009. Cetaceans of Southeast Alaska: distribution and seasonal occurrence. J. Biogeogr. 36(3):410-426.

Dahlheim, M. E, A. N. Zerbini, J. M. Waite, and A. S. Kennedy. 2015. Temporal changes in abundance of harbor porpoise (*Phocoena phocoena*) inhabiting the inland waters of Southeast Alaska. Fish. Bull., U.S. 113(2):242-255. DOI: dx.doi.org/10.7755/FB.113.3.2 .

~~Delean, B. J., V. T. Helker, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, J. Jannot, and N. C. Young. 2020. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2013-2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-401, 86 p.~~

Gaskin, D. E. 1984. The harbor porpoise *Phocoena phocoena* (L.): regional populations, status, and information on direct and indirect catches. Rep. Int. Whal. Comm. 34:569-586.

Hobbs, R. C., and J. M. Waite. 2010. Abundance of harbor porpoise (*Phocoena phocoena*) in three Alaskan regions, corrected for observer errors due to perception bias and species misidentification, and corrected for animals submerged from view. Fish. Bull., U.S. 108(3):251-267.

Laake, J. L., J. Calambokidis, S. D. Osmek, and D. J. Rugh. 1997. Probability of detecting harbor porpoise from aerial surveys: estimating g(0). J. Wildl. Manage. 61(1):63-75.

Linnenschmidt, M., J. Teilmann, T. Akamatsu, R. Dietz, and L. A. Miller. 2013. Biosonar, dive, and foraging activity of satellite tracked harbor porpoises (*Phocoena phocoena*). Mar. Mammal Sci. 29-(2):77-97.

Manly, B. F. J. 2006. Incidental catch and interactions of marine mammals and birds in the Cook Inlet salmon driftnet and setnet fisheries, 1999-2000. Final Report to NMFS Alaska Region. 98 p.

Manly, B. F. J. 2007. Incidental take and interactions of marine mammals and birds in the Kodiak Island salmon set gillnet fishery, 2002 and 2005. Final Report to NMFS Alaska Region. 221 p.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed ~~December 2019~~August 2020.

Parsons, K. M., M. Everett, M. Dahlheim, and L. Park. 2018. Water, water everywhere: environmental DNA can unlock population structure in elusive marine species. Royal Society Open Science 5:180537. DOI: dx.doi.org/10.1098/rsos.180537 .

Rosel, P. E. 1992. Genetic population structure and systematic relationships of some small cetaceans inferred from mitochondrial DNA sequence variation. Ph.D. Dissertation, University of California San Diego. 191 p.

Rosel, P. E., A. E. Dizon, and M. G. Haygood. 1995. Variability of the mitochondrial control region in populations of the harbour porpoise, *Phocoena phocoena*, on inter-oceanic and regional scales. Can. J. Fish. Aquat. Sci. 52:1210-1219.

Rosel, P. E., R. Tiedemann, and M. Walton. 1999. Genetic evidence for limited trans-Atlantic movements of the harbor porpoise *Phocoena phocoena*. Mar. Biol. 133:583-591.

Shelden, K. E. W., B. A. Agler, J. J. Brueggeman, L. A. Cornick, S. G. Speckman, and A. Prevel-Ramos. 2014. Harbor porpoise, *Phocoena phocoena vomerina*, in Cook Inlet, Alaska. Mar. Fish. Rev. 76(1-2):22-50.

Taylor, B. L., P. R. Wade, D. P. DeMaster, and J. Barlow. 1996. Models for management of marine mammals. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/48/SM50). 12 p.

Walton, M. J. 1997. Population structure of harbour porpoises *Phocoena phocoena* in the seas around the UK and adjacent waters. Proc. R. Soc. Lond. B 264:89-94.

Westgate, A. J., and K. A. Tolley. 1999. Geographical differences in organochlorine contaminants in harbour porpoises *Phocoena phocoena* from the western North Atlantic. Mar. Ecol. Prog. Ser. 177:255-268.

Wynne, K. M., D. Hicks, and N. Munro. 1991. 1990 salmon gillnet fisheries observer programs in Prince William Sound and South Unimak Alaska. Annual Report NMFS/NOAA Contract 50ABNF000036. 65 p. Available from NMFS Alaska Region, Office of Marine Mammals, P.O. Box 21668, Juneau, AK 99802.

Wynne, K. M., D. Hicks, and N. Munro. 1992. 1991 marine mammal observer program for the salmon driftnet fishery of Prince William Sound Alaska. Annual Report NMFS/NOAA Contract 50ABNF000036. 53 p. Available from NMFS Alaska Region, Office of Marine Mammals, P.O. Box 21668, Juneau, AK 99802.

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC.

HARBOR PORPOISE (*Phocoena phocoena*): Bering Sea Stock

NOTE – December 2015: In areas outside of Alaska, studies of harbor porpoise distribution have indicated that stock structure is likely more fine-scaled than is reflected in the Alaska Stock Assessment Reports. No data are available to define stock structure for harbor porpoise on a finer scale in Alaska. However, based on comparisons with other regions, it is likely that several regional and sub-regional populations exist. Should new information on harbor porpoise stocks become available, the harbor porpoise Stock Assessment Reports will be updated.

STOCK DEFINITION AND GEOGRAPHIC RANGE

In the eastern North Pacific Ocean, the harbor porpoise ranges from Point Barrow and offshore areas of the Chukchi Sea, along the Alaska coast, and down the west coast of North America to Point Conception, California (Gaskin 1984, Christman and Aerts 2015). Harbor porpoise primarily frequent the coastal waters of the Gulf of Alaska and Southeast Alaska (Dahlheim et al. 2000, 2009), typically occurring in waters less than 100 m deep; however, occasionally they occur in deeper waters (Hobbs and Waite 2010). The average density of harbor porpoise in Alaska appears to be less than that reported off the west coast of the continental U.S., although areas of high densities do occur in Glacier Bay and the adjacent waters of Icy Strait, Yakutat Bay, the Copper River Delta, Sitkalidak Strait (Dahlheim et al. 2000, 2009, 2015; Hobbs and Waite 2010), and lower Cook Inlet (Shelden et al. 2014).

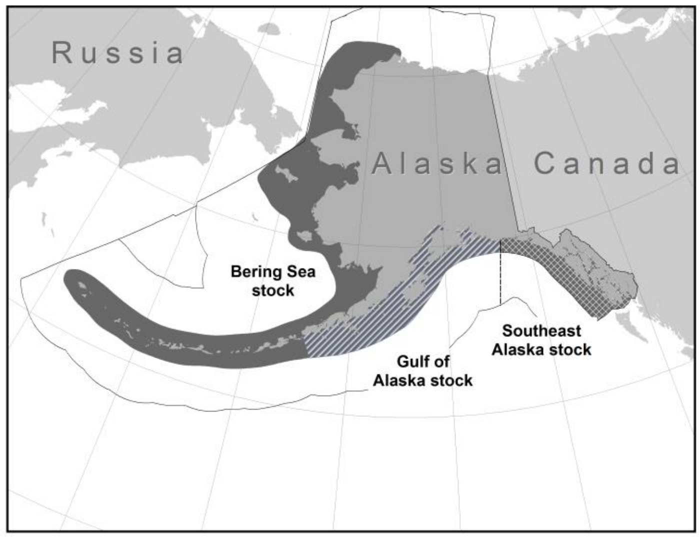

Figure 1. Approximate distribution of harbor porpoise in Alaska waters. The U.S. Exclusive Economic Zone is delineated by a black line.

Stock discreteness in the eastern North Pacific was analyzed using mitochondrial DNA from samples collected along the west coast (Rosel 1992), including one sample from Alaska. Two distinct mitochondrial DNA groupings or clades were found. One clade is present in California, Washington, British Columbia, and the single sample from Alaska (no samples were available from Oregon), while the other is found only in California and Washington. Although these two clades are not geographically distinct by latitude, the results may indicate a low mixing rate for harbor porpoise along the west coast of North America. Investigation of pollutant loads in harbor porpoise ranging from California to the Canadian border also suggests restricted harbor porpoise movements (Calambokidis and Barlow 1991); these results are reinforced by a similar study in the northwest Atlantic (Westgate and Tolley 1999). Further genetic testing of the same samples mentioned above, along with a few additional samples including eight more from Alaska, found differences between some of the four areas investigated, California, Washington, British Columbia, and Alaska, but inference was limited by small sample size (Rosel et al. 1995). Those results demonstrate that harbor porpoise along the west coast of North America are not panmictic and that movement is sufficiently restricted to result in genetic differences (Walton 1997). This is consistent with low movement suggested by genetic analysis of harbor porpoise specimens from the North Atlantic (Rosel et al. 1999). In a genetic analysis of small-scale population structure of eastern North Pacific harbor porpoise, Chivers et al. (2002) included 30 samples from Alaska, 16 of which were from the Copper River Delta, 5 from Barrow, 5 from Southeast Alaska, and 1 sample each from St. Paul, Adak, Kodiak, and Kenai. Unfortunately, no conclusions could be drawn about the genetic structure of harbor porpoise within Alaska because of the insufficient number of samples from each region. Accordingly, harbor porpoise stock structure in Alaska is defined by geographic areas.

Although it is difficult to determine the true stock structure of harbor porpoise populations in the northeast Pacific, from a management standpoint it is prudent to assume that regional populations exist and that they should be managed independently (Rosel et al. 1995, Taylor et al. 1996). Based on the above information, three harbor porpoise stocks in Alaska are currently specified, recognizing that the boundaries of these three stocks are inferred primarily based upon geography or perceived areas of low porpoise density: 1) the Southeast Alaska stock - occurring from Dixon Entrance to Cape Suckling, ~~Alaska~~including inland waters, 2) the Gulf of Alaska stock - occurring from Cape Suckling to Unimak Pass, and 3) the Bering Sea stock - occurring throughout the Aleutian Islands and all waters north of Unimak Pass (Fig. 1). There have been no analyses to assess the validity of these stock designations and research to assess substructure is ongoing only within the Southeast Alaska stock (see the Southeast Alaska harbor porpoise Stock Assessment Report and Parsons et al. 2018).

Harbor porpoise have been sighted during seismic surveys of the Chukchi Sea conducted in the nearshore and offshore waters by the oil and gas industry between July and November from 2006 to ~~2010~~2014 (Funk et al. 2010, 2011; Reiser et al. 2011; Aerts et al. 2013; Christman and Aerts 2015). Harbor porpoise were the third most frequently sighted cetacean species in the Chukchi Sea, after gray and bowhead whales, with most sightings occurring during the September to October monitoring period (Funk et al. 2011, Reiser et al. 2011, Christman and Aerts 2015). Over the 2006 to 2010 industry-sponsored monitoring period, six sightings of 11 harbor porpoise were reported in the Beaufort Sea, suggesting harbor porpoise regularly occur in both the Chukchi and Beaufort seas (Funk et al. 2011).

POPULATION SIZE

In June and July of 1999, an aerial survey covered the waters of Bristol Bay. Two types of corrections were needed for these aerial surveys: one to correct for animals available but not counted because they were missed by the observer (perception bias) and another to correct for porpoise that were submerged and not available at the surface (availability bias). The 1999 survey resulted in an observed abundance estimate for the Bering Sea harbor porpoise stock of 16,289 (coefficient of variation (CV) = 0.13: Hobbs and Waite 2010), which includes the perception bias correction factor (1.337; CV = 0.06) obtained during the survey using an independent belly window observer. Laake et al. (1997) estimated the availability bias correction factor for aerial surveys of harbor porpoise in Puget Sound to be 2.96 (CV = 0.18); the use of this correction factor is preferred to other published correction factors (e.g., Barlow et al. 1988, Calambokidis et al. 1993) because it is an empirical estimate of availability bias. Applying the Laake et al. (1997) correction factor, the corrected abundance estimate is 48,215 porpoise (16,289 × 2.96 = 48,215; CV = 0.22). The estimate for 1999 can be considered conservative for that time period, as the surveyed areas did not include known harbor porpoise range along the Aleutian Island chain, near the Pribilof Islands, or in the waters north of Cape Newenham (approximately 59°N).

Shipboard visual line-transect surveys for cetaceans were conducted on the eastern Bering Sea shelf in association with pollock stock assessment surveys in June and July of 1999, 2000, 2002, 2004, 2008, and 2010 (Moore et al. 2002; Friday et al. 2012, 2013). The entire range of the survey was completed in three of those years (2002, 2008, and 2010) and harbor porpoise abundance estimates were calculated for each of these surveys as 1,971 porpoise (CV = 0.46) for 2002, 4,056 (CV = 0.40) for 2008, and 833 (CV = 0.66) for 2010 (Friday et al. 2013)~~; however, correction factors were not applied for perception bias, availability bias, or responsive movement to the ship. The abundance estimate was 1,971 porpoise (CV = 0.46) for 2002, 4,056 (CV = 0.40) for 2008, and 833 (CV = 0.66) for 2010. Although the 2010 estimate is the lowest of the three years, it is not significantly different from the 2002 and 2008 estimates (Friday et al. 2013). These surveys are useful for showing distribution throughout the southeastern Bering Sea and the relationship to hydrographic domains; however, because the surveys were not designed to estimate abundance of harbor porpoise and no correction factors to account for groups missed on the trackline or responsive movement are available, these estimates are not used to calculate minimum population estimates.~~ The abundance estimates provided above assume the probability of detection directly on the trackline to be unity (g(0) = 1). This assumption is typically violated in harbor porpoise surveys because observers tend to miss animals on the survey trackline. Because no estimate of g(0) was computed for the Bering Sea survey in Friday et al. (2013), their abundance estimates were corrected using an averaged estimate of g(0) (weighted by the inverse of the CV) from ship surveys for harbor porpoise in other areas off the U.S. coast (g[0] = 0.71, CV = 0.052: Barlow 1988; Palka 1995, 2000). Using this value for g(0), corrected abundance estimates for harbor porpoise in the Bering Sea are 2,276 porpoise (CV = 0.46) for 2002, 5,713 (CV = 0.40) for 2008, and 1,173 (CV = 0.66) for 2010. The 2008 ship survey estimate is used below to calculate N_{MIN} because the spatial coverage during the year of the most recent estimate (2010) was limited due to poor weather conditions and missed many habitats where harbor porpoise are known to occur in the Bering Sea (e.g., Fig. 7 in Friday et al. 2013).

Minimum Population Estimate

The minimum population estimate (N_{MIN}) for this stock is calculated using Equation 1 from the potential biological removal (PBR) guidelines (NMFS 2016): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the ~~1999~~2008 ship survey partial population estimate (N) of ~~48,215~~5,713 and its associated ~~coefficient of variation (~~CV~~)~~ of ~~0.22~~0.40, N_{MIN} for the Bering Sea stock of harbor porpoise is ~~40,150~~4,130. However, this is an underestimate for the entire stock because it is based on a survey that covered only a small portion of the stock's range~~,~~. ~~b~~Because the survey data are more than 8 years old, N_{MIN} is considered unknown.

Current Population Trend

There is no reliable information on trends in abundance for the Bering Sea stock of harbor porpoise.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is not available for this stock of harbor porpoise. Until additional data become available, the default cetacean maximum theoretical net productivity rate of 4% will be used (NMFS 2016).

POTENTIAL BIOLOGICAL REMOVAL

PBR is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.5, the value for cetacean stocks with unknown population status (NMFS 2016). However, the 2016 guidelines for preparing Stock Assessment Reports (NMFS 2016) state that abundance estimates older than 8 years should not be used to calculate PBR due to a decline in confidence in the reliability of an aged abundance estimate. Therefore, the PBR for this stock is considered undetermined.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals between ~~2013~~2014 and ~~2017~~2018 is listed, by marine mammal stock, in ~~Delean et al. (2020)~~Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. The minimum estimated mean annual level of human-caused mortality and serious injury for Bering Sea harbor porpoise between ~~2013~~2014 and ~~2017~~2018 is ~~0.2~~0.4 porpoise in ~~U.S. commercial fisheries~~subsistence fisheries; however, this estimate is considered a minimum because most of the fisheries likely to interact with this stock of harbor porpoise have never been monitored. Potential threats most likely to result in direct human-caused mortality or serious injury of this stock include entanglement in fishing gear.

Fisheries Information

Information ~~on~~for federally-managed and state-managed U.S. commercial fisheries in Alaska waters ~~(including observer programs, observer coverage, and observed incidental takes of marine mammals) is presented~~available in Appendi~~ces~~x 3~~-6~~ of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

Harbor porpoise mortality and serious injury is known to occur in gillnet (both drift gillnet and set gillnet) and trawl fisheries. While much of the trawl fleet has observer coverage, there are several gillnet fisheries in the Bering Sea that do not. Given the occurrence of fishery-caused mortality and serious injury of harbor porpoise in other gillnet fisheries in Alaska, it is likely that gillnet fisheries within the range of this stock also incur mortality and serious injury of harbor porpoise.

No mortality or serious injury of Bering Sea harbor porpoise was observed incidental to U.S. federal commercial fisheries between ~~2013~~2014 and ~~2017~~2018. ~~However, strandings of marine mammals with fishing gear attached or with injuries caused by interactions with fishing gear provide some mortality data. One harbor porpoise mortality due to entanglement in a commercial salmon set gillnet in Kotzebue, Alaska, was reported to the NMFS Alaska Region stranding network in 2013 (Table 1; Delean et al. 2020), resulting in a minimum average annual mortality and serious injury rate of 0.2 Bering Sea harbor porpoise in U.S. commercial fisheries between 2013 and 2017 (Table 1). This mortality and serious injury estimate results from an actual count of verified human-caused deaths and serious injuries and is a minimum because not all entangled animals strand nor are all stranded animals found, reported, or have the cause of death determined.~~ However, ~~A~~a complete estimate of the total mortality and serious injury rate incidental to U.S. commercial fisheries is not ~~un~~available for this stock because of the absence of an observer program for all of the salmon and herring fisheries operating within the range of the stock.

Reports to the NMFS Alaska Region marine mammal stranding network of harbor porpoise entangled in fishing gear or with injuries caused by interactions with gear are another source of mortality and serious injury data (Table 1; Young et al. in press). In 2018, two harbor porpoise entanglements were reported in the Kuskokwim, Yukon, Norton Sound, Kotzebue subsistence salmon gillnet fishery, resulting in a minimum mean annual mortality and serious injury rate of 0.4 Bering Sea harbor porpoise in this subsistence fishery between 2014 and 2018 (Table 1; Young et al. in press). This mortality and serious injury estimate results from an actual count of verified human-caused deaths and serious injuries and is a minimum because not all entangled animals strand nor are all stranded animals found, reported, or have the cause of death determined.

Table 1. Summary of incidental mortality and serious injury of Bering Sea harbor porpoise, by year and type, reported to the NMFS Alaska Region marine mammal stranding network between ~~2013~~2014 and ~~2017~~2018 (~~Delean et al. 2020~~Young et al. in press).

Cause of injury	~~2013~~	2014	2015	2016	2017	2018	Mean annual mortality
~~Entangled in Kotzebue commercial salmon set gillnet~~	~~1~~	~~0~~	~~0~~	~~0~~	~~0~~		~~0.2~~
Entangled in Kuskokwim, Yukon, Norton Sound, Kotzebue subsistence salmon gillnet		0	0	0	0	2	0.4
~~Total in commercial fisheries~~							~~0.2~~
Total in subsistence fisheries							0.4

Alaska Native Subsistence/Harvest Information

Subsistence hunters in Alaska have not been reported to hunt from this stock of harbor porpoise; however, when porpoise are caught incidental to subsistence or commercial fisheries, subsistence hunters may claim the carcass for subsistence use (R. Suydam, North Slope Borough, pers. comm.).

STATUS OF STOCK

Bering Sea harbor porpoise are not designated as depleted under the Marine Mammal Protection Act or listed as threatened or endangered under the Endangered Species Act. The minimum ~~abundance~~population estimate for this stock is ~~unknown~~an underestimate for the entire stock because it is based on a survey that covered only a small portion of the stock's range. ~~b~~Because the existing estimates ~~is~~are more than 8 years old, N_{MIN} is unknown and ~~so~~ the PBR level is ~~considered~~ undetermined. Because the PBR is undetermined and most of the fisheries likely to interact with this stock have never been observed, it is unknown if the minimum estimate of the mean annual mortality and serious injury rate (~~0.2~~0.4 porpoise from stranding data) in U.S. commercial fisheries can be considered insignificant and approaching a zero mortality and serious injury rate. NMFS considers this stock strategic because the level of mortality and serious injury would likely exceed the PBR level for this stock if we had accurate information on stock structure, a newer abundance estimate, and complete observer coverage. Population trends and status of this stock relative to its Optimum Sustainable Population are unknown.

There are key uncertainties in the assessment of the Bering Sea stock of harbor porpoise. This stock likely comprises multiple, smaller stocks based on analogy with harbor porpoise populations that have been the focus of specific studies on stock structure. The most recent surveys were more than 8 years ago and covered only a small portion of the stock's range, ~~given the lack of information on population trend, the abundance estimates are not used to calculate an~~so N_{MIN} is unknown and the PBR level is undetermined. Several commercial fisheries overlap with the range of this stock and most have never been observed; thus, the estimate of commercial fishery mortality and serious injury is expected to be a minimum estimate. Coastal subsistence fisheries will occasionally cause incidental mortality or serious injury of a harbor porpoise; tracking these subsistence takes is challenging because there is no reporting mechanism. Estimates of human-caused mortality and serious injury from stranding data are underestimates because not all animals strand nor are all stranded animals found, reported, or have the cause of death determined.

HABITAT CONCERNS

Harbor porpoise are found over the shelf waters of the southeastern Bering Sea (Dahlheim et al. 2000, Hobbs and Waite 2010). In the nearshore waters of this region, harbor porpoise are vulnerable to physical modifications of nearshore habitats resulting from urban and industrial development (including waste management and nonpoint source runoff) and activities such as construction of docks and other over-water structures, filling of shallow areas, dredging, and noise (Linnenschmidt et al. 2013). Climate change and changes to sea-ice coverage may be opening up new habitats, or resulting in shifts in distribution, as evident by an increase in the number of reported sightings of harbor porpoise in the Chukchi Sea (Funk et al. 2010, 2011). Shipping and noise from oil and gas activities may also be a habitat concern for harbor porpoise, particularly in the Chukchi Sea.

CITATIONS

Aerts, L. A. M., A. E. McFarland, B. H. Watts, K. S. Lomac-MacNair, P. E. Seiser, S. S. Wisdom, A. V. Kirk, and C. A. Schudel. 2013. Marine mammal distribution and abundance in an offshore sub-region of the northeastern Chukchi Sea during the open-water season. Continental Shelf Research 67:116-126. DOI: dx.doi.org/10.1016/j.csr.2013.04.020 .

Barlow, J. 1988. Harbor porpoise, *Phocoena phocoena*, abundance estimation for California, Oregon, and Washington: I. Ship surveys. Fish. Bull., U.S. 86:417-432.

Barlow, J., C. W. Oliver, T. D. Jackson, and B. L. Taylor. 1988. Harbor porpoise, *Phocoena phocoena*, abundance estimation for California, Oregon, and Washington: II. Aerial surveys. Fish. Bull., U.S. 86:433-444.

Calambokidis, J., and J. Barlow. 1991. Chlorinated hydrocarbon concentrations and their use for describing population discreteness in harbor porpoises from Washington, Oregon, and California, p. 101-110. *In* J. E. Reynolds III and D. K. Odell (eds.), Proceedings of the Second Marine Mammal Stranding Workshop: 3-5 December 1987, Miami, Florida. U.S. Dep. Commer., NOAA Tech. Rep. NMFS-98.

Calambokidis, J., J. R. Evenson, J. C. Cubbage, S. D. Osmek, D. Rugh, and J. L. Laake. 1993. Calibration of sighting rates of harbor porpoise from aerial surveys. Final Report to the National Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115. 55 p.

Chivers, S. J., A. E. Dizon, P. J. Gearin, and K. M. Robertson. 2002. Small-scale population structure of eastern North Pacific harbor porpoise (*Phocoena phocoena*) indicated by molecular genetic analyses. J. Cetacean Res. Manage. 4(2):111-122.

Christman, C. L., and L. M. Aerts. 2015. Harbor porpoise (*Phocoena phocoena*) sightings from shipboard surveys in the Chukchi Sea during summer and fall, 2008-2014, p. 197. *In* Book of Abstracts, 2015 Alaska Marine Science Symposium, Anchorage, Alaska, January 19-23, 2015.

Dahlheim, M., A. York, R. Towell, J. Waite, and J. Breiwick. 2000. Harbor porpoise (*Phocoena phocoena*) abundance in Alaska: Bristol Bay to Southeast Alaska, 1991-1993. Mar. Mammal Sci. 16:28-45.

Dahlheim, M., P. A. White, and J. Waite. 2009. Cetaceans of Southeast Alaska: distribution and seasonal occurrence. J. Biogeogr. 36(3):410-426.

Dahlheim, M. E., A. N. Zerbini, J. M. Waite, and A. S. Kennedy. 2015. Temporal changes in abundance of harbor porpoise (*Phocoena phocoena*) inhabiting the inland waters of Southeast Alaska. Fish. Bull., U.S. 113(3):242-255.

~~Delean, B. J., V. T. Helker, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, J. Jannot, and N. C. Young. 2020. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2013-2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-401, 86 p.~~

Friday, N. A., J. M. Waite, A. N. Zerbini, and S. E. Moore. 2012. Cetacean distribution and abundance in relation to oceanographic domains on the eastern Bering Sea shelf: 1999-2004. Deep-Sea Res. II 65-70:260-272.

Friday, N. A., J. M. Waite, A. N. Zerbini, S. E. Moore, and P. J. Clapham. 2013. Cetacean distribution and abundance in relation to oceanographic domains on the eastern Bering Sea shelf, June and July of 2002, 2008 and 2010. Deep-Sea Res. II 94:244-256.

Funk, D. W., D. S. Ireland, R. Rodrigues, and W. R. Koski (eds.). 2010. Joint monitoring program in the Chukchi and Beaufort seas, open-water seasons, 2006–2008. LGL Alaska Report P1050-3, Report from LGL Alaska Research Associates, Inc., LGL, Ltd., Greeneridge Sciences, Inc., and JASCO Research, Ltd., for Shell Offshore, Inc. and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 499 p. + appendices.

Funk, D. W., C. M. Reiser, D. S. Ireland, R. Rodrigues, and W. R. Koski (eds.). 2011. Joint monitoring program in the Chukchi and Beaufort seas, 2006–2010. LGL Alaska Draft Report P1213-1, Report from LGL Alaska Research Associates, Inc., LGL, Ltd., Greeneridge Sciences, Inc., and JASCO Research, Ltd., for Shell Offshore, Inc., and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 592 p. + appendices.

Gaskin, D. E. 1984. The harbor porpoise *Phocoena phocoena* (L.): regional populations, status, and information on direct and indirect catches. Rep. Int. Whal. Comm. 34:569-586.

Hobbs, R. C., and J. M. Waite. 2010. Abundance of harbor porpoise (*Phocoena phocoena*) in three Alaskan regions, corrected for observer errors due to perception bias and species misidentification, and corrected for animals submerged from view. Fish. Bull., U.S. 108(3):251-267.

Laake, J. L., J. Calambokidis, S. D. Osmek, and D. J. Rugh. 1997. Probability of detecting harbor porpoise from aerial surveys: estimating g(0). J. Wildl. Manage. 61(1):63-75.

Linnenschmidt, M., J. Teilmann, T. Akamatsu, R. Dietz, and L. A. Miller. 2013. Biosonar, dive, and foraging activity of satellite tracked harbor porpoises (*Phocoena phocoena*). Mar. Mammal Sci. 29(2):77-97.

Moore, S. E., J. M. Waite, N. A. Friday, and T. Honkalehto. 2002. Cetacean distribution and relative abundance on the central-eastern and the southeastern Bering Sea shelf with reference to oceanographic domains. Prog. Oceanogr. 55:249-261.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed ~~December 2019~~August 2020.

Palka, D. 1995. Abundance estimate of the Gulf of Maine harbor porpoise. Rep. Int. Whal. Comm. (Special Issue 16):27-50.

Palka, D. 2000. Abundance of the Gulf of Maine/Bay of Fundy harbor porpoise based on shipboard and aerial surveys during 1999. Northeast Fisheries Science Center Reference Document 00-07. 29 p. Available online: https://www.nefsc.noaa.gov/publications/crd/crd0007/ . Accessed August 2020.

Parsons, K. M., M. Everett, M. Dahlheim, and L. Park. 2018. Water, water everywhere: environmental DNA can unlock population structure in elusive marine species. Royal Society Open Science 5:180537. DOI: dx.doi.org/10.1098/rsos.180537 .

Reiser, C. M., D. W. Funk, R. Rodrigues, and D. Hannay (eds.). 2011. Marine mammal monitoring and mitigation during marine geophysical surveys by Shell Offshore, Inc., in the Alaskan Chukchi and Beaufort seas, July–October 2010: 90-day report. LGL Report P1171E–1. Report from LGL Alaska Research Associates, Inc., Anchorage, AK, and JASCO Applied Sciences, Victoria, BC, for Shell Offshore, Inc., Houston, TX, National Marine Fisheries Service, Silver Spring, MD, and U.S. Fish and Wildlife Service, Anchorage, AK. 240 p. + appendices.

Rosel, P. E. 1992. Genetic population structure and systematic relationships of some small cetaceans inferred from mitochondrial DNA sequence variation. Ph.D. Dissertation, University of California San Diego. 191 p.

Rosel, P. E., A. E. Dizon, and M. G. Haygood. 1995. Variability of the mitochondrial control region in populations of the harbour porpoise, *Phocoena phocoena*, on inter-oceanic and regional scales. Can. J. Fish. Aquat. Sci. 52:1210-1219.

Rosel, P. E., R. Tiedemann, and M. Walton. 1999. Genetic evidence for limited trans-Atlantic movements of the harbor porpoise *Phocoena phocoena*. Mar. Biol. 133:583-591.

Shelden, K. E. W., B. A. Agler, J. J. Brueggeman, L. A. Cornick, S. G. Speckman, and A. Prevel-Ramos. 2014. Harbor porpoise, *Phocoena phocoena vomerina*, in Cook Inlet, Alaska. Mar. Fish. Rev. 76(1-2):22-50.

Taylor, B. L., P. R. Wade, D. P. DeMaster, and J. Barlow. 1996. Models for management of marine mammals. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/48/SM50). 12 p.

Walton, M. J. 1997. Population structure of harbour porpoises *Phocoena phocoena* in the seas around the UK and adjacent waters. Proc. R. Soc. Lond. B 264:89-94.

Westgate, A. J., and K. A. Tolley. 1999. Geographical differences in organochlorine contaminants in harbour porpoises *Phocoena phocoena* from the western North Atlantic. Mar. Ecol. Prog. Ser. 177:255-268.

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX.

SPERM WHALE (*Physeter macrocephalus*): North Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The sperm whale is one of the most widely distributed marine mammal species, perhaps exceeded in its global range only by the killer whale and humpback whale (Rice 1989). In the North Pacific Ocean, sperm whales were depleted by extensive commercial whaling over a period of more than a hundred years, and the species was the primary target of illegal Soviet whaling in the second half of the 20th century (Ivashchenko et al. 2013, 2014). Systematic illegal catches were also made on a large scale by Japan in both the North Pacific and Antarctic in at least the late 1960s (Ivashchenko and Clapham 2015, Clapham and Ivashchenko 2016).

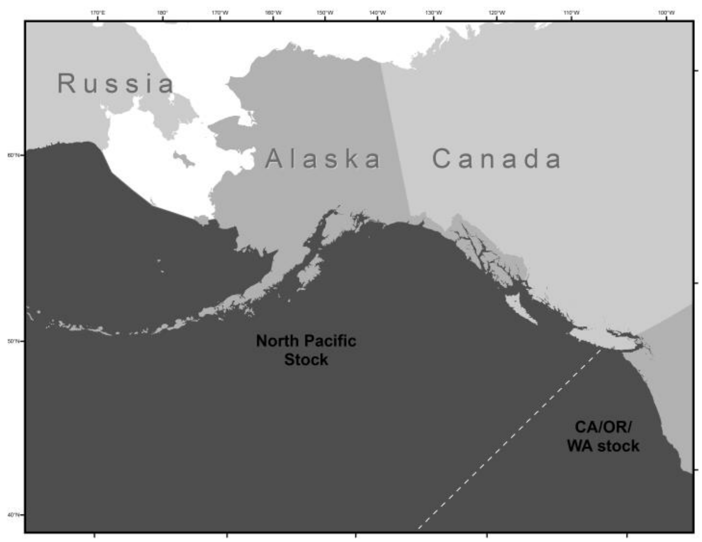

Figure 1. The approximate distribution of sperm whales in the North Pacific Ocean includes deep waters south of 62°N to the equator.

Sperm whales feed primarily on medium-sized to large-sized squids but also consume substantial quantities of large demersal and mesopelagic sharks, skates, and fishes (Rice 1989). In the North Pacific, sperm whales are distributed widely (Fig. 1). Although females and young sperm whales were thought to remain in tropical and temperate waters year-round, Mizroch and Rice (2006) and Ivashchenko et al. (2014) showed that there were extensive catches of female sperm whales above 50°N; Soviet catches of females were made as far north as Olyutorsky Bay (62°N) in the western Bering Sea, as well as in the western Aleutian Islands. Mizroch and Rice (2013) also showed movements by females into the Gulf of Alaska and western Aleutians. During summer, males are found in the Gulf of Alaska, Bering Sea, and waters around the Aleutian Islands (Kasuya and Miyashita 1988, Mizroch and Rice 2013, Ivashchenko et al. 2014). Sighting surveys conducted by the Alaska Fisheries Science Center's Marine Mammal Laboratory (MML) in the summer months between 2001 and 2010 found sperm whales to be the most frequently sighted large cetacean in the coastal waters around the central and western Aleutian Islands (MML, unpubl. data). Acoustic surveys, from fixed autonomous hydrophones, detected the presence of sperm whales year-round in the Gulf of Alaska, although they appear to be approximately two times as common in summer than in winter (Mellinger et al. 2004). This seasonality of detections is consistent with the hypothesis that sperm whales generally move to higher latitudes in summer and to lower latitudes in winter (Whitehead and Arnbom 1987).

Discovery tags implanted in sperm whales in the 1960s could, when recovered from a dead whale, provide useful information on historical movements. Mizroch and Rice (2013) examined 261 Discovery tag recoveries from the days of commercial whaling and found extensive movements from U.S. and Canadian coastal waters into the Gulf of Alaska and Bering Sea/Aleutian Islands region. The U.S. tagged 176 sperm whales from 1962 to 1969 off southern California and northern Baja California (Mizroch and Rice 2013). Seven of those tagged whales were recovered in locations ranging from offshore California, Oregon, and British Columbia to the western Gulf of Alaska. A male sperm whale tagged by Canadian researchers moved from near Vancouver Island, British Columbia, to the Aleutian Islands near Adak. A whale tagged by Soviet researchers moved from coastal Michoacán, mainland Mexico, to a location about 1,300 km offshore of Washington State. Similar extensive movements have also been demonstrated by satellite-tagging studies (Straley et al. 2014). Three adult males satellite tagged off southeastern Alaska moved far south~~,~~: one to coastal Baja California, one into the north-central Gulf of California, and the third to a location near the Mexico-Guatemala border (Straley et al. 2014).

Mizroch and Rice (2013) analyzed whaling data and found that males and females historically concentrated seasonally along oceanic frontal zones, for example, in the subtropical frontal zone (~~ca.~~approximately 28-34°N) and the subarctic frontal zones (~~ca.~~approximately 40-43°N). Males also concentrated seasonally near the Aleutian

Islands and along the Bering Sea shelf edge. More current research suggests sperm whales are likely relatively nomadic, with movements linked to geographical and temporal variations in the abundance of pelagic squids (Mizroch and Rice 2013). The authors also found no indication from Discovery tag or whaling data to indicate apparent divisions between separate demes or stocks within the North Pacific (Mizroch and Rice 2013). Analysis of Soviet catch data by Ivashchenko et al. (2014) showed broad agreement with these results, although they identified a sharp division at Amchitka Pass in the Aleutians, with mature males to the east and males and family groups to the west. There were four main areas of concentration in the Soviet catches: a large pelagic area (30-50°N) in the eastern North Pacific, including the Gulf of Alaska and western coast of North America; the northeastern and southwestern central North Pacific; and the southern Kuril Islands. Some of the catch distribution was similar to that of 19th-century Yankee whaling catches plotted by Townsend (1935), notably in the "Japan Ground" (in the pelagic western Pacific) and the "Coast of Japan Ground." Many females were caught in Olyutorsky Bay (western Bering Sea) and around the Commander Islands.

More recently, an International Whaling Commission (IWC)-sponsored survey operated by the Government of Japan recorded 284 sightings of sperm whales across the entire North Pacific between 2010 and 2016, but an abundance estimate was not calculated (IWC 2017).

The following information was considered in classifying stock structure based on the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: no apparent discontinuities based on Discovery tag data; 2) Population response data: unknown; 3) Phenotypic data: unknown; and 4) Genotypic data: genetic studies indicate the possibility of a "somewhat" discrete U.S. coastal stock (Mesnick et al. 2011). For management purposes, the IWC recognizes two management units of sperm whales in the North Pacific (eastern and western). However, the IWC has not reviewed its sperm whale stock boundaries in recent years (Donovan 1991). For management purposes, three stocks of sperm whales are currently recognized in U.S. waters: 1) Alaska (North Pacific stock) (Fig. 1); 2) California/Washington/Oregon; and 3) Hawaii. Mizroch and Rice (2013) suggest that this should be reviewed and updated to reflect additional data, but there is insufficient information to propose a reasonable alternative structure. The California/Oregon/Washington and Hawaii sperm whale stocks are reported in the Stock Assessment Reports for the U.S. Pacific Region.

POPULATION SIZE

Current and historical abundance estimates of sperm whales in the North Pacific are based on limited data and are considered unreliable; caution should be exercised in interpreting published estimates. Further, sperm whales are far-ranging and exhibit sex segregation and stock overlap that together make population size estimation difficult. The existing estimates are caveated and do not cover consistent areas, making comparisons difficult. The abundance of sperm whales in the North Pacific was estimated to be 1,260,000 prior to exploitation, which by the late 1970s was thought to have been reduced to 930,000 whales (Rice 1989). Confidence intervals for these estimates do not exist. These estimates include whales from the California/Oregon/Washington stock, for which a separate abundance estimate is available (see the Stock Assessment Reports for the U.S. Pacific Region). Estimates for a large area of the eastern temperate North Pacific were produced from line-transect and acoustic survey data by Barlow and Taylor (2005); the acoustic data produced an estimate of 32,100 sperm whales (coefficient of variation (CV) = 0.36). However, no more recent estimate exists for other areas, including for the central or western North Pacific.

Kato and Miyashita (1998) reported 102,112 sperm whales (CV = 0.155) in the western North Pacific, with the caveat that their estimate is likely positively biased. From surveys in the Gulf of Alaska in 2009 and 2015, Rone et al. (2017) estimated 129 (CV = 0.44) and 345 sperm whales (CV = 0.43) in each year, respectively. These estimates are for a small area that was unlikely to include females and juveniles and they do not account for animals missed on the trackline; therefore, they are not considered reliable estimates.

As the data used in estimating the abundance of sperm whales in the entire North Pacific are more than 8 years old, a reliable estimate of abundance for the entire North Pacific stock is considered unavailable.

Minimum Population Estimate

A minimum population estimate (N_{MIN}) for this stock can be calculated according to Equation 1 from the potential biological removal (PBR) guidelines (NMFS 2016): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the estimate (N) of 345 from surveys in the Gulf of Alaska in 2015 (Rone et al. 2017), and the associated ~~coefficient of variation~~ CV(N) of 0.43, results in an N_{MIN} of 244 sperm whales. However, this is an underestimate for the entire stock because it is based on surveys of a small portion of the stock's extensive range and it does not account for animals missed on the trackline or for females and juveniles in tropical and subtropical waters.

Current Population Trend

There is no reliable information on trends in abundance for this stock (Braham 1992).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is not available for the North Pacific stock of sperm whales. Until additional data become available, the default cetacean maximum theoretical net productivity rate of 4% will be used for this stock (NMFS 2016).

POTENTIAL BIOLOGICAL REMOVAL

Potential biological removal (PBR) is defined as the product of the minimum population estimate (N_{MIN}), one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.1, the value for cetacean stocks ~~which~~that are classified as endangered (NMFS 2016). Using the estimate of 345 (CV = 0.43) from surveys in the Gulf of Alaska in 2015 (Rone et al. 2017), and the associated N_{MIN} of 244, PBR is calculated to be 0.5 sperm whales (244 × 0.02 × 0.1). However, because the N_{MIN} is for only a small portion of the stock's range and does not account for females and juveniles in tropical and subtropical waters, the calculated PBR is not a reliable index for the entire stock.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals between ~~2013~~2014 and ~~2017~~2018 is listed, by marine mammal stock, in ~~Delean et al. (2020)~~Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. Injury events lacking detailed injury information are assigned prorated values following injury determination guidelines described in NMFS (2012). A summary of information used to determine whether an injury was serious or non-serious, as well as a table of prorate values used for large whale reports with incomplete information, is reported in ~~Delean et al. (2020)~~Young et al. (in press). A minimum estimate of the mean annual level of human-caused mortality and serious injury for North Pacific sperm whales between ~~2013~~2014 and ~~2017~~2018 is ~~4.9~~3.5 whales: ~~4.7~~3.3 in U.S. commercial fisheries and 0.2 due to ship strikes. Sperm whales have been observed depredating both halibut and sablefish longline fisheries in the Gulf of Alaska and this is particularly common in sablefish longline fisheries in the central and eastern Gulf of Alaska; this depredation can lead to mortality or serious injury if hooking or entanglement occurs. Potential threats most likely to result in direct human-caused mortality or serious injury of this stock include entanglement in fishing gear and ship strikes due to increased vessel traffic (from increased shipping in higher latitudes).

Fisheries Information

Information ~~(including observer programs, observer coverage, and observed incidental takes of marine mammals)~~ for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is ~~presented~~available in Appendi~~ces~~x 3~~-6~~ of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

Between ~~2013~~2014 and ~~2017~~2018, ~~three~~mortality and serious injur~~ies~~y of sperm whales ~~were~~was observed in the ~~Gulf of Alaska sablefish longline fishery (two in 2013 and one in 2016) and one in the~~ Bering Sea/Aleutian Islands halibut longline fishery (one serious injury in 2015, prorated at 0.75), the Aleutian Islands sablefish pot fishery (one mortality in 2018), and the Gulf of Alaska sablefish longline fishery (one serious injury in 2016, prorated at 0.75). ~~Each of these injuries was prorated at a value of 0.75 and~~The mortality and serious injury was extrapolated to fishery-wide estimates when possible, resulting in a minimum estimated mean annual mortality and serious injury rate of ~~4.7~~3.3 sperm whales in U.S. commercial fisheries between ~~2013~~2014 and ~~2017~~2018 (Table 1; Breiwick 2013; MML, unpubl. data).

Table 1. Summary of incidental mortality and serious injury of North Pacific sperm whales due to U.S. commercial fisheries between ~~2013~~2014 and ~~2017~~2018 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix ~~6~~3 of the Alaska Stock Assessment Reports. Injury events lacking detailed injury information are assigned prorated values following injury determination guidelines described in NMFS (2012). A summary of information used to determine whether an injury was serious or non-serious, as well as a table of prorate values used for large whale reports with incomplete information, is reported in ~~Delean et al. (2020)~~Young et al. (in press).

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality (CV)	Mean estimated annual mortality
Bering Sea/Aleutian Is. halibut longline	~~2013~~	obs data	~~13~~	~~0~~	~~0~~	2.0 (CV=0.98)
	2014		11	0	0	
	2015		13	0.75	10 (0.98)	
	2016		10	0	0	
	2017		6.9	0	0	
	2018		8.2	0	0	
Aleutian Is. sablefish pot	2014	obs data	0	0	0	0 (+0.2)[c] (CV = N/A)
	2015		86	0	0	
	2016		88	0	0	
	2017		33	0	0	
	2018		55	0 (+1)[a]	0 (+1)[b]	
Gulf of Alaska sablefish longline	~~2013~~	obs data	~~14~~	~~0.75 (+0.75)[a]~~	~~6.8 (+0.75)[b]~~	~~2.5~~1.1 ~~(+0.2)[c]~~ (CV = ~~0.67~~0.93)
	2014		19	0	0	
	2015		20	0	0	
	2016		14	0.75	5.7 (0.93)	
	2017		12	0	0	
	2018		9.8	0	0	
Minimum total estimated annual mortality						~~4.7~~3.3 (CV = ~~0.57~~0.71)

[a]Total mortality and serious injury observed in ~~2013~~2018: ~~0.75~~0 whales in sampled hauls + ~~0.75~~1 whale~~s~~ in an unsampled haul.
[b]Total estimate of mortality and serious injury in ~~2013~~2018: ~~6.8~~0 whales (extrapolated estimate from 0~~.75~~ whales observed in sampled hauls) + ~~0.75~~1 whale~~s~~ (~~0.75~~1 whale~~s~~ observed in an unsampled haul).
[c]Mean annual mortality and serious injury for fishery: 0 whales (mean of extrapolated estimate from 0 whales observed in sampled hauls) + 0.2 whales (mean of number observed in unsampled hauls).
~~[c]Mean annual mortality and serious injury for fishery: 2.5 whales (mean of extrapolated estimates from sampled hauls) + 0.2 whales (mean of number observed in unsampled hauls).~~

Alaska Native Subsistence/Harvest Information

Sperm whales have never been reported to be taken by subsistence hunters (Rice 1989).

Other Mortality

Sperm whales were the dominant species killed by the commercial whaling industry as it developed in the North Pacific in the years after World War II (Mizroch and Rice 2006, Ivashchenko et al. 2014). Between 1946 and 1967, most of the sperm whales were caught in waters near Japan and in the Bering Sea/Aleutian Islands region. The Bering Sea/Aleutian Islands catches were dominated by males. After 1967, whalers moved out of the Bering Sea/Aleutian Islands region and began to catch even larger numbers of sperm whales farther south in the North Pacific between 30° and 50°N latitude (Mizroch and Rice 2006: Figs. 7-9). The reported catch of sperm whales taken by commercial whalers operating in the North Pacific between 1912 and 2006 ~~was~~equaled 261,148 sperm whales, of which, 259,120 were taken between 1946 and 1987 (Allison 2012). This value underestimates the actual kill in the North Pacific as a result of under-reporting by U.S.S.R. and Japanese pelagic whaling operations. Berzin (2008) described extreme under-reporting and misreporting of Soviet sperm whale catches from the mid-1960s into the early 1970s, including enormous (and under-reported) whaling pressure on female sperm whales in the latter years of whaling. More recently, Ivashchenko et al. (2013, 2014) estimate that 157,680 sperm whales were killed by the U.S.S.R. in the North Pacific between 1948 and 1979, of which, 25,175 were unreported; the Soviets also extensively misreported the sex and length of catches. In addition, it is known that Japanese land-based whaling operations also misreported the number and sex of sperm whale catches during the post-World War II era (Kasuya

1999), and other studies indicate that falsifications also occurred on a large scale in the Japanese pelagic fishery (Cooke et al. 1983, Ivashchenko and Clapham 2015). The last year that the U.S.S.R. reported catches of sperm whales was in 1979 and the last year that Japan reported substantial catches was in 1987, but Japanese whalers reported catches of 48 sperm whales between 2000 and 2009 (IWC, BIWS catch data, October 2010 version, unpubl.). Although the Soviet data on catches of this species in the North Pacific have now been largely corrected (Ivashchenko et al. 2013), the North Pacific sperm whale data in the IWC's Catch Database (Allison 2012) are known to be incorrect (i.e., too low) because of falsified catch information from both the Japanese coastal and pelagic fisheries (Kasuya 1999, Ivashchenko and Clapham 2015).

Reports ~~from~~to the NMFS Alaska Region marine mammal stranding network are another source of information on sperm whale mortality and serious injury (Table 2; ~~Delean et al. 2020~~Young et al. in press). One sperm whale mortality due to a ship strike was reported in 2017, resulting in a mean annual mortality and serious injury rate of 0.2 sperm whales due to ship strikes between ~~2013~~2014 and ~~2017~~2018.

Table 2. Summary of mortality and serious injury of North Pacific sperm whales, by year and type, reported to the NMFS Alaska Region marine mammal stranding network between ~~2013~~2014 and ~~2017~~2018 (~~Delean et al. 2020~~Young et al. in press).

Cause of Injury	~~2013~~	2014	2015	2016	2017	2018	Mean annual mortality
Ship strike	~~0~~	0	0	0	1	0	0.2
Total due to ship strikes							0.2

Other Issues

NMFS observers aboard longline vessels targeting both sablefish and halibut have documented sperm whales feeding off longline gear in the Gulf of Alaska (Hill and Mitchell 1998, Hill et al. 1999, Perez 2006, Sigler et al. 2008). Fishery observers recorded several instances between 1995 and 1997 in which sperm whales were deterred by fishermen (i.e., throwing seal bombs in the water).

Annual longline surveys have been recording sperm whale depredation on catch since 1998 (Hanselman et al. 2008). Sperm whale depredation in the sablefish longline fishery is widespread in the central and eastern Gulf of Alaska but rarely observed in the Bering Sea; interaction rates are increasing significantly in the East Yakutat/Southeast Alaska and Central Gulf management areas (Hanselman et al. 2018). More recent research suggests that sperm whales impacted catch rates at a more significant rate than earlier studies suggested (Straley et al. 2005, Sigler et al. 2008), and sperm whales are estimated to reduce commercial fishery and NMFS annual longline survey catch rates by approximately 15% - 26% (Peterson and Hanselman 2017, Hanselman et al. 2018).

STATUS OF STOCK

Sperm whales are listed as endangered under the Endangered Species Act of 1973 and, therefore, designated as depleted under the MMPA. As a result, this stock is classified as a strategic stock. However, on the basis of total abundance, current distribution, and regulatory measures that are in place, it is unlikely that this stock is in danger of extinction (Braham 1992). Reliable estimates of the minimum population, population trends, PBR, and status of the stock relative to its Optimum Sustainable Population are not available. A minimum estimate of the mean annual level of human-caused mortality and serious injury is ~~4.9~~3.5 whales. The minimum estimate of the mean annual U.S. commercial fishery-related mortality and serious injury rate (~~4.7~~3.3 whales) is more than 10% of the PBR (10% of PBR = 0.05) calculated from the 2015 abundance estimate (Rone et al. 2017) for a small portion of the stock's range. However, because the calculated PBR level is based on an N_{MIN} which is known to be an underestimate of the abundance of the population, the PBR level is considered unreliable.

There are key uncertainties in the assessment of the North Pacific stock of sperm whales. There is little current information about the broad-scale distribution of sperm whales in Alaska waters, and there is no current abundance estimate, N_{MIN}, PBR level, or trend in abundance for the entire stock.

HABITAT CONCERNS

Potential habitat concerns for this stock include elevated levels of sound from anthropogenic sources (e.g., shipping, military exercises), possible changes in prey distribution and quality with climate change, entanglement in fishing gear, ship strikes due to increased vessel traffic (e.g., from increased shipping in higher latitudes), and oil and gas activities.

CITATIONS

Allison, C. 2012. IWC Catch Database, version 5.3 (25 October 2012). Available from International Whaling Commission, Cambridge, UK.

Barlow, J., and B. L. Taylor. 2005. Estimates of sperm whale abundance in the northeastern temperate Pacific from a combined acoustic and visual survey. Mar. Mammal Sci. 21:429-445.

Berzin, A. A. 2008. The truth about Soviet whaling: a memoir. Mar. Fish. Rev. 70(2):4-59.

Braham, H. 1992. Endangered whales: status update. Working document presented at A Workshop on the Status of California Cetacean Stocks (SOCCS/14). 35 p. + tables. Available from Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Breiwick, J. M. 2013. North Pacific marine mammal bycatch estimation methodology and results, 2007-2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-260, 40 p.

Clapham, P. J., and Y. V. Ivashchenko. 2016. Stretching the truth: length data highlight extensive falsification of Japanese sperm whale catch statistics in the Southern Hemisphere. Royal Society Open Science 3:160506. DOI: dx.doi.org/10.1098/rsos.160506 .

Cooke, J. G., W. K. de la Mare, and J. R. Beddington. 1983. Some aspects of the reliability of the length data for the western North Pacific stock of sperm whales. Rep. Int. Whal. Comm. 33:265-267.

~~Delean, B. J., V. T. Helker, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, J. Jannot, and N. C. Young. 2020. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2013-2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-401, 86 p.~~

Dizon, A. E., C. Lockyer, W. F. Perrin, D. P. DeMaster, and J. Sisson. 1992. Rethinking the stock concept: a phylogeographic approach. Conserv. Biol. 6:24-36.

Donovan, G. P. 1991. A review of IWC stock boundaries. Rep. Int. Whal. Comm. (Special Issue 13):39-68.

Hanselman, D. H., C. R. Lunsford, J. T. Fujioka, and C. J. Rodgveller. 2008. Assessment of the sablefish stock in Alaska, Section 3, p. 303-420. *In* Stock assessment and fishery evaluation report for the groundfish resources of the Gulf of Alaska. North Pacific Fisheries Management Council, Anchorage, AK.

Hanselman, D. H., B. J. Pyperb, and M. J. Peterson. 2018. Sperm whale depredation on longline surveys and implications for the assessment of Alaska sablefish. Fish. Res. 200:75-83. DOI: dx.doi.org/10.1016/j.fishres.2017.12.017 .

Hill, P. S., and E. Mitchell. 1998. Sperm whale interactions with longline vessels in Alaska waters during 1997. Unpubl. doc. submitted to Fish. Bull., U.S. Available from Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Hill, P. S., J. L. Laake, and E. Mitchell. 1999. Results of a pilot program to document interactions between sperm whales and longline vessels in Alaska waters. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-108, 42 p.

International Whaling Commission (IWC). 2017. Report of the planning meeting for the 2017 IWC-POWER cruise in the North Pacific with initial discussions for the 2018 and 2019 cruises. Document SC/67a/Rep 01. Available from International Whaling Commission, Cambridge, UK.

Ivashchenko, Y. V., and P. J. Clapham. 2015. What's the catch? Validity of whaling data for Japanese catches of sperm whales in the North Pacific. Royal Society Open Science 2:150177. DOI: dx.doi.org/10.1098/rsos.150177 .

Ivashchenko, Y. V., P. J. Clapham, and R. L. Brownell, Jr. 2013. Soviet catches of whales in the North Pacific: revised totals. J. Cetacean Res. Manage. 13(1):59-71.

Ivashchenko, Y. V., R. L. Brownell, Jr., and P. J. Clapham. 2014. Distribution of Soviet catches of sperm whales *Physeter macrocephalus* in the North Pacific. Endang. Species Res. 25:249-263.

Kasuya, T. 1999. Examination of the reliability of catch statistics in the Japanese coastal sperm whale fishery. J. Cetacean Res. Manage. 1:109-122.

Kasuya T., and T. Miyashita. 1988. Distribution of sperm whale stocks in the North Pacific. Sci. Rep. Whales Res. Inst. 39: 31-75.

Kato, H., and T. Miyashita. 1998. Current status of North Pacific sperm whales and its preliminary abundance estimates. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/50/CAWS/52). 6 p.

Mellinger, D. K., K. M. Stafford, and C. G. Fox. 2004. Seasonal occurrence of sperm whale (*Physeter macrocephalus*) sounds in the Gulf of Alaska, 1999-2001. Mar. Mammal Sci. 20(1):48-62.

Mesnick, S. L., B. L. Taylor, F. I. Archer, K. K. Martien, S. Escorza Treviño, B. L. Hancock-Hanser, S. C. Moreno Medina, V. L. Pease, K. M. Robertson, J. M. Straley, R. W. Baird, J. Calambokidis, G. S. Schorr, P. Wade, V. Burkanov, C. R. Lunsford, L. Rendell, and P. A. Morin. 2011. Sperm whale population structure in the eastern and central North Pacific inferred by the use of single nucleotide polymorphisms, microsatellites and mitochondrial DNA. Mol. Ecol. Res. 11(Suppl. 1):278-298.

Mizroch, S. A., and D. W. Rice. 2006. Have North Pacific killer whales switched prey species in response to depletion of the great whale populations? Mar. Ecol. Prog. Ser. 310:235-246.

Mizroch, S. A., and D. W. Rice. 2013. Ocean nomads: distribution and movements of sperm whales in the North Pacific shown by whaling data and Discovery marks. Mar. Mammal Sci. 29(2):E136-E165. DOI: dx.doi.org/10.1111/j.1748-7692.2012.00601.x .

National Marine Fisheries Service (NMFS). 2012. Process for distinguishing serious from non-serious injury of marine mammals. 42 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-policies-guidance-and-regulations . Accessed ~~December 2019~~August 2020.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed ~~December 2019~~August 2020.

Perez, M. A. 2006. Analysis of marine mammal bycatch data from the trawl, longline, and pot groundfish fisheries of Alaska, 1998-2004, defined by geographic area, gear type, and target groundfish catch species. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-167, 194 p.

Peterson, M. J., and D. Hanselman. 2017. Sablefish mortality associated with whale depredation in Alaska. ICES J. Mar. Sci. 74 (5):1382-1394. DOI: dx.doi.org/10.1093/icesjms/fsw239 .

Rice, D. W. 1989. Sperm whale, *Physeter macrocephalus*, p. 177-233. *In* S. H. Ridgway and R. Harrison (eds.), Handbook of Marine Mammals. Vol. 4. River Dolphins and the Larger Toothed Whales. Academic Press, New York.

Rone, B. K., A. N. Zerbini, A. B. Douglas, D. W. Weller, and P. J. Clapham. 2017. Abundance and distribution of cetaceans in the Gulf of Alaska. Mar. Biol. 164:23. DOI: dx.doi.org/10.1007/s00227-016-3052-2 .

Sigler, M. F., C. R. Lunsford, J. M. Straley, and J. B. Liddle. 2008. Sperm whale depredation of sablefish longline gear in the northeast Pacific Ocean. Mar. Mammal Sci. 24(1):16-27.

Straley, J., T. O'Connell, S. Mesnick, L. Behnken, and J. Liddle. 2005. Sperm whale and longline fisheries interactions in the Gulf of Alaska. North Pacific Research Board R0309 Final Report. 15 p.

Straley, J. M., G. S. Schorr, A. M. Thode, J. Calambokidis, C. R. Lunsford, E. M. Chenoweth, V. M. O'Connell, and R. D. Andrews. 2014. Depredating sperm whales in the Gulf of Alaska: local habitat use and long distance movements across putative population boundaries. Endang. Species Res. 24:125-135.

Townsend, C. 1935. The distribution of certain whales as shown by logbook records of American whaleships. Zoologica 19:1-50.

Whitehead, H., and T. Arnbom. 1987. Social organization of sperm whales off the Galapagos Islands, February-April 1985. Can. J. Zool. 65(4):913-919.

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX.

HUMPBACK WHALE (*Megaptera novaeangliae*): Western North Pacific Stock

NOTE – NMFS is in the process of reviewing humpback whale stock structure under the Marine Mammal Protection Act (MMPA) in light of the 14 Distinct Population Segments established under the Endangered Species Act (ESA) (81 FR 62259, 8 September 2016). A complete revision of the humpback whale stock assessments will be postponed until this review is complete. In the interim, new information on humpback whale mortality and serious injury is provided within this report.

STOCK DEFINITION AND GEOGRAPHIC RANGE

The humpback whale is distributed worldwide in all ocean basins. In winter, most humpback whales occur in the subtropical and tropical waters of the Northern and Southern Hemispheres. Humpback whales in the high latitudes of the North Pacific Ocean are seasonal migrants that feed on euphausiids and small schooling fishes (Nemoto 1957, 1959; Clapham and Mead 1999). The humpback whale population was considerably reduced as a result of intensive commercial exploitation during the 20th century.

A large-scale study of humpback whales throughout the North Pacific was conducted from 2004 to 2006 (the Structure of Populations, Levels of Abundance, and Status of Humpbacks (SPLASH) project). ~~Initial r~~Results from this project (Calambokidis et al. 2008, Barlow et al. 2011), including abundance estimates and movement information, have been reported in Baker et al. (2008, 2013) and are also summarized in Fleming and Jackson (2011); however, these results are still being considered for stock structure analysis.

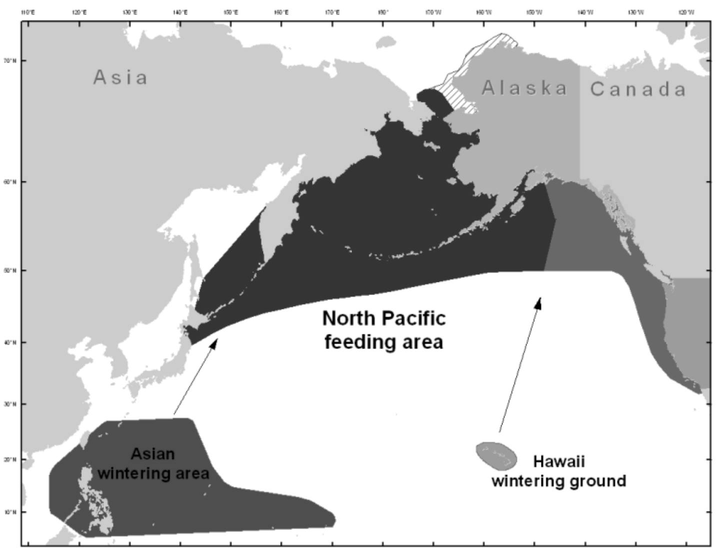

Figure 1. Approximate distribution of humpback whales in the western North Pacific (dark shaded areas). Feeding and wintering grounds are presented above (see text). Area within the hash lines is a probable distribution area based on sightings in the Beaufort Sea (Hashagen et al. 2009). See Figure 1 in the Central North Pacific humpback whale Stock Assessment Report for humpback whale distribution in the eastern North Pacific.

The historical summer feeding range of humpback whales in the North Pacific encompassed coastal and inland waters around the Pacific Rim from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk and north of the Bering Strait (Zenkovich 1954, Nemoto 1957, Tomlin 1967, Johnson and Wolman 1984). Historically, the Asian wintering area extended from the South China Sea east through the Philippines, Ryukyu Retto, Ogasawara Gunto, Mariana Islands, and Marshall Islands (Rice 1998). Humpback whales are currently found throughout this historical range (Clarke et al. 2013b), with sightings during summer months occurring as far north as the Beaufort Sea (Hashagen et al. 2009). Most of the current winter range of humpback whales in the North Pacific is relatively well known, with aggregations of whales in Japan, the Philippines, Hawaii, Mexico, and Central America. The winter range includes the main islands of the Hawaiian archipelago, with the greatest concentration along the west side of Maui. In Mexico, the winter breeding range includes waters around the southern part of the Baja California peninsula, the central portions of the Pacific coast of mainland Mexico, and the Revillagigedo Islands off the mainland coast. The winter range also extends from southern Mexico into Central America, including Guatemala, El Salvador, Nicaragua, and Costa Rica (Calambokidis et al. 2008).

Photo-identification data, distribution information, and genetic analyses have indicated that in the North Pacific there are at least three breeding populations (Asia, Hawaii, and Mexico/Central America) that all migrate between their respective winter/spring calving and mating areas and their summer/fall feeding areas (Calambokidis et al. 1997, Baker et al. 1998). Calambokidis et al. (2001) further suggested that there may be as many as six subpopulations on the wintering grounds. From photo-identification and Discovery tag information there are known connections between Asia and Russia, between Hawaii and Alaska, and between Mexico/Central America and California (Darling 1991, Darling and Cerchio 1993, Calambokidis et al. 1997, Baker et al. 1998). This information led to the designation of three stocks of humpback whales in the North Pacific: 1) the California/Oregon/Washington and Mexico stock, consisting of winter/spring populations in coastal Central America and coastal Mexico which migrate to the coast of California and as far north as southern British Columbia in summer/fall (Calambokidis et al. 1989, 1993; Steiger et al. 1991); 2) the Central North Pacific stock, consisting of winter/spring populations of the Hawaiian Islands which migrate primarily to northern British Columbia/Southeast Alaska, the Gulf of Alaska, and the Bering Sea/Aleutian Islands (Baker et al. 1990, Perry et al. 1990, Calambokidis et al. 1997); and 3) the Western North Pacific stock, consisting of winter/spring populations off Asia which migrate primarily to Russia and the Bering Sea/Aleutian Islands (Fig. 1).

Information from the SPLASH project largely confirms this view of humpback whale distribution and movements in the North Pacific. For example, the SPLASH results confirm low rates of interchange between the three principal wintering regions (Asia, Hawaii, and Mexico). However, the full SPLASH results suggest that the ~~previous~~current view of population structure ~~was inaccurate~~is incomplete. The overall pattern of movements is complex but indicates a high degree of population structure. Whales from wintering areas at the extremes of their range on both sides of the Pacific migrate to coastal feeding areas that are on the same side of the Pacific: whales from Asia in the west migrate to Russia and whales from mainland Mexico and Central America in the east migrate to coastal waters off California/Oregon.

The SPLASH data now show ~~the~~that Revillagigedo whales are seen in all sampled feeding areas except northern California/Oregon and the south side of the Aleutians. They are primarily distributed in the Bering Sea, Gulf of Alaska, and Southeast Alaska/northern British Columbia but are also found in Russia and southern British Columbia/Washington. The migratory destinations of humpback whales from Hawaii were found to be quite similar, and a significant number of matches (14) were seen during SPLASH between Hawaii and the Revillagigedos (Calambokidis et al. 2008).

The winter distribution of humpback whales in the Western stock includes several island chains in the western North Pacific. In the Ogasawara Islands, humpback whale sampling during SPLASH was conducted at the three main island groups of Chichi-jima, Haha-jima, and Muko-jima, separated from each other by approximately 50-70 km. SPLASH sampling in Okinawa (southwest of Honshu) occurred at the Okinawa mainland and Zamami in the Kerama Islands (40 km from the Okinawa mainland), and in the Philippines SPLASH sampling occurred only at the northern tip of the archipelago around the Babuyan Islands. Humpback whales are reported to also occur in the South China Sea north of the Philippines near Taiwan, and east of Ogasawara in the Marshall and Mariana Islands (Rice 1998), but there were no known areas of high density in these regions that could be efficiently sampled.

The SPLASH project also found that whales from the Aleutian Islands and Bering Sea, and perhaps the Gulf of Anadyr and the Chukotka Peninsula on the west side of the Bering Strait in Russia, have an unusually low resighting rate in winter areas compared to whales from other feeding areas. It is now believed that some of these whales have a winter migratory destination that was not sampled during the SPLASH project. Given the location of these feeding areas, the most parsimonious explanation would be that some of these whales winter somewhere between Hawaii and Asia, which would include the possibility of the Mariana Islands (southwest of the Ogasawara Islands), the Marshall Islands (approximately half-way between the Mariana Islands and the Hawaiian Islands), and the Northwestern Hawaiian Islands. Subsequent to the SPLASH project, a survey in 2007 documented humpback whales from a number of locations in the Northwestern Hawaiian Islands at relatively low densities (Johnston et al. 2007), but no sampling occurred there during the SPLASH project. Some humpback whales, including mother/calf pairs, have also been found in the Mariana Islands (Hill et al. 2016). Both of these locations are plausible migratory destinations for whales from the Aleutian Islands and Bering Sea. Which stock that whales in these locations would belong to is currently unknown.

The migratory destination of Western North Pacific humpback whales is not completely known. Discovery tag recoveries have indicated movement of whales between Ogasawara and Okinawa and feeding areas in the Bering Sea, on the southern side of the Aleutian Islands, and in the Gulf of Alaska (Omura and Ohsumi 1964, Nishiwaki 1966, Ohsumi and Masaki 1975). Research on humpback whales at the Ogasawara Islands has documented movements of whales between there and British Columbia (Darling et al. 1996), the Kodiak Archipelago in the central Gulf of Alaska (Calambokidis et al. 2001), and the Shumagin Islands in the western Gulf of Alaska (Witteveen et al. 2004), but no photo-identification studies had previously been conducted in Russia. Individual movement information from the SPLASH study documents that Russia is likely the primary migratory destination for whales in Okinawa and the Philippines but also reconfirms that some Asian whales go to Ogasawara, the

Aleutian Islands, Bering Sea, and Gulf of Alaska (Calambokidis et al. 2008). A small amount of inter-yearly interchange was also found between the wintering areas (Philippines, Okinawa, and Ogasawara).

During the SPLASH study in Russia, humpback whales were primarily found along the Pacific east side of the Kamchatka Peninsula, near the Commander Islands between Kamchatka and the Aleutian Islands, and in the Gulf of Anadyr just southwest of the Bering Strait. Analysis of whaling data shows historical catches of humpback whales well into the Bering Sea and catches in the Bering Strait and Chukchi Sea in August-October in the 1930s (Mizroch and Rice 2007), but no survey effort occurred during SPLASH north of the Bering Strait. Humpback whales are increasingly seen north of the Bering Strait into the northeastern Chukchi Sea (Clarke et al. 2013a, 2013b), with some indication that more humpback whales are seen on the Russian side north of the Bering Strait (Clarke et al. 2013b). Humpback whales are the most commonly recorded cetacean on hydrophones just north of the Bering Strait and occurred from September into early November from 2009 to 2012 (K. Stafford, Applied Physics Laboratory-University of Washington, Seattle, WA, pers. comm.). Other locations in the far western Pacific where humpback whales have been seen in summer include the northern Kuril Islands (V. Burkanov, NMFS-AFSC-MML, pers. comm.), far offshore southeast of the Kamchatka Peninsula and south of the Commander Islands (Miyashita 2006), and along the north coast of the Chukotka Peninsula in the Chukchi Sea (Melnikov 2000).

These results indicate humpback whales from the Western North Pacific (Asian) breeding stock overlap broadly on summer feeding grounds with whales from the Central North Pacific breeding stock, as well as with whales that winter in the Revillagigedos in Mexico. Given the relatively small size of the Asian population, Asian whales probably represent a small fraction of all the whales found in the Aleutian Islands, Bering Sea, and Gulf of Alaska, which are primarily whales from Hawaii and the Revillagigedos. The only feeding area that appears to be primarily (or exclusively) composed of Asian whales is along the Kamchatka Peninsula in Russia. The initial SPLASH abundance estimates for Asia ranged from about 900 to 1,100, and the estimates for Kamchatka in Russia ranged from about 100 to 700, suggesting a large portion of the Asian population migrates to Kamchatka. This also shows that Asian whales that migrate to feeding areas besides Russia would be only a small fraction of the total number of whales in those areas, given the much larger abundance estimates for the Bering Sea and Aleutian Islands (6,000-14,000) and the Gulf of Alaska (3,000-5,000) (Calambokidis et al. 2008). A full description of the distribution and density of humpback whales in the Aleutian Islands, Bering Sea, and Gulf of Alaska is in the Stock Assessment Report for the Central North Pacific stock of humpback whales.

In summary, information from a variety of sources indicates that humpback whales from the Western and Central North Pacific stocks mix to a limited extent on summer feeding grounds ranging from British Columbia through the central Gulf of Alaska and up to the Bering Sea.

NMFS conducted a global Status Review of humpback whales (Bettridge et al. 2015) and revised the ESA listing of the species (81 FR 62259, 8 September 2016); the effects of the ESA-listing final rule on the status of the stock are discussed below.

POPULATION SIZE

In the SPLASH study, fluke photographs were collected by over 400 researchers in all known feeding areas from Russia to California and in all known wintering areas from Okinawa and the Philippines to the coast of Central America and Mexico from 2004 to 2006. Over 18,000 fluke identification photographs were collected, and these have been used to estimate the abundance of humpback whales in the entire North Pacific Basin. A total of 566 unique individuals were seen in the Asian wintering areas during the 2-year period (3 winter field seasons) of the SPLASH study. Based on a comparison of all winter identifications to all summer identifications, the Chapman-Petersen estimate of abundance was 21,808 (CV = 0.04) (Barlow et al. 2011). A simulation study identifies significant biases in this estimate from violations of the closed population assumption (+5.3%), exclusion of calves (-10.3%), failure to achieve random geographic sampling (+1.5%), and missed matches (+9.8%) (Barlow et al. 2011). Sex-biased sampling favoring males in wintering areas does not add significant bias if both sexes are proportionately sampled in the feeding areas. The bias-corrected estimate is 20,800 after accounting for a net positive bias of 4.8%. This estimate is likely to be lower than the true abundance due to two additional sources of bias: individual heterogeneity in the probability of being sampled (unquantified) and the likely existence of an unknown and unsampled wintering area (-7.2%).

During the SPLASH study, surveys were conducted in three winter field seasons (2004 to 2006). The total numbers of unique individuals found in each area during the study were 77 in the Philippines, 215 in Okinawa, and 294 in the Ogasawara Islands. There was a total of 20 individuals seen in more than one area, leaving a total of 566 unique individuals seen in the Asian wintering areas (Calambokidis et al. 2008). For abundance in winter or summer areas, a multistrata Hilborn mark-recapture model was used, which is a form of a spatially-stratified model that explicitly estimates movement rates between winter and summer areas. Two broad categories of models were used making different assumptions about the movement rates, and four different models were used for capture probability. Point estimates of abundance for Asia (combined across the three areas) were relatively consistent across models, ranging from 938 to 1,107. The model that fit the data the best (as selected by AICc) gave an estimate of 1,107 for the Ogasawara Islands, Okinawa, and the Philippines. No confidence limits or coefficients of variation (CVs) were calculated for the SPLASH abundance estimates. Although no other high density aggregations of humpback whales are known on the Asian wintering ground, whales have been seen in other locations, indicating this is likely to represent an underestimate of the stock's true abundance to an unknown degree. This estimate is more than 8 years old and is outdated for use in stock assessments; however, this population increased between estimates for 1991 to 1993 and 2004 to 2006 (Calambokidis et al. 2008), and this is still considered a valid minimum population estimate (NMFS 2016).

On the summer feeding grounds, the initial SPLASH abundance estimates for Kamchatka in Russia ranged from about 100 to 700, suggesting a large portion of the Asian population occurs near Kamchatka. No separate estimates are available for the other areas in Russia, the Gulf of Anadyr and the Commander Islands; abundance from those areas is included in the estimate of abundance for the Bering Sea and Aleutian Islands, which ranged from about 6,000 to 14,000. Abundance estimates for the Gulf of Alaska and for Southeast Alaska/northern British Columbia both ranged from 3,000 to 5,000 (Calambokidis et al. 2008).

Minimum Population Estimate

Point estimates of abundance for Asia ranged from 938 to 1,107 (for 2004 to 2006), but no associated CV was calculated. The 1991 to 1993 abundance estimate for Asia using similar (though likely less) data had a CV of 0.084. Therefore, it is unlikely the CV of a SPLASH estimate would be greater than 0.300. The minimum population estimate (N_{MIN}) for this stock is calculated according to Equation 1 from the potential biological removal (PBR) guidelines (NMFS 2016): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the SPLASH population estimate (N) of 1,107 from the best fit model and an assumed conservative CV(N) of 0.300 would result in an N_{MIN} for this humpback whale stock of 865. The 2016 guidelines for preparing Stock Assessment Reports (NMFS 2016) recommend that N_{MIN} be considered unknown if the abundance estimate is more than 8 years old, unless there is compelling evidence that the stock has not declined since the last estimate. This population increased between estimates for 1991 to 1993 and 2004 to 2006 (Calambokidis et al. 2008), and this is still considered a valid minimum population estimate.

Current Population Trend

The SPLASH abundance estimate for Asia represents a 6.7% annual rate of increase over the 1991 to 1993 abundance estimate (Calambokidis et al. 2008). However, the 1991 to 1993 estimate was for Ogasawara and Okinawa only, whereas the SPLASH estimate includes the Philippines, so the annual rate of increase is unknown.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Utilizing a birth-interval model, Barlow and Clapham (1997) have estimated a population growth rate of 6.5% (SE = 1.2%) for the well-studied humpback whale population in the Gulf of Maine, although there are indications that this rate subsequently slowed (Clapham et al. 2003). Mobley et al. (2001) estimated a trend of 7% per year for 1993-2000 using data from aerial surveys that were conducted in a consistent manner for several years across all of the Hawaiian Islands and were developed specifically to estimate a trend for the Central North Pacific stock. Mizroch et al. (2004) estimated survival rates for North Pacific humpback whales using mark-recapture methods, and a Pradel model fit to data from Hawaii for the years 1980-1996 resulted in an estimated rate of increase of 10% per year (95% CI: 3-16%). For shelf waters of the northern Gulf of Alaska, Zerbini et al. (2006) estimated an annual rate of increase for humpback whales from 1987 to 2003 of 6.6% (95% CI: 5.2-8.6%). The SPLASH abundance estimate for the total North Pacific represents an annual increase of 4.9% over the most complete estimate for the North Pacific for 1991 to 1993. Comparisons of SPLASH abundance estimates for Hawaii to estimates for 1991 to 1993 gave estimates of annual increase that ranged from 5.5 to 6.0% (Calambokidis et al. 2008). No confidence limits were calculated for these rates of increase from SPLASH data.

Estimates of observed rates of increase can be used to estimate maximum net productivity rates (R_{MAX}), although in most cases these estimates may be biased low, as maximum net productivity rates are only achieved at very low population sizes. However, if the observed rates of increase are greater than the default value for R_{MAX}, it would be reasonable to use a higher value based on those observations. The rates of increase summarized above include estimates for the North Pacific of 7%, 10%, and 6.6%. Although there is no estimate of R_{MAX} for just the Western stock (i.e., from trends in abundance in the Asia breeding areas), it is reasonable to assume that R_{MAX} for this stock would be at least 7% based on the other observations from the North Pacific. Until additional data become available for the Western North Pacific humpback whale stock, 7% will be used as R_{MAX} for this stock (NMFS 2016).

POTENTIAL BIOLOGICAL REMOVAL

PBR is defined as the product of the minimum population estimate, one-half the maximum estimated net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.1, the value for cetacean stocks listed as endangered under the ESA (NMFS 2016; see Status of Stock section below regarding ESA listing status). Using the N_{MIN} of 865 calculated from the SPLASH abundance estimate for 2004 to 2006, of 1,107 with an assumed CV of 0.300, the PBR is calculated to be 3.0 whales (865 × 0.035 × 0.1).

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals between ~~2013~~2014 and ~~2017~~2018 is listed, by marine mammal stock, in ~~Delean et al. (2020)~~Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. Injury events lacking detailed injury information are assigned prorated values following injury determination guidelines described in NMFS (2012). A summary of information used to determine whether an injury was serious or non-serious, as well as a table of prorate values used for large whale reports with incomplete information, is reported in ~~Delean et al. (2020)~~Young et al. (in press). The minimum estimated mean annual level of human-caused mortality and serious injury for Western North Pacific humpback whales between ~~2013~~2014 and ~~2017~~2018 is ~~2.6~~2.8 whales: ~~0.7~~0.9 in U.S. commercial fisheries, 0.4 in recreational fisheries, ~~0.2~~0.4 in unknown (commercial, recreational, or subsistence) fisheries, 0.6 in marine debris, and ~~0.7~~0.5 due to other causes (~~entanglement in a ship's ground tackle,~~ ship strikes~~,~~ and an intentional unauthorized take); however, this estimate is considered a minimum because there are no data concerning fishery-related mortality and serious injury in Japanese, Russian, or international waters. Assignment of mortality and serious injury to both the Western North Pacific and Central North Pacific stocks of humpback whales, when the stock is unknown and events occur within the area where the stocks are known to overlap, may result in overestimating stock specific mortality and serious injury. Potential threats most likely to result in direct human-caused mortality or serious injury of this stock include entanglement in fishing gear and ship strikes due to increased vessel traffic (from increased shipping in higher latitudes with changes in sea-ice coverage).

Fisheries Information

Information for federally-managed and state-managed U.S. commercial fisheries in Alaska waters ~~(including observer programs, observer coverage, and observed incidental takes of marine mammals)~~ is ~~presented~~available in Appendi~~ces~~x 3~~-6~~ of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

~~No incidental mortality or serious injury of Western North Pacific humpback whales was observed in federally-managed U.S. commercial fisheries in Alaska waters between 2013 and 2017.~~In 2018, one humpback whale mortality occurred in the Bering Sea/Aleutian Islands pollock trawl fishery (Table 1; Breiwick 2013; MML, unpubl. data). Because the stock is unknown, and the event occurred within the area where the Western North Pacific and Central North Pacific stocks are known to overlap, the mortality in this fishery was assigned to both stocks of humpback whales. The minimum estimated mean annual mortality and serious injury rate from observed U.S. commercial fisheries between 2014 and 2018 is 0.2 Western North Pacific humpback whales (Table 1).

Table 1. Summary of incidental mortality and serious injury of Western North Pacific humpback whales due to U.S. commercial fisheries between 2014 and 2018 and calculation of the mean annual mortality and serious injury rate (Breiwick 2013; MML, unpubl. data). Methods for calculating percent observer coverage are described in Appendix 3 of the Alaska Stock Assessment Reports.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality (CV)	Mean estimated annual mortality
Bering Sea/Aleutian Is. pollock trawl*	2014 2015 2016 2017 2018	obs data	98 99 99 99 99	0 0 0 0 1	0 0 0 0 1.0 (0.11)	0.2 (CV = 0.11)
Minimum total estimated annual mortality						0.2 (CV = 0.11)

*Mortality and serious injury in this fishery was assigned to both the Western North Pacific and Central North Pacific stocks of humpback whales, because the stock is unknown and the two stocks overlap within the area of operation of the fishery.

Mortality and serious injury ~~due to entanglements in Kodiak Island commercial salmon set gillnet (one serious injury in 2015, prorated at 0.75), Bering Sea/Aleutian Islands commercial pot gear (one mortality in 2015), and Alaska State-managed commercial cod pot gear parallel fishery (one serious injury in 2017) was~~ reported to the NMFS Alaska Region marine mammal stranding network ~~between 2013 and 2017, as well as a serious injury (prorated at 0.52) from a ship strike by an Alaska/Washington/Oregon/California commercial passenger fishing vessel in 2017 (Table 1; Delean et al. 2020). Because~~, for fisheries in which observer data are not available, ~~for these fisheries, these reports of mortality and serious injury are used to calculate~~resulted in a minimum mean annual mortality and serious injury rate of 0.7 humpback whales in U.S. commercial fisheries between ~~2013~~2014 and ~~2017~~2018 (Table ~~1~~2; Young et al. in press). ~~Since~~Because all of these events occurred in the area where the two stocks overlap, this mortality and serious injury was assigned to both the Western North Pacific and Central North Pacific stocks of humpback whales (NMFS 2016). These mortality and serious injury estimates result from an actual count of verified human-caused deaths and serious injuries and are minimums because not all entangled animals strand or are self-reported nor are all stranded animals found, reported, or have the cause of death determined.

The minimum estimate of the mean annual mortality and serious injury rate incidental to U.S. commercial fisheries between ~~2013~~2014 and ~~2017~~2018 is ~~0.7~~0.9 Western North Pacific humpback whales, based on observer data (0.2) and reports to the NMFS Alaska Region stranding network in which the commercial fishery can be confirmed (0.7). However, this estimate is considered a minimum because there are no data concerning fishery-related mortality and serious injury in Japanese, Russian, or international waters.

Reports to the NMFS Alaska Region marine mammal stranding network of swimming, floating, or beachcast humpback whales entangled in fishing gear or with injuries caused by interactions with gear, which may be from commercial, recreational, or subsistence fisheries, are another source of fishery-related mortality and serious injury data (Table ~~1~~2). These mortality and serious injury estimates result from an actual count of verified human-caused deaths and serious injuries and are minimums because not all entangled animals strand nor are all stranded animals found, reported, or have the cause of death determined. ~~Since~~Because all of these events occurred in the area where the two stocks overlap, the mortality and serious injury was assigned to both the Western North Pacific and Central North Pacific stocks of humpback whales. ~~In 2015~~Between 2014 and 2018, two humpback whales (each with a serious injury prorated at 0.75) entangled in ~~Gulf of Alaska~~ recreational pot fisheries gear~~(one in Dungeness crab pot gear and one in shrimp pot gear) were reported to the NMFS Alaska Region stranding network~~, resulting in a minimum mean annual mortality and serious injury rate of 0.4 whales in recreational gear ~~between 2013 and 2017~~ (Table ~~1~~2; ~~Delean et al. 2020~~Young et al. in press). ~~An a~~Additional entanglements in Prince William Sound shrimp pot gear and unidentified fishing gear~~was reported to the NMFS Alaska Region stranding network in 2014,~~ result~~ing~~ed in a minimum mean annual mortality and serious injury rate of ~~0.2~~0.4 humpback whales in unknown (commercial, recreational, or subsistence) fisheries between ~~2013~~2014 and ~~2017~~2018 (Table ~~1~~2; ~~Delean et al. 2020~~Young et al. in press).

The minimum ~~average~~mean annual mortality and serious injury rate due to interactions with all fisheries between ~~2013~~2014 and ~~2017~~2018 is ~~1.3~~1.7 Western North Pacific humpback whales (~~0.7~~0.9 in commercial fisheries + 0.4 in recreational fisheries + ~~0.2~~0.4 in unknown fisheries).

Table 12. Summary of mortality and serious injury of Western North Pacific humpback whales, by year and type, reported to the NMFS Alaska Region marine mammal stranding network between 20132014 and 20172018 (Delean et al. 2020Young et al. in press). All events occurred within the area of known overlap between the Western North Pacific and Central North Pacific humpback whale stocks. SinceBecause the stock is unknown, the mortality and serious injury is reflected in the Stock Assessment Reports for both stocks. Injury events lacking detailed injury information are assigned prorated values following injury determination guidelines described in NMFS (2012). A summary of information used to determine whether an injury was serious or non-serious, as well as a table of prorate values used for large whale reports with incomplete information, is reported in Delean et al. (2020)Young et al. (in press).

Cause of injury	2013	2014	2015	2016	2017	2018	Mean annual mortality
Entangled in Kodiak Island commercial salmon set gillnet	0	0	0.75	0	0	0	0.2
Entangled in Bering Sea/Aleutian Is. commercial pot gear	0	0	1	0	0	0	0.2
Entangled in Alaska State-managed commercial cod pot gear (parallel fishery)	0	0	0	0	1	0	0.2
Ship strike by AK/WA/OR/CA commercial passenger fishing vessel	0	0	0	0	0.52	0	0.1
Entangled in Gulf of Alaska recreational Dungeness crab pot gear	0	0	0.75	0	0	0	0.2
Entangled in Gulf of Alaska recreational shrimp pot gear	0	0	0.75	0	0	0	0.2
Entangled in Prince William Sound shrimp pot gear*	0	1	0	0	0	0	0.2
Entangled in unidentified fishing gear*		0	0	0	0	0.75	0.2
Entangled in marine debris	0	0.75	0	2	0	0	0.6
Entangled in ship's ground tackle	1	0	0	0	0		0.2
Ship strike	0	1.2	0	0.2	0	0	0.3
Intentional unauthorized take	0	0	0	1	0	0	0.2
Total in commercial fisheries							0.7
Total in recreational fisheries							0.4
*Total in unknown (commercial, recreational, or subsistence) fisheries							0.20.4
Total in marine debris							0.6
Total due to other sourcescauses (entangled in ship's ground tackle, ship strike, intentional unauthorized take)							0.70.5

Brownell et al. (2000) compiled records of bycatch in Japanese and Korean commercial fisheries between 1993 and 2000. From 1995 to 1999, there were six humpback whales indicated as "bycatch." In addition, two strandings were reported during this period. Furthermore, genetic analysis of four samples from meat found in markets indicated that humpback whale meat was being sold. It is not known whether any or all strandings were caused by incidental interactions with commercial fisheries; similarly, it is not known whether the humpback whales identified in market samples were killed as a result of incidental interactions with commercial fisheries. It is also not known which fishery may be responsible for the bycatch. Regardless, these data indicate a minimum mortality level of 1.1 per year (using bycatch data only) to 2.4 per year (using bycatch, stranding, and market data) in the waters of Japan and Korea. Because many mortalities pass unreported, the actual rate in these areas is likely higher. An analysis of entanglement rates from photographs collected for the SPLASH study found a minimum entanglement rate of 31% for humpback whales from the Asia breeding grounds (Cascadia Research NFWF Report #2003-0170-019).

Alaska Native Subsistence/Harvest Information

Subsistence hunters in Alaska are not authorized to take humpback whales from this stock. An intentional unauthorized take of a humpback whale by Alaska Natives in 2016 in Toksook Bay is reported in the Other Mortality section of this report.

Other Mortality

In 2015, increased mortality of large whales was observed along the western Gulf of Alaska (including the areas around Kodiak Island, Afognak Island, Chirikof Island, the Semidi Islands, and the southern shoreline of the Alaska Peninsula) and along the central British Columbia coast (from the northern tip of Haida Gwaii to ~~S~~southern Vancouver Island). NMFS declared an Unusual Mortality Event (UME) for large whales that occurred from 22 May to 31 December 2015 in the western Gulf of Alaska and from 23 April 2015 to 16 April 2016 in British Columbia (https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events, accessed ~~December 2019~~August 2020). Forty-six large whale deaths attributed to the UME included 12 fin whales and 22 humpback whales in Alaska and 5 fin whales and 7 humpback whales in British Columbia. Based on the findings from the investigation, the UME was likely caused by ecological factors (i.e., the 2015 El Niño, Warm Water Blob, and Pacific Coast Domoic Acid Bloom).

Entanglements in marine debris and ship strikes by vessels unrelated to fisheries reported to the NMFS Alaska Region marine mammal stranding network account for ~~a~~ minimum mean annual mortality and serious injury rates of 0.6 and 0.3 Western North Pacific humpback whales, respectively, between ~~2013~~2014 and ~~2017~~2018 (Table ~~1~~2; ~~Delean et al. 2020~~Young et al. in press).~~ Ship strikes and other interactions with vessels unrelated to fisheries resulted in a minimum mean annual mortality and serious injury rate of 0.5 humpback whales from this stock between 2013 and 2017, based on ship strikes (0.3) and entanglement in a ship's ground tackle (0.2) reported to the NMFS Alaska Region stranding network (Table 1; Delean et al. 2020).~~ Because all of these events occurred in the area where the stocks overlap, the mortality and serious injury was assigned to both the Western North Pacific and Central North Pacific stocks of humpback whales. These mortality and serious injury estimates result from an actual count of verified human-caused deaths and serious injuries and are minimums because not all animals strand nor are all stranded animals found, reported, or have the cause of death determined.

An intentional unauthorized take of a humpback whale by Alaska Natives in Toksook Bay in 2016 resulted in a mean annual mortality and serious injury rate of 0.2 whales between ~~2013~~2014 and ~~2017~~2018 (Table ~~1~~2).

HISTORICAL WHALING

Rice (1978) estimated that the number of humpback whales in the North Pacific may have been approximately 15,000 individuals prior to exploitation; however, this was based upon incomplete data and, given the level of known catches (legal and illegal) since World War II, may be an underestimate. Intensive commercial whaling removed more than 28,000 animals from the North Pacific during the 20th century (Rice 1978). A total of 3,277 reported catches occurred in Asia between 1910 and 1964, with 817 catches from Ogasawara between 1924 and 1944 (Nishiwaki 1966, Rice 1978). After World War II, substantial catches occurred in Asia near Okinawa (including 970 between 1958 and 1961), as well as around the main islands of Japan and the Ogasawara Islands. On the feeding grounds, substantial catches occurred around the Commander Islands and western Aleutian Islands, as well as in the Gulf of Anadyr (Springer et al. 2006).

Humpback whales in the North Pacific were theoretically fully protected in 1965, but illegal catches by the U.S.S.R. continued until 1972 (Ivashchenko et al. 2013). From 1948 to 1971, 7,334 humpback whales were killed by the U.S.S.R., and 2,654 of these were illegally taken and not reported to the IWC (Ivashchenko et al. 2013). Many animals during this period were taken from the Gulf of Alaska and Bering Sea (Doroshenko 2000); ~~however,~~ additional illegal catches were made across the North Pacific, from the Kuril Islands to Haida Gwaii, and other takes may have gone unrecorded. The Soviet factory ship *Aleut* is known to have taken 535 humpback whales from 1933 to 1947 (Ivashchenko et al. 2013).

STATUS OF STOCK

The minimum estimated mean annual level of human-caused mortality and serious injury of ~~2.6~~2.8 Western North Pacific humpback whales is less than the calculated PBR level for this stock (3.0). The minimum estimate of the mean annual U.S. commercial fishery-related mortality and serious injury rate for this stock (~~0.7~~0.9 whales) exceeds 10% of the PBR (10% of PBR = 0.3) and cannot be considered insignificant and approaching a zero mortality and serious injury rate. In addition, there is a lack of information about fisheries bycatch from Russia, Japan, Korea, and international waters, as well as earlier evidence of bycatch in Japan and Korea (Brownell et al. 2000: 1.1 to 2.4 whales per year based on bycatch, stranding, and market data). The humpback whale ESA listing final rule (81 FR 62259, 8 September 2016) established 14 Distinct Population Segments (DPSs) with different listing statuses. The DPSs that occur in waters under the jurisdiction of the United States do not equate to the existing MMPA stocks. Some of the listed DPSs partially coincide with the currently defined Western North Pacific stock. Because we cannot manage one portion of an MMPA stock as ESA-listed and another portion of a stock as not ESA-listed, until such time as the MMPA stock delineations are reviewed in light of the DPS designations and Bettridge et al. (2015), NMFS continues to use the existing MMPA stock structure and considers this stock to be endangered and depleted for MMPA management purposes (e.g., selection of a recovery factor, stock status). As a result, the Western North Pacific stock of humpback whales is classified as a strategic stock.

There are key uncertainties in the assessment of the Western North Pacific stock of humpback whales. New DPSs were ~~recently~~ identified under the ESA; however, stocks have not yet been revised. The feeding areas of the Western North Pacific stock and the Central North Pacific stock overlap in waters from British Columbia to the Bering Sea, so human-related mortality and serious injury estimates must be assigned to or prorated to multiple stocks. The migratory destination of the Western North Pacific stock is not well understood. The population estimate was based on studies from the Asian wintering grounds; although no other large aggregations of whales are known, the estimate is likely conservative relative to the actual abundance. An estimate of variance is not available. The abundance estimate is calculated using data collected from 2004 to 2006; however, the population increased between estimates for 1991 to 1993 and 2004 to 2006 (Calambokidis et al. 2008), and the N_{MIN} is still considered a valid minimum population estimate (NMFS 2016). Estimates of human-caused mortality and serious injury from stranding data and fisherman self-reports are underestimates because not all animals strand or are self-reported nor are all stranded animals found, reported, or have the cause of death determined.

HABITAT CONCERNS

Potential concerns for this stock include elevated levels of sound from anthropogenic sources (e.g., shipping, military sonars), harmful algal blooms (Geraci et al. 1989), possible changes in prey distribution with climate change, entanglement in fishing gear, ship strikes due to increased vessel traffic (e.g., from increased shipping in higher latitudes), and oil and gas activities.

The overall trend for most humpback whale populations found in U.S. waters is positive and points toward recovery (81 FR 62259; 8 September 2016)~~,~~; ~~indicating that prey availability is not a major problem~~however, this may not be uniform for all breeding areas. ~~However, a~~A sharp decline in observed reproduction and encounter rates of humpback whales from the Central North Pacific stock between 2013 and 2018 has been related to oceanographic anomalies and consequent impacts on prey resources (Cartwright et al. 2019), suggesting that humpback whales are vulnerable to major environmental changes.

CITATIONS

Baker, C. S., S. R. Palumbi, R. H. Lambertsen, M. T. Weinrich, J. Calambokidis, and S. J. O'Brien. 1990. Influence of seasonal migration on geographic distribution of mitochondrial DNA haplotypes in humpback whales. Nature 344:238-240.

Baker, C. S., L. Medrano-Gonzalez, J. Calambokidis, A. Perry, F. Pichler, H. Rosenbaum, J. M. Straley, J. Urban-Ramirez, M. Yamaguchi, and O. von Ziegesar. 1998. Population structure of nuclear and mitochondrial DNA variation among humpback whales in the North Pacific. Mol. Ecol. 7:695-707.

Baker, C. S., D. Steel, J. Calambokidis, J. Barlow, A. M. Burdin, P. J. Clapham, E. A. Falcone, J. K. B. Ford, C. M. Gabriele, U. González-Peral, R. LeDuc, D. Mattila, T. J. Quinn, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. Urbán-R., M. Vant, P. Wade, D. Weller, B. H. Witteveen, K. Wynne, and M. Yamaguchi. 2008. *geneSPLASH*: an initial, ocean-wide survey of mitochondrial (mt) DNA diversity and population structure among humpback whales in the North Pacific. Final Report for Contract 2006-0093-008 to the National Fish and Wildlife Foundation.

Baker, C. S., D. Steel, J. Calambokidis, E. Falcone, U. González-Peral, J. Barlow, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, D. Mattila, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. Urbán, P. R. Wade, D. Weller, B. H. Witteveen, and M. Yamaguchi. 2013. Strong maternal fidelity and natal philopatry shape genetic structure in North Pacific humpback whales. Mar. Ecol. Prog. Ser. 494:291-306. DOI: dx.doi.org/10.3354/meps10508 .

Barlow, J., and P. J. Clapham. 1997. A new birth-interval approach to estimating demographic parameters of humpback whales. Ecology 78(2):535-546.

Barlow, J., J. Calambokidis, E. A. Falcone, C. S. Baker, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, R. LeDuc, D. K. Mattila, T. J. Quinn II, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. Urbán R., P. Wade, D. Weller, B. H. Witteveen, and M. Yamaguchi. 2011. Humpback whale abundance in the North Pacific estimated by photographic capture-recapture with bias correction from simulation studies. Mar. Mammal Sci. 27:793-818.

Bettridge, S., C. S. Baker, J. Barlow, P. J. Clapham, M. Ford, D. Gouveia, D. K. Mattila, R. M. Pace III, P. E. Rosel, G. K. Silber, and P. R. Wade. 2015. Status review of the humpback whale (*Megaptera novaeangliae*) under the Endangered Species Act. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-540, 240 p.

Breiwick, J. M. 2013. North Pacific marine mammal bycatch estimation methodology and results, 2007-2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-260, 40 p.

Brownell, R. L., T. Kasuya, W. P. Perrin, C. S. Baker, F. Cipriano, J. Urban R., D. P. DeMaster, M. R. Brown, and P. J. Clapham. 2000. Unknown status of the western North Pacific humpback whale population: a new conservation concern. Unpubl. report to the International Whaling Commission. 5 p.

Calambokidis, J., G. H. Steiger, J. C. Cubbage, K. C. Balcomb III, and P. Bloedel. 1989. Biology of humpback whales in the Gulf of the Farallones. Report to Gulf of the Farallones National Marine Sanctuary, San Francisco, CA, by Cascadia Research Collective, 218½ West Fourth Avenue, Olympia, WA. 93 p.

Calambokidis, J., G. H. Steiger, and J. R. Evenson. 1993. Photographic identification and abundance estimates of humpback and blue whales off California in 1991-92. Final Contract Report 50ABNF100137 to Southwest Fisheries Science Center, 8901 La Jolla Shores Drive, La Jolla, CA 92037. 67 p.

Calambokidis, J., G. H. Steiger, J. M. Straley, T. Quinn, L. M. Herman, S. Cerchio, D. R. Salden, M. Yamaguchi, F. Sato, J. Urban R., J. Jacobson, O. von Ziegesar, K. C. Balcomb, C. M. Gabriele, M. E. Dahlheim, N. Higashi, S. Uchida, J. K. B. Ford, Y. Miyamura, P. Ladrón de Guevara, S. A. Mizroch, L. Schlender, and K. Rasmussen. 1997. Abundance and population structure of humpback whales in the North Pacific basin. Final Contract Report 50ABNF500113 to Southwest Fisheries Science Center, 8901 La Jolla Shores Drive, La Jolla, CA 92037. 72 p.

Calambokidis, J., G. H. Steiger, J. M. Straley, L. M. Herman, S. Cerchio, D. R. Salden, J. Urbán R., J. K. Jacobsen, O. von Ziegesar, K. C. Balcomb, C. M. Gabriele, M. E. Dahlheim, S. Uchida, G. Ellis, Y. Miyamura, P. Ladrón de Guevara P., M. Yamaguchi, F. Sato, S. A. Mizroch, L. Schlender, K. Rasmussen, J. Barlow, and T. J. Quinn II. 2001. Movements and population structure of humpback whales in the North Pacific. Mar. Mammal Sci. 17(4):769-794.

Calambokidis, J., E. A. Falcone, T. J. Quinn, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, R. LeDuc, D. Mattila, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. Urbán R., D. Weller, B. H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K. Flynn, A. Havron, J. Huggins, and N. Maloney. 2008. SPLASH: Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific. Final Report for Contract AB133F-03-RP-00078, U.S. Dep. Commer., Western Administrative Center, Seattle, WA. Available online: http://www.cascadiaresearch.org/files/publications/SPLASH-contract-Report-May08.pdf . Accessed ~~December 2019~~August 2020.

Cartwright, R., A. Venema, V. Hernandez, C. Wyels, J. Cesere, and D. Cesere. 2019. Fluctuating reproductive rates in Hawaii's humpback whales, *Megaptera novaeangliae*, reflect recent climate anomalies in the North Pacific. Roy. Soc. Open Sci. 6:181463. DOI: dx.doi.org/10.1098/rsos.181463 .

Clapham, P. J., and J. G. Mead. 1999. *Megaptera novaeangliae*. Mamm. Species 604:1-9.

Clapham, P. J., J. Barlow, M. Bessinger, T. Cole, D. Mattila, R. Pace, D. Palka, J. Robbins, and R. Seton. 2003. Abundance and demographic parameters of humpback whales from the Gulf of Maine, and stock definition relative to the Scotian Shelf. J. Cetacean Res. Manage. 5:13-22.

Clarke, J. T., C. L. Christman, A. A. Brower, and M. C. Ferguson. 2013a. Distribution and relative abundance of marine mammals in the northeastern Chukchi and western Beaufort seas, 2012. Annual Report, OCS Study BOEM 2013-00117. Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Clarke, J., K. Stafford, S. E. Moore, B. Rone, L. Aerts, and J. Crance. 2013b. Subarctic cetaceans in the southern Chukchi Sea: evidence of recovery or response to a changing ecosystem. Oceanography 26(4):136-149.

Darling, J. D. 1991. Humpback whales in Japanese waters. Ogasawara and Okinawa. Fluke identification catalog 1987-1990. Final Contract Report, World Wide Fund for Nature, Japan. 22 p.

Darling, J. D., and S. Cerchio. 1993. Movement of a humpback whale (*Megaptera novaeangliae*) between Japan and Hawaii. Mar. Mammal Sci. 1:84-89.

Darling, J. D., J. Calambokidis, K. C. Balcomb, P. Bloedel, K. Flynn, A. Mochizuki, K. Mori, F. Sato, H. Suganuma, and M. Yamaguchi. 1996. Movement of a humpback whale (*Megaptera novaeangliae*) from Japan to British Columbia and return. Mar. Mammal Sci. 12(2):281-287.

~~Delean, B. J., V. T. Helker, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, J. Jannot, and N. C. Young. 2020. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2013-2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-401, 86 p.~~

Doroshenko, N. V. 2000. Soviet catches of humpback whales (*Megaptera novaeangliae*) in the North Pacific, p. 48-95. *In* A. V. Yablokov and V. A. Zemsky (eds.), Soviet Whaling Data (1949-1979). Center for Russian Environmental Policy, Marine Mammal Council, Moscow.

Fleming, A., and J. Jackson. 2011. Global review of humpback whales (*Megaptera novaeangliae*). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-474, 206 p.

Geraci, J. R., D. M. Anderson, R. J. Timperi, D. St. Aubin, G. A. Early, J. H. Prescott, and C. A. Mayo. 1989. Humpback whales (*Megaptera novaeangliae*) fatally poisoned by dinoflagellate toxin. Can. J. Fish. Aquat. Sci. 46(11):1895-1898. DOI: dx.doi.org/10.1139/f89-238 .

Hashagen, K. A., G. A. Green, and B. Adams. 2009. Observations of humpback whales, *Megaptera novaeangliae*, in the Beaufort Sea, Alaska. Northwest. Nat. 90:160-162.

Hill, M. C., E. M. Oleson, S. Baumann-Pickering, A. M. Van Cise, A. D. Ligon, A. R. Bendlin, A. C. Ü, J. S. Trickey, and A. L. Bradford. 2016. Cetacean monitoring in the Mariana Islands Range Complex, 2015. Prepared for the U.S. Pacific Fleet Environmental Readiness Office. PIFSC Data Report DR-16-01. 36 p. + appendix.

Ivashchenko, Y. V., R. L. Brownell, Jr., and P. J. Clapham. 2013. Soviet whaling in the North Pacific: revised catch totals. J. Cetacean Res. Manage. 13:59-71.

Johnson, J. H., and A. A. Wolman. 1984. The humpback whale, *Megaptera novaeangliae*. Mar. Fish. Rev. 46(4):30-37.

Johnston, D. W., M. E. Chapla, L. E. Williams, and D. K. Mattila. 2007. Identification of humpback whale *Megaptera novaeangliae* wintering habitat in the Northwestern Hawaiian Islands using spatial habitat modeling. Endang. Species Res. 3:249-257.

Melnikov, V. V. 2000. Humpback whales *Megaptera novaeangliae* off Chukchi Peninsula. Russ. J. Oceanogr. 4:844-849.

Miyashita, T. 2006. Cruise report of the sighting survey in the waters east of the Kuril Islands and the Kamchatka Peninsula in 2005. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/58/NPM5).

Mizroch, S. A., and D. W. Rice. 2007. Distribution and movements of humpback whales (*Megaptera novaeangliae*) in the North Pacific Ocean. Presented at the 17th Biennial Conference on the Biology of Marine Mammals, Cape Town, South Africa.

Mizroch, S. A., L. M. Herman, J. M. Straley, D. Glockner-Ferrari, C. Jurasz, J. Darling, S. Cerchio, C. Gabriele, D. Salden, and O. von Ziegesar. 2004. Estimating the adult survival rate of central North Pacific humpback whales. J. Mammal. 85(5):963-972.

Mobley, J. M., S. Spitz, R. Grotefendt, P. Forestell, A. Frankel, and G. Bauer. 2001. Abundance of humpback whales in Hawaiian waters: Results of 1993-2000 aerial surveys. Report to the Hawaiian Islands Humpback Whale National Marine Sanctuary. 16 p.

National Marine Fisheries Service (NMFS). 2012. Process for distinguishing serious from non-serious injury of marine mammals. 42 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-policies-guidance-and-regulations . Accessed ~~December 2019~~August 2020.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed ~~December 2019~~August 2020.

Nemoto, T. 1957. Foods of baleen whales in the northern Pacific. Sci. Rep. Whales Res. Inst. Tokyo 12:33-89.

Nemoto, T. 1959. Food of baleen whales with reference to whale movements. *S*ci. Rep. Whales Res. Inst. 14**:**149-290.

Nishiwaki, M. 1966. Distribution and migration of the larger cetaceans in the North Pacific as shown by Japanese whaling results, p. 172-191. *In* K. S. Norris (ed.), Whales, Dolphins and Porpoises. University of California Press, Berkeley, CA.

Ohsumi, S., and Y. Masaki. 1975. Japanese whale marking in the North Pacific, 1963-1972. Bull. Far Seas Fish. Res. 12:171-219.

Omura, H., and S. Ohsumi. 1964. A review of Japanese whale marking in the North Pacific to the end of 1962, with some information on marking in the Antarctic. Norsk Hvalfangst-Tidende 4:90-112.

Perry, A., C. S. Baker, and L. M. Herman. 1990. Population characteristics of individually identified humpback whales in the central and eastern North Pacific: a summary and critique. Rep. Int. Whal. Comm. (Special Issue 12):307-317.

Rice, D. W. 1978. The humpback whale in the North Pacific: distribution, exploitation and numbers, Appendix 4, p. 29-44. *In* K. S. Norris and R. R. Reeves (eds.), Report on a workshop on problems related to humpback whales (*Megaptera novaeangliae*) in Hawaii. U.S. Dep. Commer., Nat. Tech. Info. Serv. PB-280 794. Springfield, VA.

Rice, D. W. 1998. Marine Mammals of the World: Systematics and Distribution. Soc. Mar. Mammal. Spec. Publ. No. 4.

Springer, A. M., G. B. van Vliet, J. F. Piatt, and E. M. Danner. 2006. Whales and whaling in the North Pacific Ocean and Bering Sea: oceanographic insights and ecosystem impacts, p. 245-261. *In* J. A. Estes, R. L. Brownell, Jr., D. P DeMaster, D. F. Doak, and T. M. Williams (eds.), Whales, Whaling and Ocean Ecosystems. University of California Press. 418 p.

Steiger, G. H., J. Calambokidis, R. Sears, K. C. Balcomb, and J. C. Cubbage. 1991. Movement of humpback whales between California and Costa Rica. Mar. Mammal Sci. 7:306-310.

Tomlin, A. G. 1967. Mammals of the USSR and adjacent countries. Vol. 9. Cetacea. Israel Program for Scientific Translations No. 1124, Natl. Tech. Info. Serv. TT 65-50086. Springfield, VA. 717 p. (Translation of Russian text published in 1957.)

Witteveen, B. H., J. M. Straley, O. von Ziegesar, D. Steel, and C. S. Baker. 2004. Abundance and mtDNA differentiation of humpback whales (*Megaptera novaeangliae*) in the Shumagin Islands, Alaska. Can. J. Zool. 82:1352-1359.

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX.

Zenkovich, B. A. 1954. Vokrug sveta za kitami, Vol. Gosudarstvennoe Izdatel'stvo Geograficheskoi Literatury, Moscow.

Zerbini, A. N., J. M. Waite, J. L. Laake, and P. R. Wade. 2006. Abundance, trends and distribution of baleen whales off western Alaska and the central Aleutian Islands. Deep-Sea Res. I 53(11):1772-1790.

Revised ~~12/30/2019~~8/14/2020

HUMPBACK WHALE (*Megaptera novaeangliae*): Central North Pacific Stock

NOTE – NMFS is in the process of reviewing humpback whale stock structure under the Marine Mammal Protection Act (MMPA) in light of the 14 Distinct Population Segments established under the Endangered Species Act (ESA) (81 FR 62259, 8 September 2016). A complete revision of the humpback whale stock assessments will be postponed until this review is complete. In the interim, new information on humpback whale mortality and serious injury is provided within this report.

STOCK DEFINITION AND GEOGRAPHIC RANGE

The humpback whale is distributed worldwide in all ocean basins. In winter, most humpback whales occur in the subtropical and tropical waters of the Northern and Southern Hemispheres. Humpback whales in the high latitudes of the North Pacific Ocean are seasonal migrants that feed on euphausiids and small schooling fishes (Nemoto 1957, 1959; Clapham and Mead 1999). The humpback whale population was considerably reduced as a result of intensive commercial exploitation during the 20th century.

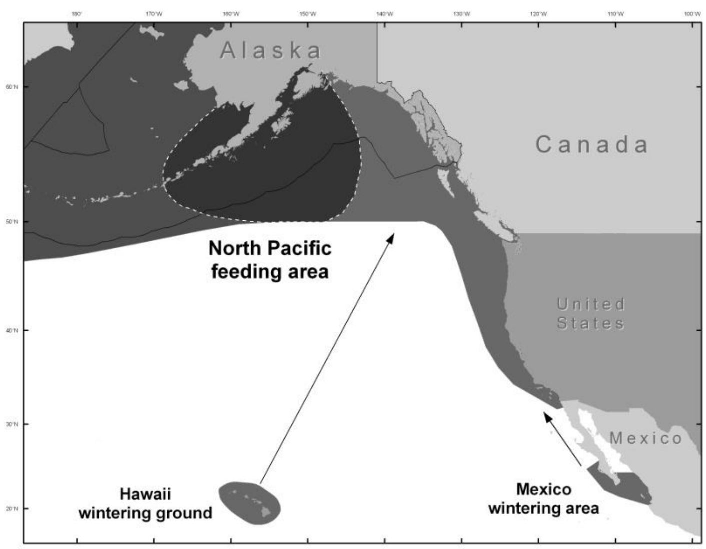

Figure 1. Approximate distribution of humpback whales in the eastern North Pacific (dark shaded areas). Feeding and wintering areas are presented above (see text). Area within the dotted line is known to be an area where the Central North Pacific and Western North Pacific stocks overlap. See Figure 1 in the Western North Pacific humpback whale Stock Assessment Report for distribution of humpback whales in the western North Pacific.

A large-scale study of humpback whales throughout the North Pacific was conducted from 2004 to 2006 (the Structure of Populations, Levels of Abundance, and Status of Humpbacks (SPLASH) project). Results from this project (Calambokidis et al. 2008, Barlow et al. 2011), including abundance estimates and movement information, have been reported in Baker et al. (2008, 2013) and are also summarized in Fleming and Jackson (2011); however, these results are still being considered for stock structure analysis.

The historical summer feeding range of humpback whales in the North Pacific encompassed coastal and inland waters around the Pacific Rim from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk and north of the Bering Strait (Zenkovich 1954, Nemoto 1957, Tomlin 1967, Johnson and Wolman 1984). Historically, the Asian wintering area extended from the South China Sea east through the Philippines, Ryukyu Retto, Ogasawara Gunto, Mariana Islands, and Marshall Islands (Rice 1998). Humpback whales are currently found throughout this historical range (Clarke et al. 2013), with sightings during summer months occurring as far north as the Beaufort Sea (Hashagen et al. 2009). Most of the current winter range of humpback whales in the North Pacific is relatively well known, with aggregations of whales in Japan, the Philippines, Hawaii, Mexico, and Central America. The winter range includes the main islands of the Hawaiian archipelago, with the greatest concentration along the west side of Maui. In Mexico, the winter breeding range includes waters around the southern part of the Baja California peninsula, the central portions of the Pacific coast of mainland Mexico, and the Revillagigedo Islands off the mainland coast. The winter range also extends from southern Mexico into Central America, including Guatemala, El Salvador, Nicaragua, and Costa Rica (Calambokidis et al. 2008).

Photo-identification data, distribution information, and genetic analyses have indicated that in the North Pacific there are at least three breeding populations (Asia, Hawaii, and Mexico/Central America) that all migrate between their respective winter/spring calving and mating areas and their summer/fall feeding areas (Calambokidis et al. 1997, Baker et al. 1998). Calambokidis et al. (2001) further suggested that there may be as many as six subpopulations on the wintering grounds. From photo-identification and Discovery tag information there are known connections between Asia and Russia, between Hawaii and Alaska, and between Mexico/Central America and California (Darling 1991, Darling and Cerchio 1993, Calambokidis et al. 1997, Baker et al. 1998). This information led to the designation of three stocks of humpback whales in the North Pacific: 1) the California/Oregon/Washington and Mexico stock, consisting of winter/spring populations in coastal Central America and coastal Mexico which migrate to the coast of California and as far north as southern British Columbia in summer/fall (Calambokidis et al. 1989, 1993; Steiger et al. 1991); 2) the Central North Pacific stock, consisting of winter/spring populations of the Hawaiian Islands which migrate primarily to northern British Columbia/Southeast Alaska, the Gulf of Alaska, and the Bering Sea/Aleutian Islands (Baker et al. 1990, Perry et al. 1990, Calambokidis et al. 1997) (Fig. 1) ; and 3) the Western North Pacific stock, consisting of winter/spring populations off Asia which migrate primarily to Russia and the Bering Sea/Aleutian Islands.

Information from the SPLASH project largely confirms this view of humpback whale distribution and movements in the North Pacific. For example, the SPLASH results confirm low rates of interchange between the three principal wintering regions (Asia, Hawaii, and Mexico). However, the full SPLASH results suggest that the current view of population structure is incomplete. The overall pattern of movements is complex but indicates a high degree of population structure. Whales from wintering areas at the extremes of their range on both sides of the Pacific migrate to coastal feeding areas that are on the same side of the Pacific: whales from Asia in the west migrate to Russia and whales from mainland Mexico and Central America in the east migrate to coastal waters off California/Oregon.

The SPLASH data now show ~~the~~that Revillagigedo whales are seen in all sampled feeding areas except northern California/Oregon and the south side of the Aleutians. They are primarily distributed in the Bering Sea, Gulf of Alaska, and Southeast Alaska/northern British Columbia but are also found in Russia and southern British Columbia/Washington. The migratory destinations of humpback whales from Hawaii were found to be quite similar, and a significant number of matches (14) were seen during SPLASH between Hawaii and the Revillagigedos (Calambokidis et al. 2008). The SPLASH project also found that whales from the Aleutian Islands and Bering Sea, and perhaps the Gulf of Anadyr and the Chukotka Peninsula on the west side of the Bering Strait in Russia, have an unusually low resighting rate in winter areas compared to whales from other feeding areas. It is now believed that some of these whales have a winter migratory destination that was not sampled during the SPLASH project. Given the location of these feeding areas, the most parsimonious explanation would be that some of these whales winter somewhere between Hawaii and Asia, which would include the possibility of the Mariana Islands (southwest of the Ogasawara Islands), the Marshall Islands (approximately half-way between the Mariana Islands and the Hawaiian Islands), and the Northwestern Hawaiian Islands. Subsequent to the SPLASH project, a survey in 2007 documented humpback whales from a number of locations in the Northwestern Hawaiian Islands at relatively low densities (Johnston et al. 2007), but no sampling occurred there during the SPLASH project. Some humpback whales, including mother/calf pairs, have also been found in the Mariana Islands (Hill et al. 2016). Both of these locations are plausible migratory destinations for whales from the Aleutian Islands and Bering Sea. Which stock that whales in these locations would belong to is currently unknown.

The winter distribution of the Central North Pacific stock is primarily in the Hawaiian archipelago. In the SPLASH study, sampling occurred on Kauai, Oahu, Penguin Bank (off the southwest tip of the island of Molokai), Maui, and the island of Hawaii (the Big Island). Interchange within Hawaii was extensive. Although most of the Hawaii identifications came from the Maui sub-area, identifications from the Big Island and Kauai at the eastern and western end of the region showed a high rate of interchange with Maui.

In summer, the majority of whales from the Central North Pacific stock are found in the Aleutian Islands, Bering Sea, Gulf of Alaska, and Southeast Alaska/northern British Columbia. High densities of humpback whales are found in the eastern Aleutian Islands, particularly along the northern side of Unalaska Island, and along the Bering Sea shelf edge and break to the north towards the Pribilof Islands. Small numbers of humpback whales are known from a few locations not sampled during the SPLASH study, including northern Bristol Bay and the Chukchi and Beaufort seas. In the Gulf of Alaska, high densities of humpback whales are found in the Shumagin Islands, south and east of Kodiak Island, and from the Barren Islands through Prince William Sound. Although densities in any particular location are not high, humpback whales are also found in deep waters south of the continental shelf from the eastern Aleutians through the Gulf of Alaska. Relatively high densities of humpback whales occur throughout much of Southeast Alaska and northern British Columbia.

NMFS conducted a global Status Review of humpback whales (Bettridge et al. 2015) and revised the ESA listing of the species (81 FR 62259, 8 September ~~8,~~ 2016); the effects of the ESA-listing final rule on the status of the stock are discussed below.

POPULATION SIZE

Prior to the SPLASH study, the most complete estimate of abundance for humpback whales in the North Pacific was from data collected from 1991 to 1993, with a best mark-recapture estimate of 6,010 (coefficient of variation (CV) = 0.08) for the entire North Pacific, using a winter-to-winter comparison (Calambokidis et al. 1997). Estimates for Hawaii and Mexico were higher, using marks from summer feeding areas with recaptures on the winter grounds, and totaled almost 10,000 summed across all winter areas. In the SPLASH study, fluke photographs were collected by over 400 researchers in all known feeding areas from Russia to California and in all known wintering areas from Okinawa and the Philippines to the coast of Central America and Mexico from 2004 to 2006. Over 18,000 fluke identification photographs were collected, and these have been used to estimate the abundance of humpback whales in the entire North Pacific Basin. Based on a comparison of all winter identifications to all summer identifications, the Chapman-Petersen estimate of abundance is 21,808 (CV = 0.04) (Barlow et al. 2011). A simulation study identifies significant biases in this estimate from violations of the closed population assumption (+5.3%), exclusion of calves (-10.3%), failure to achieve random geographic sampling (+1.5%), and missed matches (+9.8%) (Barlow et al. 2011). Sex-biased sampling favoring males in wintering areas does not add significant bias if both sexes are proportionately sampled in the feeding areas. The bias-corrected estimate is 20,800 after accounting for a net positive bias of 4.8%. This estimate is likely to be lower than the true abundance due to two additional sources of bias: individual heterogeneity in the probability of being sampled (unquantified) and the likely existence of an unknown and unsampled wintering area (-7.2%).

The Central North Pacific stock of humpback whales winters in Hawaiian waters (Baker et al. 1986). Preliminary mark-recapture abundance estimates from the SPLASH data were calculated in Calambokidis et al. (2008), using a multistrata Hilborn model. The best estimate for Hawaii (as chosen by AICc) was 10,103; no confidence limit or coefficient of variation (CV) was calculated for that estimate. This estimate is more than 8 years old and is outdated for use in stock assessments; however, because this population is increasing in localized areas in Alaska, e.g., Prince William Sound (Teerlink et al. 2015), this is still considered a valid minimum population estimate (NMFS 2016).

In the SPLASH study, the number of unique identifications in different regions during 2004 and 2005 included 63 in the Aleutian Islands (defined as everything on the south side of the islands), 491 in the Bering Sea, 301 in the western Gulf of Alaska (including the Shumagin Islands), and 1,038 in the northern Gulf of Alaska (including Kodiak and Prince William Sound), with a few whales seen in more than one area (Calambokidis et al. 2008). The SPLASH combined estimates ranged from 6,000 to 19,000 for the Aleutian Islands, Bering Sea, and Gulf of Alaska, a considerable increase from previous estimates that were available (e.g., Waite et al. 1999, Moore et al. 2002, Witteveen et al. 2004, Zerbini et al. 2006). However, the SPLASH surveys covered areas not covered in those previous surveys, such as parts of Russian waters (Gulf of Anadyr and Commander Islands), the western and central Aleutian Islands, offshore waters in the Gulf of Alaska and Aleutian Islands, and Prince William Sound. Additionally, mark-recapture estimates can be higher than line-transect estimates because they estimate the total number of whales that have used the study area during the study period, whereas, line-transect surveys provide a snapshot of average abundance in the survey area at the time of the survey. For the Aleutian Islands and Bering Sea (including the Commander Islands and Gulf of Anadyr in Russia), the SPLASH estimates ranged from 2,889 to 13,594; for the Gulf of Alaska (from Prince William Sound to the Shumagin Islands, including Kodiak Island), the SPLASH estimates ranged from 2,845 to 5,122. Given known overlap in the distribution of the Western and Central North Pacific humpback whale stocks, estimates for these feeding areas may include whales from the Western North Pacific stock.

The SPLASH study showed a relatively high rate of interchange between Southeast Alaska and northern British Columbia, so they are considered together. Humpback whale studies have been conducted since the late 1960s in Southeast Alaska. Straley et al. (2009) examined data for the northern portion of Southeast Alaska from 1994 to 2000 and provided an updated abundance estimate of 961 (CV = 0.12). Using 1992 to 2006 photo-identification data and an SIR Jolly-Seber model, Ford et al. (2009) estimated an abundance of 2,145 humpback whales (95% CI: 1,970-2,331) in British Columbia waters. During the SPLASH study, 1,115 unique identifications were made in Southeast Alaska and 583 in northern British Columbia, for a total of 1,669 individual whales, after subtracting whales seen in both areas (1,115+583-13-16 = 1,669) (Calambokidis et al. 2008). From the SPLASH study, the estimates of abundance for Southeast Alaska/northern British Columbia ranged from 2,883 to 6,414. The estimates from SPLASH are considerably larger than the estimate from Straley et al. (2009). This is because the SPLASH estimates included areas not part of the Straley et al. (2009) estimate, including southern Southeast Alaska, northern British Columbia, and offshore waters of both British Columbia and Southeast Alaska.

Minimum Population Estimate

A total of 2,367 unique individuals were seen in the Hawaiian wintering areas during the 2-year period (3 winter field seasons, 2004 to 2006) of the SPLASH study. As discussed above, point estimates of abundance for Hawaii from SPLASH ranged from 7,469 to 10,103: the estimate from the best model was 10,103, but no associated CV was calculated. The 1991 to 1993 abundance estimate for Hawaii using similar (but less) data had a CV of 0.095. Therefore, it is unlikely the CV of a SPLASH estimate would be greater than 0.300. The minimum population estimate (N_{MIN}) for this stock is calculated according to Equation 1 from the potential biological removal (PBR) guidelines (NMFS 2016): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the population estimate (N) of 10,103 from the best fit model and an assumed conservative CV(N) of 0.300 results in an N_{MIN} for the Central North Pacific humpback whale stock of 7,891. The 2016 guidelines for preparing Stock Assessment Reports (NMFS 2016) recommend that N_{MIN} be considered unknown if the abundance estimate is more than 8 years old, unless there is compelling evidence that the stock has not declined since the last estimate. Because this population is increasing in localized areas in Alaska, e.g., Prince William Sound (Teerlink et al. 2015), this is still considered a valid minimum population estimate.

Although the Southeast Alaska/northern British Columbia feeding aggregation is not formally considered a stock, the calculation of what a PBR would be for this area is useful for management purposes. The total number of unique individuals seen during the SPLASH study was 1,669 (1,115 in Southeast Alaska). The abundance estimate of Straley et al. (2009) had a CV of 0.12, and the SPLASH abundance estimates are unlikely to have a much higher CV. Using the lowest population estimate (N) of 2,883 and an assumed worst case CV(N) of 0.300, N_{MIN} for this aggregation is 2,252. Similarly, for the Aleutian Islands and Bering Sea, using the lowest SPLASH estimate of 2,889 with an assumed worst-case CV of 0.300 results in an N_{MIN} of 2,256. For the Gulf of Alaska (from Prince William Sound to the Shumagin Islands, including Kodiak Island), using the lowest SPLASH estimate of 2,845 with an assumed worst-case CV of 0.300 results in an N_{MIN} of 2,222. Estimates for these feeding areas may include whales from the Western North Pacific stock and the Mexican breeding population.

Current Population Trend

Comparison of the estimate for the entire stock provided by Calambokidis et al. (1997) with the 1981 estimate of 1,407 (95% CI: 1,113-1,701) from Baker et al. (1987) suggests that abundance increased in Hawaii between the early 1980s and early 1990s. Mobley et al. (2001) estimated a trend of 7% per year for 1993 to 2000 using data from aerial surveys that were conducted in a consistent manner for several years across all of the Hawaiian Islands and were developed specifically to estimate a trend for the Central North Pacific stock. Mizroch et al. (2004) estimated survival rates for North Pacific humpback whales using mark-recapture methods, and a Pradel model fit to data from Hawaii for the years 1980 to 1996 resulted in an estimated rate of increase of 10% per year (95% CI: 3-16%). For shelf waters of the northern Gulf of Alaska, Zerbini et al. (2006) estimated an annual rate of increase for humpback whales from 1987 to 2003 of 6.6% (95% CI: 5.2-8.6%). The SPLASH abundance estimate for the total North Pacific represents an annual increase of 4.9% over the most complete estimate for the North Pacific for 1991 to 1993. Comparisons of SPLASH abundance estimates for Hawaii to estimates for 1991 to 1993 gave estimates of annual increase that ranged from 5.5 to 6.0% (Calambokidis et al. 2008). No confidence limits were calculated for these rates of increase from SPLASH data. It is also clear that the abundance has increased in Southeast Alaska, although a trend for the Southeast Alaska portion of this stock cannot be estimated from the data because of differences in methods and areas covered.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Using a birth-interval model, Barlow and Clapham (1997) have estimated a population growth rate of 6.5% (SE = 1.2%) for the well-studied humpback whale population in the Gulf of Maine, although there are indications that this rate has slowed over the last decade (Clapham et al. 2003). Estimated rates of increase for the Central North Pacific stock include values for Hawaii of 7.0% (from aerial surveys), 5.5-6.0% (from mark-recapture abundance estimates), and 10% (95% CI: 3-16%) (from a model fit to mark-recapture data) and a value for the northern Gulf of Alaska of 6.6% (95% CI: 5.2-8.6%) from ship surveys (Calambokidis et al. 2008). Although there is no estimate of the maximum net productivity rate (R_{MAX}) for the Central North Pacific stock, it is reasonable to assume that R_{MAX} for this stock would be at least 7%. Until additional data become available for the Central North Pacific humpback whale stock, 7% will be used as R_{MAX} for this stock.

POTENTIAL BIOLOGICAL REMOVAL

PBR is defined as the product of the minimum population estimate, one-half the maximum estimated net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The default recovery factor (F_R) for this stock is 0.1, the recommended value for cetacean stocks listed as endangered under the ESA (NMFS 2016; see Status of Stock section below regarding ESA listing status); however, a recovery factor of 0.3 is used in calculating the PBR for this stock based on the suggested guidelines of Taylor et al. (2003). The default value of 4% for R_{MAX} is replaced by 7%, which is the best estimate of the current rate of increase and is considered a conservative estimate of R_{MAX}. For the Central North Pacific stock of humpback whales, using the SPLASH study abundance estimate from the best fit model for 2004 to 2006 for Hawaii of 10,103 with an assumed CV of 0.300 and its associated N_{MIN} of 7,891, PBR is calculated to be 83 whales (7,891 × 0.035 × 0.3).

At this time, stock structure of humpback whales is under consideration and revisions may be proposed within the next few years. For informational purposes, PBR calculations are completed here for the feeding area aggregations. For Southeast Alaska and northern British Columbia, the smallest abundance estimates from the SPLASH study were used with an assumed worst-case CV of 0.300 to calculate PBRs for feeding areas. Using the suggested guidelines presented in Taylor et al. (2003), it would be appropriate to use a recovery factor of 0.3 for the Southeast Alaska/northern British Columbia feeding aggregation ~~since~~because this aggregation has an N_{MIN} greater than 1,500 and less than 5,000 and has an increasing population trend. A recovery factor of 0.1 is appropriate for the Aleutian Islands and Bering Sea feeding aggregation and the Gulf of Alaska feeding aggregation because the N_{MIN} is greater than 1,500 and less than 5,000 and has an unknown population trend. If we calculated a PBR for the Southeast Alaska/northern British Columbia feeding aggregation it would be 24 (2,252 × 0.035 × 0.3). If we calculated a PBR for the Aleutian Islands and Bering Sea, it would be 7.9 (2,256 × 0.035 × 0.1). If we calculated a PBR for the Gulf of Alaska, it would be 7.8 (2,222 × 0.035 × 0.1). However, note that the actual PBR for the Central North Pacific stock is 83 based on the breeding population size in Hawaii, as calculated above.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals between ~~2013~~2014 and ~~2017~~2018 is listed, by marine mammal stock, in ~~Delean et al. (2020)~~Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. Injury events lacking detailed injury information are assigned prorated values following injury determination guidelines described in NMFS (2012). A summary of information used to determine whether an injury was serious or non-serious, as well as a table of prorate values used for large whale reports with incomplete information, is reported in ~~Delean et al. (2020)~~Young et al. (in press). The minimum estimated mean annual level of human-caused mortality and serious injury for Central North Pacific humpback whales between ~~2013~~2014 and ~~2017~~2018 is ~~25~~26 whales: ~~9.5~~9.8 in U.S. commercial fisheries, ~~0.4~~0.6 in recreational fisheries, 0.4 in subsistence fisheries, ~~7.7~~7.9 in unknown (commercial, recreational, or subsistence) fisheries, ~~2.6~~2.3 in marine debris, and ~~4.3~~4.5 due to other causes (ship strikes and entanglement in ~~a ship's ground tackle,~~ an Alaska Department of Fish and Game (ADF&G) salmon net pen~~,~~ and in mooring gear); however, this estimate is considered a minimum because no observers have been assigned to several fisheries that are known to interact with this stock and, due to limited Canadian observer program data, mortality and serious injury incidental to Canadian commercial fisheries (i.e., those similar to U.S. fisheries known to interact with humpback whales) is uncertain. Assignment of mortality and serious injury to both the Central North Pacific and Western North Pacific stocks of humpback whales, when the stock is unknown and events occur within the area where the stocks are known to overlap, may result in overestimating stock specific mortality and serious injury. Potential threats most likely to result in direct human-caused mortality or serious injury of this stock include ship strikes and entanglement in fishing gear.

Fisheries Information

Information ~~(including observer programs, observer coverage, and observed incidental takes of marine mammals)~~ for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is ~~presented~~available in Appendi~~ces~~x 3~~-6~~ of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

~~No incidental mortality or serious injury of Central North Pacific humpback whales was observed in federally-managed U.S. commercial fisheries in Alaska waters between 2013 and 2017; however,~~In 2018, one humpback whale mortality occurred in the Bering Sea/Aleutian Islands pollock trawl fishery, resulting in a minimum estimated mean annual mortality and serious injury rate of 0.2 humpback whales between 2014 and 2018 (Table 1; Breiwick 2013; MML, unpubl. data). Because the stock is unknown, and the event occurred within the area where the Central North Pacific and Western North Pacific stocks are known to overlap, the mortality in this fishery was assigned to both stocks of humpback whales. ~~o~~One Central North Pacific humpback whale was seriously injured in the Hawaii deep-set longline fishery in 2014, resulting in a mean annual mortality and serious injury rate of 0.9 whales in this fishery between ~~2013~~2014 and ~~2017~~2018 (Table 1; Bradford and Forney 2017; Bradford 2018a, 2018b; NMFS-PIFSC, unpubl. data).

In 2012 and 2013, the Alaska Marine Mammal Observer Program placed observers on independent vessels in the state-managed Southeast Alaska salmon drift gillnet fishery to assess mortality and serious injury of marine mammals. Areas around and adjacent to Wrangell and Zarembo Islands (ADF&G Districts 6, 7, and 8) were observed during the 2012 and 2013 programs (Manly 2015). In 2013, one humpback whale was seriously injured. Based on the one observed serious injury, 11 serious injuries were estimated for Districts 6, 7, and 8 in 2013, resulting in an estimated mean annual mortality and serious injury rate of 5.5 Central North Pacific humpback whales in 2012 and 2013 (Table 1). ~~Since~~Because these three districts represent only a portion of the overall fishing effort in this fishery, we expect this to be a minimum estimate of mortality and serious injury for the fishery.

Mortality and serious injury ~~due to entanglements in Southeast Alaska commercial salmon purse seine gear (one serious injury in both 2013 and 2015, each prorated at 0.75), Kodiak Island commercial salmon set gillnet (one serious injury in 2015, prorated at 0.75), Prince William Sound commercial salmon drift gillnet (two serious injuries in 2015, each prorated at 0.75), Southeast Alaska salmon drift gillnet (nine serious injuries between 2013 and 2017 in ADF&G Districts that were not observed in 2012 and 2013 (i.e., districts with no observer data), including eight serious injuries prorated at 0.75), Bering Sea/Aleutian Islands commercial pot gear (one mortality in 2015), Southeast Alaska commercial pot gear (two serious injuries in 2015, each prorated at 0.75, including the dependent calf of a seriously injured whale), and Alaska State-managed commercial cod pot gear parallel fishery (one serious injury in 2017) was~~ reported to the NMFS Alaska Region marine mammal stranding network and ~~by~~through Marine Mammal Authorization Program (MMAP) fisherman self-reports~~ between 2013 and 2017, as well as a serious injury (prorated at 0.52) from a ship strike by an Alaska/Washington/Oregon/California commercial passenger fishing vessel in 2017 (Table 2; Delean et al. 2020). Because~~, for fisheries in which observer data are not available~~ for these fisheries~~, ~~these reports of mortality and serious injury are used to calculate~~resulted in a minimum mean annual mortality and serious injury rate of ~~3.1~~3.2 humpback whales in U.S. commercial fisheries in Alaska waters between ~~2013~~2014 and ~~2017~~2018 (Table 2; Young et al. in press). Mortality and serious injury in events that occurred in the area where the two stocks overlap was assigned to both the Central North Pacific and Western North Pacific stocks of humpback whales (as noted in Table 2). These mortality and serious injury estimates result from an actual count of verified human-caused deaths and serious injuries and are minimums because not all entangled animals strand or are self-reported nor are all stranded animals found, reported, or have the cause of death determined.

The minimum estimate of the mean annual mortality and serious injury rate incidental to U.S. commercial fisheries for the Central North Pacific stock between ~~2013~~2014 and ~~2017~~2018 (or the most recent data available) is ~~9.5~~9.8 humpback whales, based on observer data from Alaska (Table 1: 0.2 in the federally-managed Bering Sea/Aleutian Islands pollock trawl fishery and 5.5 in the state-managed Southeast Alaska salmon drift gillnet fishery), observer data from Hawaii (Table 1: 0.9), and MMAP fishermen self-reports and reports, in which the commercial fishery is confirmed, to the NMFS Alaska Region stranding network (Table 2: ~~3.1~~3.2).

Table 1. Summary of incidental mortality and serious injury of Central North Pacific humpback whales due to U.S. commercial fisheries between ~~2013~~2014 and ~~2017~~2018 (or the most recent data available) and calculation of the mean annual mortality and serious injury rate for Alaska fisheries (Breiwick 2013; Manly 2015; MML, unpubl. data) and Hawaii fisheries (Bradford and Forney 2017; Bradford 2018a, 2018b; NMFS-PIFSC, unpubl. data). Methods for calculating percent observer coverage for Alaska fisheries are described in Appendix ~~6~~3 of the Alaska Stock Assessment Reports.

Fishery name	**Years**	**Data type**	**Percent observer coverage**	**Observed mortality**	**Estimated mortality (CV)**	**Mean estimated annual mortality**
Bering Sea/Aleutian Is. pollock trawl*	2014 2015 2016 2017 2018	obs data	98 99 99 99 99	0 0 0 0 1	0 0 0 0 1.0 (0.11)	0.2 (CV = 0.11)
Southeast Alaska salmon drift gillnet (Districts 6, 7, 8)	2012 2013	obs data	6.4 6.6	0 1	0 11	5.5 (CV = 1.0)

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality (CV)	Mean estimated annual mortality
Hawaii deep-set longline	~~2013~~ 2014 2015 2016 2017 2018	obs data	~~20~~ 20 20 20 20 20	~~0~~ 1 0 0 0 0	~~0~~ 5 0 0 0 0	0.9 (CV = 2.1)
Minimum total estimated annual mortality					Bering Sea/Aleutian Islands	0.2
					Southeast Alaska:	5.5
					Hawaii:	0.9
					Total:	~~6.4~~6.6 (CV = 0.88)

*Mortality and serious injury in this fishery was assigned to both the Central North Pacific and Western North Pacific stocks of humpback whales, because the stock is unknown and the two stocks overlap within the area of operation of the fishery.

Reports to the NMFS Alaska Region marine mammal stranding network of swimming, floating, or beachcast humpback whales entangled in fishing gear or with injuries caused by interactions with gear, which may be from commercial, recreational, or subsistence fisheries, are another source of information on fishery-related mortality and serious injury. Mortality and serious injury in events that occurred in the area where the two stocks overlap was assigned to both the Central North Pacific and Western North Pacific stocks (as noted in Table 2). These mortality and serious injury estimates result from an actual count of verified human-caused deaths and serious injuries and are minimums because not all entangled animals strand or are self-reported nor are all stranded animals found, reported, or have the cause of death determined. ~~In 2015~~Between 2014 and 2018, ~~two~~three humpback whales (each with a serious injury prorated at 0.75) entangled in ~~Gulf of Alaska~~ recreational pot fisheries gear ~~(1 in Dungeness crab pot gear and 1 in shrimp pot gear) were reported to the NMFS Alaska Region stranding network~~, resulting in a minimum mean annual mortality and serious injury rate of ~~0.4~~0.6 whales in recreational gear in Alaska waters ~~between 2013 and 2017~~ (Table 2; ~~Delean et al. 2020~~Young et al. in press). Humpback ~~W~~whales ~~with serious injuries (prorated at 0.75)~~that entangled in Southeast Alaska subsistence halibut longline gear ~~(one in 2015)~~ and in unidentified subsistence gillnet ~~(one in 2016) were reported to the NMFS Alaska Region stranding network between 2013 and 2017,~~ result~~ing~~ed in a minimum mean annual mortality and serious injury rate of 0.4 humpback whales in subsistence fisheries between 2014 and 2018 (Table 2; ~~Delean et al. 2020~~Young et al. in press). Additional entanglements in unknown (commercial, recreational, or subsistence) ~~fisheries~~fishing gear ~~reported to the NMFS stranding networks~~ between ~~2013~~2014 and ~~2017~~2018 resulted in a minimum mean annual mortality and serious injury rate of ~~7.7~~7.9 humpback whales: ~~1.4~~1.5 reported to the NMFS Alaska Region stranding network (Table 2; ~~Delean et al. 2020~~Young et al. in press) and ~~6.3~~6.4 reported to the NMFS Pacific Islands Region stranding network (Table 3; Bradford and Lyman 2018, 2019, 2020).

The minimum ~~average~~mean annual mortality and serious injury rate due to interactions with all fisheries between ~~2013~~2014 and ~~2017~~2018 is ~~18~~19 Central North Pacific humpback whales (~~9.5~~9.8 in commercial fisheries + ~~0.4~~0.6 in recreational fisheries + 0.4 in subsistence fisheries + ~~7.7~~7.9 in unknown fisheries).

Table 2. Summary of mortality and serious injury of Central North Pacific humpback whales, by year and type, reported to the NMFS Alaska Region marine mammal stranding network and by Marine Mammal Authorization Program (MMAP) fisherman self-reports between ~~2013~~2014 and ~~2017~~2018 (~~Delean et al. 2020~~Young et al. in press). Injury events lacking detailed injury information are assigned prorated values following injury determination guidelines described in NMFS (2012). A summary of information used to determine whether an injury was serious or non-serious, as well as a table of prorate values used for large whale reports with incomplete information, is reported in ~~Delean et al. (2020)~~Young et al. (in press).

Cause of injury	~~2013~~	2014	2015	2016	2017	2018	Mean annual mortality
Entangled in Southeast Alaska commercial salmon purse seine gear	~~0.75[a]~~	0	0.75	0	0	0	~~0.3~~0.2
Entangled in Kodiak Island commercial salmon set gillnet	~~0~~	0	0.75~~[b]~~[a]	0	0	0	0.2
Entangled in Prince William Sound commercial salmon drift gillnet	~~0~~	0	1.5	0	0	0	0.3
Entangled in Southeast Alaska commercial salmon drift gillnet (in ADF&G Districts that were not observed in 2012 and 2013)	~~0.75~~	~~3.25[c]~~ 2.5 + 0.75[b]	0.75	2.25	0	1.5	~~1.4~~1.6
Entangled in Bering Sea/Aleutian Is. commercial pot gear	~~0~~	0	1~~[b]~~[a]	0	0	0	0.2
Entangled in Southeast Alaska commercial pot gear	~~0~~	0	0.75	0	0	0	0.2
Dependent calf of animal seriously injured in Southeast Alaska commercial pot gear	~~0~~	0	0.75	0	0	0	0.2
Entangled in Alaska State-managed commercial cod pot gear (parallel fishery)	~~0~~	0	0	0	1~~[b]~~[a]	0	0.2
Ship strike by AK/WA/OR/CA commercial passenger fishing vessel	~~0~~	0	0	0	0.2 + 0.52~~[b]~~[a]	0	0.1
Entangled in Gulf of Alaska recreational Dungeness crab pot gear	~~0~~	0	0.75~~[b]~~[a]	0	0	0	0.2
Entangled in Gulf of Alaska recreational shrimp pot gear	~~0~~	0	0.75~~[b]~~[a]	0	0	0	0.2
Entangled in Southeast Alaska recreational shrimp pot gear		0	0	0	0	0.75	0.2
Entangled in Southeast Alaska subsistence halibut longline gear	~~0~~	0	0.75	0	0	0	0.2
Entangled in unidentified subsistence gillnet	~~0~~	0	0	0.75	0	0	0.2
Entangled in Prince William Sound shrimp pot gear*	~~0~~	1~~[b]~~[a]	0	0	0	0	0.2
Entangled in Southeast Alaska unidentified fishing gear*	~~0~~	0	1.5	0	0	0	0.3
Dependent calf of animal seriously injured in Southeast Alaska unidentified fishing gear*	~~0~~	0	0.75	0	0	0	0.2
Entangled in Southeast Alaska unidentified net*	~~0.75~~	0	1.5	0	0	0	~~0.5~~0.3
Entangled in unidentified fishing gear*	~~0~~	0	0	0	1	0.75 + 0.75[a]	~~0.2~~0.5
Entangled in marine debris	~~1.5~~	~~4.5[d]~~ 3.75 + 0.75[a]	1.75	~~4.25[d]~~ 2.25 + 2[a]	0.75	0	~~2.6~~2.3

Cause of injury	~~2013~~	2014	2015	2016	2017	2018	Mean annual mortality
Entangled in ADF&G salmon net pen	~~0~~	0	0	0.75	0	0	0.2
Entangled in mooring gear	~~0~~	0	0	0.75	0	0	0.2
~~Entangled in ship's ground tackle~~	~~1[b]~~	~~0~~	~~0~~	~~0~~	~~0~~		~~0.2~~
Ship strike[e]	~~1.14~~	~~4.72~~ 3.52 + 1.2[a]	2.8	~~1.2~~ 1 + 0.2[a]	~~1.68~~ 1.34	3	~~2.3~~2.6
Total in commercial fisheries							~~3.1~~3.2
Total in recreational fisheries							~~0.4~~0.6
Total in subsistence fisheries							0.4
*Total in unknown (commercial, recreational, or subsistence) fisheries							~~1.4~~1.5
Total in marine debris							~~2.6~~2.3
Total due to other ~~sources~~causes (entangled in salmon net pen, entangled in mooring gear~~, entangled in ship's ground tackle~~, ship strike)							~~2.9~~3

~~[a]MMAP fisherman self-report.~~
~~[b]~~[a]Mortality and serious injury assigned to both the Central North Pacific (CNP) and Western North Pacific (WNP) stocks.
~~[c]~~[b]~~One of the serious injuries, prorated at 0.75, was reported by~~ MMAP fisherman self-report.
~~[d]Marine debris mortality and serious injury (prorated values) assigned to both the CNP and WNP stocks: 0.75 whales in 2014 and 2 in 2016.~~
~~[e]Ship strike mortality and serious injury (prorated values) assigned to both the CNP and WNP stocks: 1.2 whales in 2014 and 0.2 in 2016.~~

Table 3. Summary of mortality and serious injury of Central North Pacific humpback whales reported to the NMFS Pacific Islands Region stranding network between ~~2013~~2014 and ~~2017~~2018 (Bradford and Lyman 2018, 2019, 2020).

Cause of injury	~~2013~~	2014	2015	2016	2017	2018	Mean annual mortality
Entangled in Alaska shrimp pot gear*	~~0~~	1	0	0	0	0	0.2
Entangled in Alaska king crab, tanner crab, or finfish pot gear*	~~0~~	0.75	0	0	0	0	0.2
Entangled in British Columbia pot gear*		0	0	0	0	2	0.4
Entangled in longline gear*	~~1~~	1	0	0	0	0	~~0.4~~0.2
Entangled in unidentified gillnet*		0	0	0	0	1	0.2
Entangled in unidentified fishing gear*	~~5.25~~	6.5	7.75	2.5	5.25	4	~~5.5~~5.2
Ship strike	~~3.56~~	1	1.2	0.2	1.2	4	~~1.4~~1.5
*Total in unknown (commercial, recreational, or subsistence) fisheries							~~6.3~~6.4
Total due to other ~~sources~~causes (ship strike)							~~1.4~~1.5

However, these estimates of mortality and serious injury levels should be considered minimums. No observers have been assigned to several fisheries that are known to interact with this stock, making the estimated mortality and serious injury rate an underestimate of actual mortality and serious injury. Further, due to limited Canadian observer program data, mortality and serious injury incidental to Canadian commercial fisheries (i.e., those similar to U.S. fisheries known to interact with humpback whales) is uncertain. Though interactions are thought to be minimal, data regarding the level of humpback whale mortality and serious injury related to commercial fisheries in northern British Columbia are not available, again indicating that the estimated mortality and serious injury incidental to commercial fisheries is underestimated for this stock.

Alaska Native Subsistence/Harvest Information

Subsistence hunters in Alaska are not authorized to take ~~from this stock of~~ humpback whales from this stock, and no takes were reported between ~~2013~~2014 and ~~2017~~2018.

Other Mortality

In 2015, increased mortality of large whales was observed along the western Gulf of Alaska (including the areas around Kodiak Island, Afognak Island, Chirikof Island, the Semidi Islands, and the southern shoreline of the Alaska Peninsula) and along the central British Columbia coast (from the northern tip of Haida Gwaii to southern Vancouver Island). NMFS declared an Unusual Mortality Event (UME) for large whales that occurred from 22 May to 31 December 2015 in the western Gulf of Alaska and from 23 April 2015 to 16 April 2016 in British Columbia (https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events, accessed ~~December 2019~~August 2020). Forty-six large whale deaths attributed to the UME included 12 fin whales and 22 humpback whales in Alaska and 5 fin whales and 7 humpback whales in British Columbia. Based on the findings from the investigation, the UME was likely caused by ecological factors (i.e., the 2015 El Niño, Warm Water Blob, and Pacific Coast Domoic Acid Bloom).

Entanglements in marine debris, an ADF&G salmon net pen, and mooring gear reported to the NMFS Alaska Region marine mammal stranding network resulted in minimum mean annual mortality and serious injury rates of ~~2.6~~2.3, 0.2, and 0.2 Central North Pacific humpback whales, respectively, between ~~2013~~2014 and ~~2017~~2018 (Table 2; ~~Delean et al. 2020~~Young et al. in press). Ship strikes and other interactions with vessels unrelated to fisheries occur frequently with humpback whales (Tables 2 and 3). The minimum mean annual mortality and serious injury rate due to ship strikes ~~and entanglement in a ship's ground tackle reported~~ in Alaska (Table 2: ~~2.5~~2.6) and ship strikes reported in Hawaii (Table 3: ~~1.4~~1.5) between ~~2013~~2014 and ~~2017~~2018 is ~~3.9~~4.1 humpback whales. These mortality and serious injury estimates result from an actual count of verified human-caused deaths and serious injuries and are minimums because not all animals strand nor are all stranded animals found, reported, or have the cause of death determined. Neilson et al. (2012) summarized 108 large whale ship-strike events in Alaska from 1978 to 2011, 25 of which are known to have resulted in the whale's death. Eighty-six percent of these reports involved humpback whales. Most ship strikes of humpback whales are reported from Southeast Alaska; however, there are also reports from the southcentral, ~~and~~ Kodiak Island, and Prince William Sound areas of Alaska (~~Delean et al. 2020~~Young et al. in press). Many of the ship strikes occurring off Hawaii are reported from waters near Maui (Bradford and Lyman 2018, 2019). It is not known whether the difference in ship-strike rates between Southeast Alaska and the northern portion of this stock is due to differences in reporting, amount of vessel traffic, densities of animals, or other factors.

HISTORICAL WHALING

Rice (1978) estimated that the number of humpback whales in the North Pacific may have been approximately 15,000 individuals prior to exploitation; however, this was based upon incomplete data and, given the level of known catches (legal and illegal) since World War II, may be an underestimate. Intensive commercial whaling removed more than 28,000 animals from the North Pacific during the 20th century. Humpback whales in the North Pacific were theoretically fully protected in 1965, but illegal catches by the U.S.S.R. continued until 1972 (Ivashchenko et al. 2013). From 1948 to 1971, 7,334 humpback whales were killed by the U.S.S.R., and 2,654 of these were illegally taken and not reported to the IWC (Ivashchenko et al. 2013). Many animals during this period were taken from the Gulf of Alaska and Bering Sea (Doroshenko 2000); additional illegal catches were made across the North Pacific, from the Kuril Islands to Haida Gwaii, and other takes may have gone unrecorded. The Soviet factory ship *Aleut* is known to have taken 535 humpback whales from 1933 to 1947 (Ivashchenko et al. 2013).

On the feeding grounds of the Central North Pacific stock after World War II, the highest densities of catches occurred around the western Aleutian Islands, in the eastern Aleutian Islands (and adjacent Bering Sea to the north and Pacific Ocean to the south), and British Columbia (Springer et al. 2006). Lower but still relatively high densities of catches occurred south of the Commander Islands, along the south side of the Alaska Peninsula, and around Kodiak Island. Lower densities of catches also occurred in the Gulf of Anadyr, in the central Aleutian Islands, in much of the offshore Gulf of Alaska, and in Southeast Alaska. No catches were reported in the winter grounds of the Central North Pacific stock in Hawaii nor in Mexican winter areas.

STATUS OF STOCK

NMFS recently concluded a global humpback whale Status Review (Bettridge et al. 2015). Although the estimated mean annual level of human-caused mortality and serious injury for the entire Central North Pacific stock (~~25~~26 whales) is considered a minimum, it is unlikely that the total mean annual level of human-caused mortality and serious injury exceeds the PBR level (83) for the entire stock. The minimum estimate of the mean annual U.S. commercial fishery-related mortality and serious injury rate for this stock (~~9.5~~9.8 whales) is more than 10% of the calculated PBR for the entire stock (10% of PBR = 8.3) and, therefore, cannot be considered insignificant and approaching a zero mortality and serious injury rate. The humpback whale ESA listing final rule (81 FR 62259, 8

September 2016) established 14 Distinct Population Segments (DPSs) with different listing statuses. The DPSs that occur in waters under the jurisdiction of the United States do not equate to the existing MMPA stocks. Some of the listed DPSs partially coincide with the currently defined Central North Pacific stock. Because we cannot manage one portion of an MMPA stock as ESA-listed and another portion of a stock as not ESA-listed, until such time as the MMPA stock delineations are reviewed in light of the DPS designations and Bettridge et al. (2015), NMFS continues to use the existing MMPA stock structure and considers this stock to be endangered and depleted for MMPA management purposes (e.g., selection of a recovery factor, stock status). As a result, the Central North Pacific stock of humpback whales is classified as a strategic stock. Humpback whale mortality and serious injury in Hawaii-based fisheries involves whales from the Hawaii DPS; this DPS is not listed as threatened or endangered under the ESA.

There are key uncertainties in the assessment of the Central North Pacific stock of humpback whales. New DPSs were ~~recently~~ identified under the ESA; however, stocks have not yet been revised. No estimate of variance is available for the abundance estimate. The feeding areas of the Central North Pacific stock and the Western North Pacific stock overlap in waters from British Columbia to the Bering Sea, so human-related mortality and serious injury estimates must be assigned to or prorated to multiple stocks. The current abundance estimate is calculated using data collected from 2004 to 2006; however, the N_{MIN} is still considered a valid minimum population estimate because the population is increasing (NMFS 2016). There is considerable site fidelity of humpback whales to particular feeding areas; human-related mortality and serious injury could have a disproportionate impact on a local feeding population even if the impacts to the DPS as currently described are low relative to the PBR level. Estimates of human-caused mortality and serious injury from stranding data and fisherman self-reports are underestimates because not all animals strand or are self-reported nor are all stranded animals found, reported, or have the cause of death determined.

HABITAT CONCERNS

This stock is the focus of a large whale-watching industry in its wintering grounds (Hawaii) and summering grounds (Alaska). Regulations concerning the minimum distance to keep from whales and how to operate vessels when in the vicinity of whales have been developed for Hawaii and Alaska waters in an attempt to minimize the effect of whale watching. Additional concerns have been raised in Hawaii about the effect of jet skis and similar fast waterborne tourist-related traffic, notably in nearshore areas inhabited by mothers and calves. In Alaska, NMFS issued regulations in 2001 to prohibit approaches to humpback whales within 100 yards (91.4 m: 66 FR 29502, 31 May 2001). In 2015, NMFS introduced a voluntary responsible viewing program called Whale SENSE to Juneau area whale-watch operators to provide additional protections for whales in Alaska (https://whalesense.org, accessed ~~December 2019~~August 2020). The growth of the whale-watching industry is an ongoing concern as preferred habitats may be abandoned if disturbance levels are too high.

Other potential concerns for this stock include elevated levels of sound from anthropogenic sources (e.g., shipping, military sonars), harmful algal blooms (Geraci et al. 1989), possible changes in prey distribution with climate change, entanglement in fishing gear, ship strikes due to increased vessel traffic (e.g., from increased shipping in higher latitudes), and oil and gas activities.

The overall trend for most humpback whale populations found in U.S. waters is positive and points toward recovery (81 FR 62259~~;~~, 8 September 2016)~~,~~; ~~indicating that prey availability is not a major problem~~however, this may not be uniform for all breeding areas. ~~However, a~~A sharp decline in observed reproduction and encounter rates of humpback whales from the Central North Pacific stock between 2013 and 2018 has been related to oceanographic anomalies and consequent impacts on prey resources (Cartwright et al. 2019), suggesting that humpback whales are vulnerable to major environmental changes.

CITATIONS

Baker, C. S., L. M. Herman, A. Perry, W. S. Lawton, J. M. Straley, A. A. Wolman, G. D. Kaufman, H. E. Winn, J. D. Hall, J. M. Reinke, and J. Ostman. 1986. Migratory movement and population structure of humpback whales (*Megaptera novaeangliae*) in the central and eastern North Pacific. Mar. Ecol. Prog. Ser. 31:105-119.

Baker, C. S., A. Perry, and L. M. Herman. 1987. Reproductive histories of female humpback whales (*Megaptera novaeangliae*) in the North Pacific. Mar. Ecol. Prog. Ser. 41:103-114.

Baker, C. S., S. R. Palumbi, R. H. Lambertsen, M. T. Weinrich, J. Calambokidis, and S. J. O'Brien. 1990. Influence of seasonal migration on geographic distribution of mitochondrial DNA haplotypes in humpback whales. Nature 344:238-240.

Baker, C. S., L. Medrano-Gonzalez, J. Calambokidis, A. Perry, F. Pichler, H. Rosenbaum, J. M. Straley, J. Urban-Ramirez, M. Yamaguchi, and O. von Ziegesar. 1998. Population structure of nuclear and mitochondrial DNA variation among humpback whales in the North Pacific. Mol. Ecol. 7:695-707.

Baker, C. S., D. Steel, J. Calambokidis, J. Barlow, A. M. Burdin, P. J. Clapham, E. A. Falcone, J. K. B. Ford, C. M. Gabriele, U. González-Peral, R. LeDuc, D. Mattila, T. J. Quinn, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. Urbán-R., M. Vant, P. Wade, D. Weller, B. H. Witteveen, K. Wynne, and M. Yamaguchi. 2008. *geneSPLASH*: an initial, ocean-wide survey of mitochondrial (mt) DNA diversity and population structure among humpback whales in the North Pacific. Final Report for Contract 2006-0093-008 to the National Fish and Wildlife Foundation.

Baker, C. S., D. Steel, J. Calambokidis, E. Falcone, U. González-Peral, J. Barlow, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, D. Mattila, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. Urbán, P. R. Wade, D. Weller, B. H. Witteveen, and M. Yamaguchi. 2013. Strong maternal fidelity and natal philopatry shape genetic structure in North Pacific humpback whales. Mar. Ecol. Prog. Ser. 494:291-306. DOI: dx.doi.org/10.3354/meps10508 .

Barlow, J., and P. J. Clapham. 1997. A new birth-interval approach to estimating demographic parameters of humpback whales. Ecology 78(2):535-546.

Barlow, J., J. Calambokidis, E. A. Falcone, C. S. Baker, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, R. LeDuc, D. K. Mattila, T. J. Quinn, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. Urbán R., P. Wade, D. Weller, B. H. Witteveen, and M. Yamaguchi. 2011. Humpback whale abundance in the North Pacific estimated by photographic capture-recapture with bias correction from simulation studies. Mar. Mammal Sci. 27:793-818.

Bettridge, S., C. S. Baker, J. Barlow, P. J. Clapham, M. Ford, D. Gouveia, D. K. Mattila, R. M. Pace III, P. E. Rosel, G. K. Silber, and P. R. Wade. 2015. Status review of the humpback whale (*Megaptera novaeangliae*) under the Endangered Species Act. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-540, 240 p.

Bradford, A. L. 2018a. Injury determinations for marine mammals observed interacting with Hawaii and American Samoa longline fisheries during 2015-2016. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-PIFSC-70, 27 p. DOI: dx.doi.org/10.7289/V5/TM-PIFSC-70 .

Bradford, A. L. 2018b. Injury determinations for marine mammals observed interacting with Hawaii and American Samoa longline fisheries during 2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-PIFSC-76, 14 p. DOI: dx.doi.org/10.25923/fzad-4784 .

Bradford, A. L., and K. A. Forney. 2017. Injury determinations for marine mammals observed interacting with Hawaii and American Samoa longline fisheries during 2010-2014. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-PIFSC-62, 28 p. DOI: dx.doi.org/10.7289/V5/TM-PIFSC-62 .

Bradford, A. L., and E. Lyman. 2018. Injury determinations for humpback whales and other cetaceans reported to NOAA Response Networks in the Hawaiian Islands during 2013-2016. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-PIFSC-75, 24 p.

Bradford, A. L., and E. G. Lyman. 2019. Injury determinations for humpback whales and other cetaceans reported to NOAA response networks in the Hawaiian Islands during 2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-PIFSC-81, 18 p. DOI: dx.doi.org/10.25923/7csm-h961 .

Bradford, A. L., and E. G. Lyman. 2020. Injury determinations for humpback whales and other cetaceans reported to NOAA response networks in the Hawaiian Islands during 2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-PIFSC-103, 18 p. DOI: dx.doi.org/10.25923/mtcd-f441 .

Breiwick, J. M. 2013. North Pacific marine mammal bycatch estimation methodology and results, 2007-2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-260, 40 p.

Calambokidis, J., G. H. Steiger, J. C. Cubbage, K. C. Balcomb III, and P. Bloedel. 1989. Biology of humpback whales in the Gulf of the Farallones. Report to Gulf of the Farallones National Marine Sanctuary, San Francisco, CA, by Cascadia Research Collective, 218½ West Fourth Avenue, Olympia, WA. 93 p.

Calambokidis, J., G. H. Steiger, and J. R. Evenson. 1993. Photographic identification and abundance estimates of humpback and blue whales off California in 1991-92. Final Contract Report 50ABNF100137 to Southwest Fisheries Science Center, La Jolla, CA 92037. 67 p.

Calambokidis, J., G. H. Steiger, J. M. Straley, T. Quinn, L. M. Herman, S. Cerchio, D. R. Salden, M. Yamaguchi, F. Sato, J. Urban R., J. Jacobson, O. von Ziegesar, K. C. Balcomb, C. M. Gabriele, M. E. Dahlheim, N. Higashi, S. Uchida, J. K. B. Ford, Y. Miyamura, P. Ladrón de Guevara, S. A. Mizroch, L. Schlender, and K. Rasmussen. 1997. Abundance and population structure of humpback whales in the North Pacific basin. Final Contract Report 50ABNF500113 to Southwest Fisheries Science Center, 8901 La Jolla Shores Drive, La Jolla, CA 92037. 72 p.

Calambokidis, J., G. H. Steiger, J. M. Straley, L. M. Herman, S. Cerchio, D. R. Salden, J. Urban R., J. K. Jacobsen, O. von Ziegesar, K. C. Balcomb, C. M. Gabriele, M. E. Dahlheim, S. Uchida, G. Ellis, Y. Miyamura, P. Ladrón de Guevara P., M. Yamaguchi, F. Sato, S. A. Mizroch, L. Schlender, K. Rasmussen, J. Barlow, and T. J. Quinn II. 2001. Movements and population structure of humpback whales in the North Pacific. Mar. Mammal Sci. 17(4):769-794.

Calambokidis, J., E. A. Falcone, T. J. Quinn, A. M. Burdin, P. J. Clapham, J. K. B. Ford, C. M. Gabriele, R. LeDuc, D. Mattila, L. Rojas-Bracho, J. M. Straley, B. L. Taylor, J. Urbán R., D. Weller, B. H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K. Flynn, A. Havron, J. Huggins, and N. Maloney. 2008. SPLASH: Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific. Final Report for Contract AB133F-03-RP-00078. 58 p. Available online: http://www.cascadiaresearch.org/files/publications/SPLASH-contract-Report-May08.pdf . Accessed ~~December 2019~~August 2020.

Cartwright, R., A. Venema, V. Hernandez, C. Wyels, J. Cesere, and D. Cesere. 2019. Fluctuating reproductive rates in Hawaii's humpback whales, *Megaptera novaeangliae*, reflect recent climate anomalies in the North Pacific. Roy. Soc. Open Sci. 6:181463. DOI: dx.doi.org/10.1098/rsos.181463 .

Clapham, P. J., and J. G. Mead. 1999. *Megaptera novaeangliae*. Mamm. Species 604:1-9.

Clapham, P. J., J. Barlow, M. Bessinger, T. Cole, D. Mattila, R. Pace, D. Palka, J. Robbins, and R. Seton. 2003. Abundance and demographic parameters of humpback whales from the Gulf of Maine, and stock definition relative to the Scotian Shelf. J. Cetacean Res. Manage. 5:13-22.

Clarke, J., K. Stafford, S. E. Moore, B. Rone, L. Aerts, and J. Crance. 2013. Subarctic cetaceans in the southern Chukchi Sea: evidence of recovery or response to a changing ecosystem. Oceanography 26(4):136-149.

Darling, J. D. 1991. Humpback whales in Japanese waters. Ogasawara and Okinawa. Fluke identification catalog 1987-1990. Final Contract Report, World Wide Fund for Nature, Japan. 22 p.

Darling, J. D., and S. Cerchio. 1993. Movement of a humpback whale (*Megaptera novaeangliae*) between Japan and Hawaii. Mar. Mammal Sci. 1:84-89.

~~Delean, B. J., V. T. Helker, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, J. Jannot, and N. C. Young. 2020. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2013-2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-401, 86 p.~~

Doroshenko, N. V. 2000. Soviet catches of humpback whales (*Megaptera novaeangliae*) in the North Pacific, p. 48-95. *In* A. V. Yablokov and V. A. Zemsky (eds.), Soviet Whaling Data (1949-1979), Center for Russian Environmental Policy, Marine Mammal Council, Moscow.

Fleming, A., and J. Jackson. 2011. Global review of humpback whales (*Megaptera novaeangliae*). U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-474, 206 p.

Ford J. K. B., A. L. Rambeau, R. M. Abernethy, M. D. Boogaards, L. M. Nichol, and L. D. Spaven. 2009. An assessment of the potential for recovery of humpback whales off the Pacific coast of Canada. DFO Can. Sci. Advis. Sec. Res. Doc. 2009/015. iv + 33 p.

Geraci, J. R., D. M. Anderson, R. J. Timperi, D. St. Aubin, G. A. Early, J. H. Prescott, and C. A. Mayo. 1989. Humpback whales (*Megaptera novaeangliae*) fatally poisoned by dinoflagellate toxin. Can. J. Fish. Aquat. Sci. 46(11):1895-1898. DOI: dx.doi.org/10.1139/f89-238 .

Hashagen, K. A., G. A. Green, and B. Adams. 2009. Observations of humpback whales, *Megaptera novaeangliae*, in the Beaufort Sea, Alaska. Northwest. Nat. 90:160-162.

Hill, M. C., E. M. Oleson, S. Baumann-Pickering, A. M. Van Cise, A. D. Ligon, A. R. Bendlin, A. C. Ü, J. S. Trickey, and A. L. Bradford. 2016. Cetacean monitoring in the Mariana Islands Range Complex, 2015. Prepared for the U.S. Pacific Fleet Environmental Readiness Office. PIFSC Data Report DR-16-01. 36 p. + appendix.

Ivashchenko, Y. V., R. L. Brownell, Jr., and P. J. Clapham. 2013. Soviet whaling in the North Pacific: revised catch totals. J. Cetacean Res. Manage. 13:59-71.

Johnson, J. H., and A. A. Wolman. 1984. The humpback whale, *Megaptera novaeangliae*. Mar. Fish. Rev. 46:30-37.

Johnston, D. W., M. E. Chapla, L. E. Williams, and D. K. Mattila. 2007. Identification of humpback whale *Megaptera novaeangliae* wintering habitat in the Northwestern Hawaiian Islands using spatial habitat modeling. Endang. Species Res. 3:249-257.

Manly, B. F. J. 2015. Incidental takes and interactions of marine mammals and birds in districts 6, 7 and 8 of the Southeast Alaska salmon drift gillnet fishery, 2012 and 2013. Final Report to NMFS Alaska Region. 52 p.

Mizroch, S. A., L. M. Herman, J. M. Straley, D. Glockner-Ferrari, C. Jurasz, J. Darling, S. Cerchio, C. Gabriele, D. Salden, and O. von Ziegesar. 2004. Estimating the adult survival rate of central North Pacific humpback whales. J. Mammal. 85(5):963-972.

Mobley, J. M., S. Spitz, R. Grotefendt, P. Forestell, A. Frankel, and G. Bauer. 2001. Abundance of humpback whales in Hawaiian waters: results of 1993-2000 aerial surveys. Report to the Hawaiian Islands Humpback Whale National Marine Sanctuary. 16 p.

Moore, S. E., J. M. Waite, N. A. Friday, and T. Honkalehto. 2002. Distribution and comparative estimates of cetacean abundance on the central and south-eastern Bering Sea shelf with observations on bathymetric and prey associations. Prog. Oceanogr. 55(1-2):249-262.

National Marine Fisheries Service (NMFS). 2012. Process for distinguishing serious from non-serious injury of marine mammals. 42 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-policies-guidance-and-regulations . Accessed ~~December 2019~~August 2020.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed ~~December 2019~~August 2020.

Neilson, J. L., C. M. Gabriele, A. S. Jensen, K. Jackson, and J. M. Straley. 2012. Summary of reported whale-vessel collisions in Alaskan waters. J. Mar. Biol. 2012: Article ID 106282. 18 p. DOI: dx.doi.org/10.1155/2012/106282 .

Nemoto, T. 1957. Foods of baleen whales in the northern Pacific. Sci. Rep. Whales Res. Inst. Tokyo 12:33-89.

Nemoto, T. 1959. Food of baleen whales with reference to whale movements. Sci. Rep. Whales Res. Inst. 14:149-290.

Perry, A., C. S. Baker, and L. M. Herman. 1990. Population characteristics of individually identified humpback whales in the central and eastern North Pacific: a summary and critique. Rep. Int. Whal. Comm. (Special Issue 12):307-317.

Rice, D. W. 1978. The humpback whale in the North Pacific: distribution, exploitation and numbers, Appendix 4, p. 29-44. *In* K. S. Norris and R. R. Reeves (eds.), Report on a workshop on problems related to humpback whales (*Megaptera novaeangliae*) in Hawaii. U.S. Dep. Commer., Natl. Tech. Info. Serv. PB-280794. Springfield, VA.

Rice, D. W. 1998. Marine Mammals of the World: Systematics and Distribution. Soc. Mar. Mammal. Spec. Publ. No. 4.

Springer, A. M., G. B. van Vliet, J. F. Piatt, and E. M. Danner. 2006. Whales and whaling in the North Pacific Ocean and Bering Sea: oceanographic insights and ecosystem impacts, p. 245-261. *In* J. A. Estes, R. L. Brownell, Jr., D. P. DeMaster, D. F. Doak, and T. M. Williams (eds.), Whales, Whaling and Ocean Ecosystems. University of California Press. 418 p.

Steiger, G. H., J. Calambokidis, R. Sears, K. C. Balcomb, and J. C. Cubbage. 1991. Movement of humpback whales between California and Costa Rica. Mar. Mammal Sci. 7:306-310.

Straley, J. M., C. M. Gabriele, and T. J. Quinn II. 2009. Assessment of mark recapture models to estimate the abundance of a humpback whale feeding aggregation in Southeast Alaska. J. Biogeogr. 36:427-438.

Taylor, B. L., M. Scott, J. Heyning, and J. Barlow. 2003. Suggested guidelines for recovery factors for endangered marine mammals. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-SWFSC-354, 6 p.

Teerlink, S. F., O. von Ziegesar, J. M. Straley, T. J. Quinn II, C. O. Matkin, and E. L. Saulitis. 2015. First time series of estimated humpback whale (*Megaptera novaeangliae*) abundance in Prince William Sound. Environ. Ecol. Stat. 22:345. DOI: dx.doi.org/10.1007/s10651-014-0301-8 .

Tomlin, A. G. 1967. Mammals of the USSR and Adjacent Countries. Vol. 9. Cetacea. Israel Program for Scientific Translations No. 1124, Natl. Tech. Info. Serv. TT 65-50086. Springfield, VA. 717 p. (Translation of Russian text published in 1957.)

Waite, J. M., M. E. Dahlheim, R. C. Hobbs, S. A. Mizroch, O. von Ziegesar-Matkin, J. M. Straley, L. M. Herman, and J. Jacobsen. 1999. Evidence of a feeding aggregation of humpback whales (*Megaptera novaeangliae*) around Kodiak Island, Alaska. Mar. Mammal Sci. 15:210-220.

Witteveen, B. H., J. M. Straley, O. von Ziegesar, D. Steel, and C. S. Baker. 2004. Abundance and mtDNA differentiation of humpback whales (*Megaptera novaeangliae*) in the Shumagin Islands, Alaska. Can. J. Zool. 82:1352-1359.

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX.

Zenkovich, B. A. 1954. Vokrug sveta za kitami, Vol. Gosudarstvennoe Izdatel'stvo Geograficheskoi Literatury, Moscow.

Zerbini, A. N., J. M. Waite, J. L. Laake, and P. R. Wade. 2006. Abundance, trends and distribution of baleen whales off western Alaska and the central Aleutian Islands. Deep-Sea Res. I 53(11):1772-1790.

FIN WHALE (*Balaenoptera physalus*): Northeast Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Within the U.S. waters in the Pacific Ocean, fin whales are found seasonally off the coast of North America and in the Bering Sea during the summer (Fig. 1). Information on seasonal fin whale distribution has been gleaned from the detection of fin whale calls using bottom-mounted, offshore hydrophone arrays along the U.S. Pacific coast, in the central North Pacific, and in the western Aleutian Islands (Moore et al. 1998, 2006; Watkins et al. 2000; Stafford et al. 2007; Širović et al. 2013; Soule and Wilcock 2013; Archer et al. 2019). Moore et al. (1998, 2006), Watkins et al. (2000), and Stafford et al. (2007) documented fin whale calling along the U.S. Pacific coast where rates were highest from August/September through February, suggesting that these may be important feeding areas during the winter. Širović et al. (2013) speculated that both resident and migratory fin whales may occur off southern California based on shifts in peaks in fin whale calling data. Širović et al. (2015) noted that fin whales were detected in the Southern California Bight year-round and found an overall increase in the fin whale call index from 2006 to 2012. Soule and Wilcock (2013) documented fin whale call rates in a presumed feeding area along the Juan de Fuca Ridge, offshore of northern Washington State, and found that some whales appear to transit northwest from August to October. They speculate that some fin whales migrate northward from the Juan de Fuca Ridge in fall and southward in winter. While peaks in call rates occurred during late summer, fall, and winter in the central North Pacific and the Aleutian Islands, fin whale calls were seldom detected during summer months even though fin whales are regularly seen in summer months in the Gulf of Alaska (Stafford et al. 2007). Fin whale calls have been detected in the southeast Bering Sea by a moored hydrophone. During April 2006 through April 2007, peaks in fin whale call detections were found from September through November 2006 and also in February and March 2007 (Stafford et al. 2010). In addition, fin whale calls were detected in the northeastern Chukchi Sea using instruments moored there from July through October between 2007 and 2010 (Delarue et al. 2013). Call data collected from the Bering Sea suggest that several putative fin whale stocks may feed in the Bering Sea; however, only one of these likely migrates into the Chukchi Sea to feed (Delarue et al. 2013). Some fin whale calls have also been recorded in the Hawaiian portion of the U.S. Exclusive Economic Zone in all months except June and July (Thompson and Friedl 1982, McDonald and Fox 1999). Sightings of fin whales in Hawaii are extremely rare: there was a sighting in 1976 (Shallenberger 1981), a sighting in 1979 (Mizroch et al. 2009), a sighting during an aerial survey in 1994 (Mobley et al. 1996), and five sightings during a survey in 2002 (Barlow 2006).

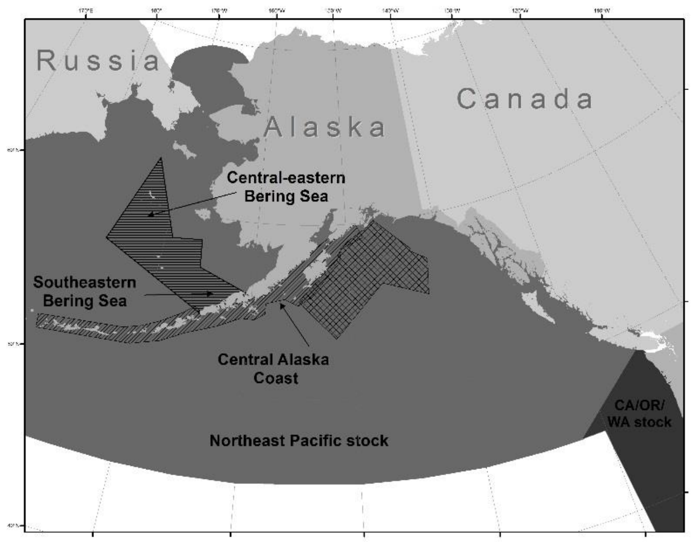

Figure 1. Approximate distribution of fin whales in the eastern North Pacific. Striped areas indicate where vessel surveys occurred in 1999-2010 (horizontal stripes - Bering Sea: Moore et al. 2002; Friday et al. 2012, 2013); 2001-2003 (diagonal stripes - Central Alaska coast and Aleutian Islands: Zerbini et al. 2006); and 2009, 2013, and 2015 (crosshatch - Gulf of Alaska: Rone et al. 2017).

Surveys on the Bering Sea shelf in 1997, 1999, 2000, 2002, 2004, 2008, and 2010 and in coastal waters of the Aleutian Islands and the Alaska Peninsula from 2001 to 2003 provided information about the distribution and abundance of fin whales in these areas (Moore et al. 2000, 2002; Zerbini et al. 2006; Friday et al. 2012, 2013). Fin whales were the most common large whale sighted during the Bering Sea shelf surveys in all years except for 1997 and 2004 (Friday et al. 2012, 2013). Fin whales were consistently distributed both in the "green belt," an area of high productivity along the edge of the eastern Bering Sea continental shelf (Springer et al. 1996), and, at a lower frequency, in the middle shelf. Abundance estimates for fin whales in the Bering Sea were consistently higher in cold years than in warm years (Friday et al. 2012, 2013) indicating a shift in distribution. This is consistent with a fine-scale comparison of fin whale occurrence on the middle shelf between a cold year (1999) and a warm year (2002), which found that the group and individual encounter rates were 7 to 12 times higher in the cold year (Stabeno et al. 2012). Cold years are known to be more favorable for large copepods and euphausiids over the Bering Sea shelf (Stabeno et al. 2012) and fin whale distributions are likely driven by availability of preferred prey.

Based on whaling data, the historical range of fin whales extended into the southern Sea of Okhotsk and Chukchi Sea. It was assumed that they passed through the Bering Strait into the southwestern Chukchi Sea during August and September. Many fin whales were taken as far west as Mys (Cape) Shmidta (68°55'N, 179°24'E) and as far north as 69°04'N, 171°06'W (Mizroch et al. 2009). Fin whale sightings have been increasing during surveys conducted in the U.S. portion of the northern Chukchi Sea from July to October (Funk et al. 2010, Aerts et al. 2012, Clarke et al. 2013, Brower et al. 2018) and fin whale calls were recorded each year from 2007 to 2010 in August and September in the northeastern Chukchi Sea (Delarue et al. 2013) and August to October just north of the Bering Strait (Tsujii et al. 2016), suggesting they may be re-occupying habitat used prior to large-scale commercial whaling. A comparison of data from aerial surveys that covered the same general areas between 1982 and 1991 and between 2008 and 2016 found no fin whale sightings in the earlier time period as compared to regular sightings of fin whales in the latter (Brower et al 2018). In part, this could be due to increased effort from 2008 to 2016; however, the combination of acoustic and visual data seem to support increasing numbers and extended seasonal residency of fin whales in the Alaska Arctic.

The following information was considered in classifying stock structure based on the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: geographic distribution continuous in winter, possibly isolated in summer; 2) Population response data: unknown; 3) Phenotypic data: unknown; and 4) Genotypic data: unknown. Based on this limited information, the International Whaling Commission (IWC) considers fin whales in the North Pacific to all belong to the same stock (Mizroch et al. 1984), although Mizroch et al. (1984) cited additional evidence that supported the establishment of subpopulations in the North Pacific. Further, Fujino (1960) described eastern and western groups, which are mostly isolated with the exception of potential intermingling around the Aleutian Islands. Recoveries of Discovery tags (Rice 1974, Mizroch et al. 2009) indicate that animals wintering off the coast of southern California range from central California to the Gulf of Alaska during the summer months.

Mizroch et al. (2009) provided a comprehensive summary of whaling catch data, recovery of Discovery tags, and opportunistic sightings data and found evidence to suggest there may be at least six populations of fin whales: two that are migratory (eastern and western North Pacific) and two to four more that are resident year-round in peripheral seas such as the Gulf of California, East China Sea, Sanriku-Hokkaido, and possibly the Sea of Japan. It appears likely that the two migratory stocks mingle in the Bering Sea in July and August, rather than in the Aleutian Islands as Fujino (1960) previously concluded (Mizroch et al. 2009). During winter months, fin whales have been seen over a wide geographic area from 23°N to 60°N, but winter distribution and location of primary wintering areas (if any) are poorly known and need further study. As a result, stock structure of fin whales remains uncertain.

For management purposes, three stocks of fin whales are currently recognized in U.S. Pacific waters: 1) Alaska (Northeast Pacific) (Fig. 1), 2) California/Washington/Oregon, and 3) Hawaii. Mizroch et al. (2009) suggest that this structure should be reviewed and updated, if appropriate, to reflect recent analyses, but the absence of any substantial new data on stock structure makes this difficult. The California/Oregon/Washington and Hawaii fin whale stocks are reported in the Stock Assessment Reports for the U.S. Pacific Region.

POPULATION SIZE

There are no reliable estimates of current and historical abundances for the entire Northeast Pacific fin whale stock. Several studies provide information on the distribution and occurrence of fin whales in the Northeast Pacific, as well as estimates of abundance in certain areas within the range of the stock, however, many of these are over a decade or more old.

Visual shipboard surveys for cetaceans were conducted on the eastern Bering Sea shelf during summer in 1997, 1999, 2000, 2002, 2004, 2008, and 2010 (Moore et al. 2000, 2002; Friday et al. 2012, 2013). These surveys were conducted in conjunction with the Alaska Fisheries Science Center (AFSC) echo-integrated trawl surveys for walleye pollock. The surveys covered 789 to 3,752 km of tracklines and observation effort for marine mammals varied according to the availability of observers during each cruise. Results of the surveys in 2002, 2008, and 2010, years when the entire AFSC pollock survey sampling area was surveyed (see Fig. 1), provided estimates of 419 (coefficient of variation (CV) = 0.33), 1,368 (CV = 0.34), and 1,061 (CV = 0.38) fin whales (Friday et al. 2013).

Dedicated line-transect cruises were conducted in coastal waters (as far as 85 km offshore) of western Alaska and the eastern and central Aleutian Islands in July and August from 2001 to 2003 (Zerbini et al. 2006). Over 9,053 km of tracklines were surveyed between the Kenai Peninsula (150°W) and Amchitka Pass (178°W). Fin whales (n = 276) were observed from east of Kodiak Island to Samalga Pass, with high aggregations recorded near the Semidi Islands. Zerbini et al. (2006) estimated that 1,652 fin whales (95% CI: 1,142-2,389) occurred in these areas between 2001 and 2003.

In 2013 and 2015, dedicated line-transect surveys of the offshore waters of the Gulf of Alaska recorded, respectively, 171 and 38 sightings of fin whales (Rone et al. 2017). These surveys provided fin whale abundance estimates of 3,168 fin whales (CV = 0.26) in 2013 and 916 (CV = 0.39) in 2015. The marked differences in these estimates can be partially explained by differences in sampling coverage across the two cruises (Rone et al. 2017).

Estimates of fin whale abundance in the eastern Bering Sea and in the Gulf of Alaska in any given year cannot be considered representative of the entire Northeast Pacific stock because the geographic coverage of surveys was limited relative to the range of the stock. In addition, these estimates have not been corrected for animals missed on the trackline, animals submerged when the ship passed, and responsive movement away from or towards the survey vessel. However, even though no data are available to compute correction factors, it is expected that these estimates are robust because previous studies have shown that these sources of bias are small for this species (Barlow 1995).

Minimum Population Estimate

Although the full range of the Northeast Pacific stock of fin whales in Alaska waters has not been surveyed, a rough estimate of the size of the population west of the Kenai Peninsula has been calculated in previous Stock Assessment Reports by summing the estimates from Moore et al. (2002) and Zerbini et al. (2006) (n = 5,700). However, based on analyses presented in Mizroch et al. (2009), whales surveyed in the Aleutians (Zerbini et al. 2006) could migrate northward and be counted during the Bering Sea surveys. There are also indications that fin whale distribution in the Bering Sea is related to oceanographic conditions and prey density (Stabeno et al. 2012, Friday et al. 2013, Zerbini et al. 2016), making it possible that whales could be double counted when estimates from different years are summed (Moore et al. 2002). Until recently, the best provisional estimate of the fin whale population west and north of the Kenai Peninsula in U.S. waters was 1,368 whales, the greater of the minimum estimates from the 2008 and 2010 surveys (Friday et al. 2013). However, the Gulf of Alaska surveys (Rone et al. 2017) are more recent. The higher of the two abundances computed for fin whales in this region, 3,168 whales (CV = 0.26), better represents a minimum abundance for the Northeast Pacific stock because it is more precise and because it represents a broader survey coverage. A minimum population estimate (N_{MIN}) for this stock can be calculated according to Equation 1 from the potential biological removal (PBR) guidelines (NMFS 2016): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the best provisional estimate (N) of 3,168 from the 2013 survey and the associated ~~coefficient of variation~~ CV(N) of 0.26 results in an N_{MIN} of 2,554 whales. However, this is an underestimate for the entire stock because it is based on surveys which covered only a small portion of the stock's range.

Current Population Trend

Zerbini et al. (2006) estimated rates of increase of fin whales in coastal waters south of the Alaska Peninsula (Kodiak and Shumagin Islands). An annual increase of 4.8% (95% CI: 4.1-5.4%) was estimated between 1987 and 2003. This estimate is the first available for North Pacific fin whales and is consistent with other estimates of population growth rates of large whales. It should be used with caution, however, due to uncertainties in the initial population estimate (in 1987) and due to uncertainties about the population structure of fin whales in the area. Also, the study represented only a small fraction of the range of the Northeast Pacific stock and it may not be appropriate to extrapolate this to a broader range.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Zerbini et al. (2006) estimated an annual increase of 4.8% (95% CI: 4.1-5.4%) between 1987 and 2003 for fin whales in coastal waters south of the Alaska Peninsula ~~of 4.8% (95% CI: 4.1-5.4%) for 1987-2003~~. However, there are uncertainties in the initial population estimate from 1987, as well as uncertainties regarding fin whale population structure in this area. Therefore, a reliable estimate of the maximum net productivity rate (R_{MAX}) is not ~~un~~available for the Northeast Pacific fin whale stock. Until additional data become available, the default cetacean maximum theoretical net productivity rate of 4% will be used for this stock (NMFS 2016).

POTENTIAL BIOLOGICAL REMOVAL

PBR is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: $PBR = N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.1, the recommended value for cetacean stocks ~~which~~that are listed as endangered (NMFS 2016). Using the best provisional estimate of 3,168 (CV = 0.26) from the 2013 survey and the associated N_{MIN} of 2,554, PBR is calculated to be 5.1 fin whales (2,554 × 0.02 × 0.1). However, because the estimate of minimum abundance is for only a small portion of the stock's range, the calculated PBR is likely biased low for the entire Northeast Pacific fin whale stock.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals between 20132014 and 20172018 is listed, by marine mammal stock, in Delean et al. (2020)Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. The minimum estimated mean annual level of human-caused mortality and serious injury for Northeast Pacific fin whales between 20132014 and 20172018 is 0.40.6 whales due to ship strikes. Ship strikes are a known threat for this stock and reductions in sea-ice coverage may lead to range extension and increased susceptibility to ship strikes from increased shipping in the Chukchi and Beaufort seas.

Fisheries Information

Information (including observer programs, observer coverage, and observed incidental takes of marine mammals) for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is presentedavailable in Appendicesx 3-6 of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

No incidental mortality or serious injury of Northeast Pacific fin whales due to interactions with fisheries in Alaska waters was reported to the NMFS Alaska Region marine mammal stranding network between 20132014 and 20172018 (Delean et al. 2020).

Table 1. Summary of mortality and serious injury of Northeast Pacific fin whales, by year and type, reported to the NMFS Alaska Region marine mammal stranding network between 20132014 and 20172018 (Delean et al. 2020Young et al. in press).

Cause of injury	2013	2014	2015	2016	2017	2018	Mean annual mortality
Ship strike	0	1	0	1	0	1	0.40.6
Total due to ship strikes							0.40.6

Alaska Native Subsistence/Harvest Information

Subsistence hunters in Alaska and Russia have not been reported to take fin whales from this stock.

Other Mortality

Between 1900 and 1999, 75,538 fin whales were reportedly killed in commercial whaling operations throughout the North Pacific (Rocha et al. 2014).

In 2015, increased mortality of large whales was observed along the western Gulf of Alaska (including the areas around Kodiak Island, Afognak Island, Chirikof Island, the Semidi Islands, and the southern shoreline of the Alaska Peninsula) and along the central British Columbia coast (from the northern tip of Haida Gwaii to Ssouthern Vancouver Island). NMFS declared an Unusual Mortality Event (UME) for large whales that occurred from 22 May to 31 December 2015 in the western Gulf of Alaska and from 23 April 2015 to 16 April 2016 in British Columbia (https://www.fisheries.noaa.gov/national/marine-life-distress/active-and-closed-unusual-mortality-events, accessed December 2019August 2020). Forty-six large whale deaths attributed to the UME included 12 fin whales and 22 humpback whales in Alaska and 5 fin whales and 7 humpback whales in British Columbia. Based on the findings from the investigation, the UME was likely caused by ecological factors (i.e., the 2015 El Niño, Warm Water Blob, and Pacific Coast Domoic Acid Bloom).

Fin whale mortality due to ship strikes in Alaska waters was reported to the NMFS Alaska Region marine mammal stranding network in 2014, and 2016, and 2018 (Delean et al. 2020Young et al. in press), resulting in a minimum mean annual mortality and serious injury rate of 0.40.6 fin whales due to ship strikes between 20132014 and 20172018 (Table 1).

STATUS OF STOCK

The fin whale is listed as endangered under the Endangered Species Act of 1973, and therefore designated as depleted under the MMPA. As a result, the Northeast Pacific stock is classified as a strategic stock. While estimates of the minimum population size and population trends are available for a portion of this stock, much of the North Pacific range has not been surveyed. Therefore, the status of the stock relative to its Optimum Sustainable Population is not available. The minimum estimated mean annual level of human-caused mortality and serious injury for Northeast Pacific fin whales (~~0.4~~0.6 whales) does not exceed the calculated PBR (5.1 whales). The minimum estimated mean annual rate of U.S. commercial fishery-related mortality and serious injury (0 whales) is less than 10% of the calculated PBR (10% of PBR = 0.5) and, therefore, can be considered insignificant and approaching a zero mortality and serious injury rate.

There are key uncertainties in the assessment of the Northeast Pacific stock of fin whales. While a single stock of fin whales is currently recognized in the Northeast Pacific, fin whale acoustic data suggest that multiple stocks overlap in the Bering Sea. Little is known about the pelagic distribution of fin whales due to the lack of dedicated marine mammal survey effort in the Bering Sea and Gulf of Alaska. The calculated PBR level is likely biased low because only a portion of the range has been surveyed. A reliable estimate of the trend in abundance is not available for this stock.

HABITAT CONCERNS

Changes in ocean conditions that affect the seasonal distribution and quality of prey may affect fin whale movements, distribution, and foraging energetics. Ship strikes are a known source of mortality, and reductions in sea-ice coverage may lead to range extension and concomitant exposure to increased shipping and oil and gas activities in the Bering and Chukchi seas. Ocean warming may increase the frequency of algal blooms that produce biotoxins known to be associated with large whale mortality. However, few data are available to assess the likelihood or extent of such impacts.

CITATIONS

Aerts, L. A. M., A. Kirk, C. Schudel, B. Watts, P. Seiser, A. Mcfarland, and K. Lomac-MacNair. 2012. Marine mammal distribution and abundance in the northeastern Chukchi Sea, July-October 2008-2011. Report prepared by LAMA Ecological for ConocoPhillips Alaska, Inc., Shell Exploration and Production Company and Statoil USA E&P, Inc. 69 p.

Archer, F. I., S. Rankin, K. M. Stafford, M. Castellote, and J. Delarue. 2019. Quantifying spatial and temporal variation of North Pacific fin whale (*Balaenoptera physalus*) acoustic behavior. Mar. Mammal Sci. DOI: dx.doi.org/10.1111/mms.12640 .

Barlow, J. 1995. The abundance of cetaceans in California waters. Part 1: Ship surveys in summer and fall of 1991. Fish. Bull., U.S. 93:1-14.

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Mar. Mammal Sci. 22(2):446-464.

Brower, A. A., J. T. Clarke, and M. C. Ferguson. 2018. Increased sightings of subArctic cetaceans in the eastern Chukchi Sea, 2008-2016: population recovery, response to climate change, or increased survey effort? Polar Biol. 41:1033-1039. DOI: dx.doi.org/10.1007/s00300-018-2257-x .

Clarke, J., K. Stafford, S. E. Moore, B. Rone, L. Aerts, and J. Crance. 2013. Subarctic cetaceans in the southern Chukchi Sea: evidence of recovery or response to a changing ecosystem. Oceanography 26(4):136-149. DOI: dx.doi.org/10.5670/oceanog.2013.81 .

Delarue, J., B. Martin, D. Hannay, and C. Berchok. 2013. Acoustic occurrence and affiliation of fin whales detected in the northeastern Chukchi Sea, July to October 2007–2010. Arctic 66(2):159-172.

~~Delean, B. J., V. T. Helker, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, J. Jannot, and N. C. Young. 2020. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2013-2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-401, 86 p.~~

Dizon, A. E., C. Lockyer, W. F. Perrin, D. P. DeMaster, and J. Sisson. 1992. Rethinking the stock concept: a phylogeographic approach. Conserv. Biol. 6:24-36.

Friday, N. A., A. N. Zerbini, J. M. Waite, and S. E. Moore. 2012. Cetacean distribution and abundance in relation to oceanographic domains on the eastern Bering Sea shelf: 1999-2004. Deep-Sea Res. II 65-70:260-272. DOI: dx.doi.org/10.1016/j.dsr2.2012.02.006 .

Friday, N. A., A. N. Zerbini, J. M. Waite, S. E. Moore, and P. J. Clapham. 2013. Cetacean distribution and abundance in relation to oceanographic domains on the eastern Bering Sea shelf in June and July of 2002, 2008, and 2010. Deep-Sea Res. II 94:244-256. DOI: dx.doi.org/10.1016/j.dsr2.2013.03.011 .

Fujino, K. 1960. Monogenetic and marking approaches to identifying sub-populations of the North Pacific whales. Sci. Rep. Whales Res. Inst. Tokyo 15:84-142.

Funk, D. W., D. S. Ireland, R. Rodrigues, and W. R. Koski (eds.). 2010. Joint monitoring program in the Chukchi and Beaufort seas, open water seasons, 2006–2008. LGL Alaska Report P1050-2, Report from LGL Alaska Research Associates, Inc., LGL Ltd., Greeneridge Sciences, Inc., and JASCO Research, Ltd., for Shell Offshore, Inc. and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 506 p. + appendices.

McDonald, M. A., and C. G. Fox. 1999. Passive acoustic methods applied to fin whale population density estimation. J. Acoust. Soc. Am. 105(5):2643-2651.

Mizroch, S. A., D. W. Rice, and J. M. Breiwick. 1984. The fin whale, *Balaenoptera physalus*. Mar. Fish. Rev. 46(4):20-24.

Mizroch, S. A., D. Rice, D. Zwiefelhofer, J. Waite, and W. Perryman. 2009. Distribution and movements of fin whales in the North Pacific Ocean. Mammal Rev. 39(3):193-227.

Mobley, J. R., Jr., M. Smultea, T. Norris, and D. Weller. 1996. Fin whale sighting north of Kaua'i, Hawai'i. Pac. Sci. 50(2):230-233.

Moore, S. E., K. M. Stafford, M. E. Dahlheim, C. G. Fox, H. W. Braham, J. J. Polovina, and D. E. Bain. 1998. Seasonal variation in reception of fin whale calls at five geographic areas in the North Pacific. Mar. Mammal Sci. 14(3):617-627.

Moore, S. E., J. M. Waite, L. L. Mazzuca, and R. C. Hobbs. 2000. Provisional estimates of mysticete whale abundance on the central Bering Sea shelf. J. Cetacean Res. Manage. 2(3):227-234.

Moore, S. E., J. M. Waite, N. A. Friday, and T. Honkalehto. 2002. Distribution and comparative estimates of cetacean abundance on the central and south-eastern Bering Sea shelf with observations on bathymetric and prey associations. Prog. Oceanogr. 55(1-2):249-262.

Moore, S. E., K. M. Stafford, D. K. Mellinger, and C. G. Hildebrand. 2006. Listening for large whales in the offshore waters of Alaska. BioScience 56(1):49-55.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed ~~December 2019~~August 2020.

Rice, D. W. 1974. Whales and whale research in the eastern North Pacific, p. 170-195. *In* W. E. Schevill (ed.), The Whale Problem: A Status Report. Harvard Press, Cambridge, MA.

Rocha, R. C., Jr., P. J. Clapham, and Y. V. Ivashchenko. 2014. Emptying the oceans: a summary of industrial whaling catches in the 20th century. Mar. Fish. Rev. 76:37-48. DOI: dx.doi.org/10.7755/MFR.76.4.3 .

Rone, B. K., A. N. Zerbini, A. B. Douglas, D. W. Weller, and P. J. Clapham. 2017. Abundance and distribution of cetaceans in the Gulf of Alaska. Mar. Biol. 164:23. DOI: dx.doi.org/10.1007/s00227-016-3052-2 .

Shallenberger, E. W. 1981. The status of Hawaiian cetaceans. Final Report for MMC Contract MM7AC028. Natl. Tech. Info. Ser. PB82-109398.

Širović, A., L. N. Williams, S. M. Kerosky, S. M. Wiggins, and J. A. Hildebrand. 2013. Temporal separation of two fin whale call types across the eastern North Pacific. Mar. Biol. 160:47-57.

Širović, A., A. Rice, E. Chou, J. A. Hildebrand, S. M. Wiggins, and M. A. Roch. 2015. Seven years of blue and fin whale call abundance in the Southern California Bight. Endang. Species Res. 28:61-76.

Soule, D. C., and W. S. D. Wilcock. 2013. Fin whale tracks recorded by a seismic network on the Juan de Fuca Ridge, Northeast Pacific Ocean. J. Acoust. Soc. Am. 133(3):1751-1761.

Springer, A. M., C. P. McRoy, and M. V. Flint. 1996. The Bering Sea green belt: shelf-edge processes and ecosystem production. Fish. Oceanogr. 5:205-223.

Stabeno, P., S. Moore, J. Napp, M. Sigler, and A. Zerbini. 2012. Comparison of warm and cold years on the southeastern Bering Sea shelf and some implications for the ecosystem. Deep-Sea Res. II 65-70:31-45.

Stafford, K. M., D. K. Mellinger, S. E. Moore, and C. G. Fox. 2007. Seasonal variability and detection range modeling of baleen whale calls in the Gulf of Alaska, 1999-2002. J. Acoust. Soc. Amer. 122(6):3378-3390.

Stafford, K. M., S. E. Moore, P. J. Stabeno, D. V. Holliday, J. M. Napp, and D. K. Mellinger. 2010. Biophysical ocean observation in the southeastern Bering Sea. Geophys. Res. Lett. 37:L02606. DOI: dx.doi.org/10.1029/2009GL040724 .

Thompson, P. O., and W. A. Friedl. 1982. A long term study of low frequency sound from several species of whales off Oahu, Hawaii. Cetology 45:1-19.

Tsujii, K., M. Otsuki, T. Akamatsu, I. Matsuo, K. Amakasu, M. Kitamura, T. Kikuchi, K. Miyashita, and Y. Mitani. 2016. The migration of fin whales into the southern Chukchi Sea as monitored with passive acoustics. ICES Journal of Marine Science 73(8):2085-2092. DOI: dx.doi.org/10.1093/icesjms/fsv271 .

Watkins, W. A., M. A. Daher, G. M. Reppucci, J. E. George, D. L. Martin, N. A. DiMarzio, and D. P. Gannon. 2000. Seasonality and distribution of whale calls in the North Pacific. Oceanography 13(1):62-67.

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX.

Zerbini, A. N., J. M. Waite, J. L. Laake, and P. R. Wade. 2006. Abundance, trends and distribution of baleen whales off western Alaska and the central Aleutian Islands. Deep-Sea Res. I 53(11):1772-1790.

Zerbini, A. N., N. A. Friday, D. M. Palacios, J. M. Waite, P. H. Ressler, B. K. Rone, S. E. Moore, and P. J. Clapham. 2016. Baleen whale abundance and distribution in relation to environmental variables and prey density in the eastern Bering Sea. Deep-Sea Res. II 134:312-330. DOI: dx.doi.org/10.1016/j.dsr2.2015.11.002 .

NORTH PACIFIC RIGHT WHALE (*Eubalaena japonica*): Eastern North Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Once distributed widely across the North Pacific from North America to the Far East, North Pacific right whales (*Eubalaena japonica*) are today among the world's rarest marine mammals (Wade et al. 2011). A distinct geographic distribution, different catch and recovery histories, and recent genetic analysis have led to the generally accepted belief that the species comprises eastern and western populations that are largely or wholly discrete (Brownell et al. 2001, LeDuc et al. 2012). The summer range of the eastern stock includes the Gulf of Alaska and the Bering Sea, while the western stock is believed to feed in the Okhotsk Sea and in pelagic waters of the northwestern North Pacific. The winter calving grounds of both stocks remain unknown.

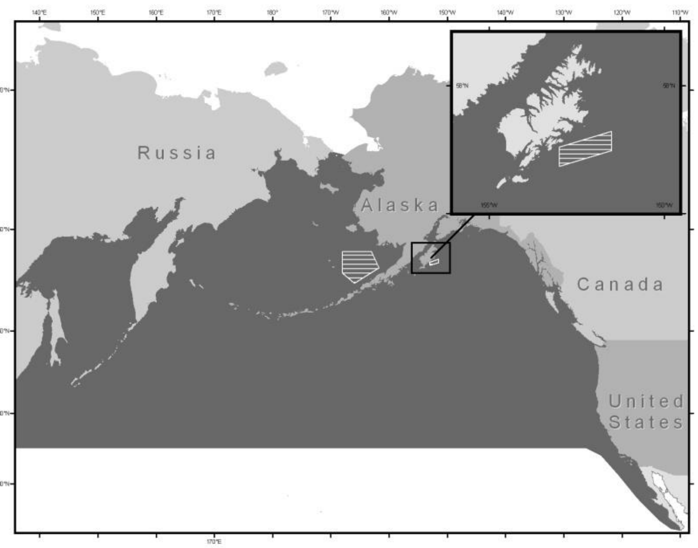

Figure 1. Approximate historical distribution of North Pacific right whales in the North Pacific (dark shaded area). Striped areas indicate North Pacific right whale critical habitat (73 FR 19000, 8 April 2008).

Right whales were the subject of intensive commercial exploitation, beginning in the Gulf of Alaska in 1835, and by 1849 were already seriously depleted in the eastern Pacific (Scarff 1986, 1991; Josephson et al. 2008). Additional hunting in the 1850s reduced the population in the western Pacific, and by 1900 the species was effectively considered commercially extinct throughout its range. Although there were sporadic opportunistic catches in the early 20th century, the stock was likely undergoing a modest recovery by about 1960; however, this was entirely negated by large illegal catches by the U.S.S.R. in the 1960s, which likely wiped out the bulk of the eastern population (Ivashchenko and Clapham 2012, Ivashchenko et al. 2017).

Analysis of whaling records from the 19th century, together with the more recent Soviet catches, has shown that right whales were broadly distributed across the eastern North Pacific (Scarff 1986, Brownell et al. 2001, Ivashchenko and Clapham 2012). There are sporadic records from below 20°N, but the bulk of the data show right whales concentrated north of 35°N. This includes coastal and offshore waters ranging from Washington State and British Columbia through the Gulf of Alaska, Alaska Peninsula, Aleutian Islands, and Bering Sea.

Modern information on the summer and autumn distribution of right whales has been derived from dedicated vessel and aerial surveys, bottom-mounted acoustic recorders, and vessel surveys for fisheries ecology and management that have also included dedicated marine mammal observers. Aerial and vessel surveys for right whales (LeDuc et al. 2001, Wade et al. 2006, Clapham et al. 2013) have occurred in a portion of the southeastern Bering Sea (Fig. 1) where right whales have been observed or acoustically detected in most summers since 1996 (Goddard and Rugh 1998, Munger et al. 2008, Rone et al. 2012, Wright 2017). North Pacific right whales have been observed consistently in this area, although it is clear from historical and Japanese sighting survey data (Fig. 2) that right whales often range outside this area and occur elsewhere in the Bering Sea (Scarff 1986, Moore et al. 2000, 2002; LeDuc et al. 2001; Clapham et al. 2004). Because of the paucity of right whales in the eastern North Pacific, sightings today are relatively rare and are often of single individuals (Fig. 2). In the summer of 2017, however, the International Whaling Commission's (IWC) Pacific Ocean Whale and Ecosystem Research (POWER) survey used a combination of passive acoustic monitoring and visual sightings to find 15 right whales in the southeastern Bering Sea (Matsuoka et al. 2017). The majority of these sightings (10 of 15 animals) were in Bristol Bay approximately 60 nmi east of the North Pacific right whale critical habitat, with others in the critical habitat itself. Three additional right whales were sighted during the 2018 IWC POWER survey (Matsuoka et al. 2018). Two were within the critical habitat, while the third was sighted approximately 5 nmi south of St. Lawrence Island, in the northern Bering Sea.

Bottom-mounted acoustic recorders were deployed in the southeastern Bering Sea (2000-~~2018~~present) and the northern Gulf of Alaska (1999-2001) to document the seasonal distribution of right whale calls~~ (Mellinger et al. 2004)~~. Analysis of the data from those recorders ~~deployed between October 2000 and January 2006 indicates~~supports the survey data and shows that right whales remain in the southeastern Bering Sea from May through December with peak call detection in September (Mellinger et al. 2004, ~~Munger and Hildebrand 2004~~Munger et al. 2008, Stafford and Mellinger 2009, Stafford et al. 2010, Clapham et al. 2013, Wright 2017, Wright et al. 2019). ~~Data from recorders deployed between May 2006 and April 2007 show the same trends (Stafford and Mellinger 2009, Stafford et al. 2010), as do r~~Recorders deployed by the Alaska Fisheries Science Center's Marine Mammal Laboratory ~~(MML)~~ ~~from 2007 through 2017 (Wright 2017, Wright et al. 2019). Results of the latter monitoring from the eastern Bering shelf (2011-2015) ~~indicated that North Pacific right whales occurred in two passes of the eastern Aleutian Islands (Umnak and Unimak Pass) ~~and that North Pacific right whale calling occurred at consistently high levels in the southeastern Bering shelf during ice-free months ~~(Wright 2017, Wright et al. 2018). No North Pacific right whale calls were detected from January to April in the southeastern Bering Sea, which ~~coincides with persistent winter detections in the waters of the eastern Aleutian Islands,~~ support~~ing~~s the theory that North Pacific right whales migrate out of the Bering Sea during winter months (Wright 2017).

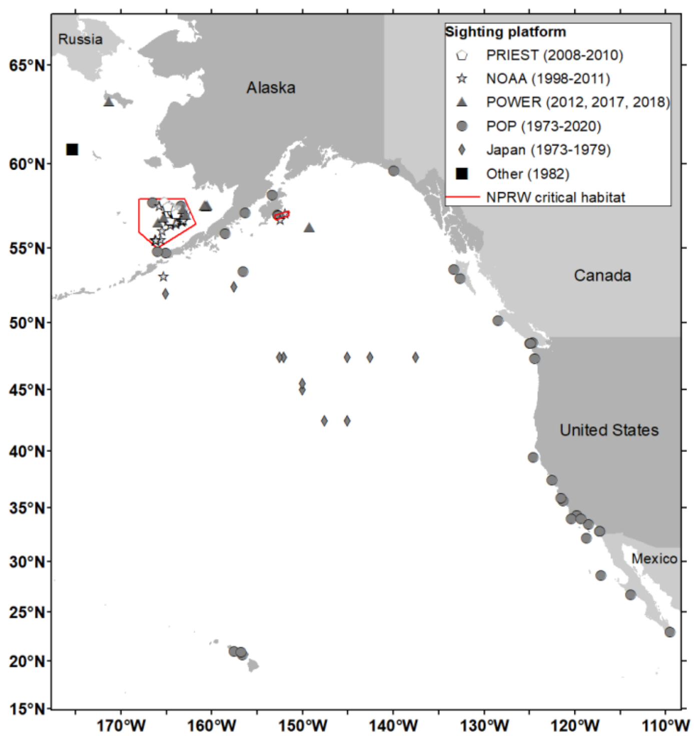

Figure 2. Location of all Eastern North Pacific right whale sightings in the North Pacific by platform since 1970. PRIEST = BOEM-NOAA (Pacific RIght whale Ecology STudy) survey; NOAA = other NOAA surveys; POWER = IWC's Pacific Ocean Whale and Ecosystem Research survey; POP = opportunistic sighting documented in MML's Platforms of Opportunity database; Japan = Japanese sighting survey; Other = Bering Sea (Navarin Basin) survey (Brueggeman et al. 1984).

There continues to be debate regarding the northern extent of the right whale's range, specifically whether they once commonly occurred in the northern Bering Sea and north of the Bering Strait. Records from historical whaling in such areas are often compromised by uncertainty regarding whether these could have been bowhead whales; the extent of overlap between the two species remains unclear. In recent years, ~~in addition to the acoustic data noted above, ~~there have been a few reliable records of right whales in this region: an individual right whale was visually identified north of St. Lawrence Island in November 2012, an individual was sighted on 26 June 2018 by hunters off of St. Lawrence Island on the northeast side of Sivuqaq mountain (G. Sheffield, University of Alaska Fairbanks, Nome, AK), and the IWC POWER cruise recorded a single right whale just south of St. Lawrence in July 2018 (Matsuoka et al. 2018). This latter individual was subsequently observed and photographed by an ecotourism cruise in Pengkingney Fjord in Russian waters just south of the Bering Strait (D. Brown, Heritage Expeditions). Passive acoustic monitoring from 2008 to ~~2015~~2016 of the northern Bering Sea detected calls matching the North Pacific right whale up-call criterion in late fall through spring only in 2016 (Wright et al. 2019)~~, suggesting that North Pacific right whales occur in the northern Bering Sea during winter months; however, due to similarity of call types, there remains a possibility that some winter calls were made by bowhead whales. Taken together, the historical and modern data suggest that right whales do occasionally penetrate the Bering Strait, but even in the 19th century their occurrence in the Chukchi Sea does not appear to have been common~~. It remains unknown whether these recent northern detections and sightings represent a reoccupation of their historical distribution or a northward shift in their distribution.

There have been far fewer sightings of right whales in the Gulf of Alaska than in the Bering Sea (Brownell et al. 2001)~~,~~; although, until the summer of 2015, survey effort was lacking in the Gulf, notably in the offshore areas where right whales commonly occurred during whaling days (Ivashchenko and Clapham 2012). Nonetheless, sightings in the Gulf of Alaska since the cessation of whaling ~~have been so~~are extremely rare (Fig. 2)~~ that they can be listed individually~~, and there have been only a few acoustic detections (Mellinger et al. 2004, Širović et al. 2015).

Three separate surveys have occurred in the Gulf of Alaska in the summer. In summer 2013, the U.S. Navy-funded Gulf of Alaska Line-Transect Survey (GOALS-II) surveyed for marine mammals within the Temporary Maritime Activities Area (TMAA) using visual line-transect methods and passive acoustic monitoring (Rone et al. 2014). ~~The survey followed pre-determined tracklines within four different strata in the TMAA: inshore, slope, seamount, and offshore strata.~~In August 2015, a dedicated vessel survey for right whales was conducted by NMFS using visual and acoustic survey techniques, surveying both the shelf and deeper waters to the south (Rone et al. 2017). And in summer 2019, the IWC POWER cruise systematically surveyed the northern Gulf of Alaska, within the U.S. Exclusive Economic Zone, from Umnak Pass in the Aleutian Islands to the Canadian border in the eastern North Pacific (Matsuoka et al. 2020). In all three surveys, ~~R~~right whales were acoustically detected in the Barnabus Trough area ~~outside the study area~~off Kodiak Island, but were not visually observed.

~~A dedicated vessel survey for right whales was conducted by NMFS in August 2015 aboard the NOAA ship *Reuben Lasker*; the cruise used visual and acoustic survey techniques and followed tracklines on the shelf and in deeper waters to the south and east of Kodiak Island (Rone et al. 2017). Right whales were acoustically detected twice on the shelf in the Barnabus Trough area, but none were visually observed.~~

Most of the illegal Soviet catches of right whales occurred in offshore areas, including a large area to the east and southeast of Kodiak Island (Doroshenko 2000, Ivashchenko and Clapham 2012); the Soviet catch distribution closely parallels that seen in plots of 19th-century American whaling catches by Townsend (1935). Whether this region remains an important habitat for this species is currently unknown. The sightings and acoustic detection of right whales in coastal waters east of Kodiak Island indicate at least occasional use of this area; however, the lack of visual detections of right whales during the GOALS-II cruise in July 2013, ~~and *Reuben Lasker*~~ the NMFS cruise in August 2015, and the IWC POWER cruise in 2019 adds to the concern that right whales may today be extremely rare in the Gulf of Alaska. To date, there have been no matches of photographically identified individuals between the Gulf of Alaska and the Bering Sea, and there is no information to address the question of whether these regions are connected or whether they form largely separate subpopulations.

As noted above, the location of winter calving grounds for North Pacific right whales has long been a mystery. North Atlantic (*E. glacialis*) and Southern Hemisphere (*E. australis*) right whales calve in coastal waters during the winter months. However, in the eastern North Pacific no such calving grounds have been identified (Scarff 1986). Migratory patterns of North Pacific right whales are unknown, although it is thought they migrate from high-latitude feeding grounds in summer to more temperate waters during the winter, possibly including offshore waters (Braham and Rice 1984, Scarff 1986, Clapham et al. 2004). A right whale sighted off Maui in April 1996 (Salden and Michelsen 1999) was identified 119 days later and 4,111 km north in the Bering Sea (Kennedy et al. 2011); to date this is the only low- to high-latitude match of an individually identified right whale in the eastern North Pacific. There is one other modern record from Hawaii of a right whale, an animal seen twice in March and April 1979 (Herman et al. 1980, Rowntree et al. 1980) (Fig. 2).

Although there were a handful of sightings of right whales in the eastern North Pacific from Japanese sighting surveys in the 1970s (Fig. 2), sightings in that area since then have been extremely rare. Two sightings of individual right whales occurred off British Columbia in 2013, one in June and one in October (Ford et al. 2016). The two different individuals represent the first right whale sightings in Canadian waters since the 1950s. Another right whale sighting was made by the Canadian Coast Guard in the same area in June 2018. Most recently, a right whale was sighted off Vancouver Island in May 2020. The timing of these sightings lends support to the theory that right whales migrate to more temperate waters during the winter.

Occasional sightings of right whales have been made off California and off Baja California, Mexico (Fig. 2); this includes two recent records from California in 2017, off La Jolla and in the Channel Islands (both of which were single whales). While the scarcity of records from this region superficially suggests (as did Brownell et al. 2001) that it lacked historical importance for the species, this ignores the fact that right whales had been severely depleted in their feeding grounds prior to 1854, when the first coastal whaling station was established in California. It remains possible that California and Mexico, and possibly offshore waters of Hawaii, were once the principal calving grounds for right whales from the Gulf of Alaska and Bering Sea.

The following information was considered in classifying stock structure according to the Dizon et al. (1992) phylogeographic approach: 1) Distributional data: distinct geographic distribution; 2) Population response data: unknown; 3) Phenotypic data: unknown; and 4) Genotypic data: evidence for some isolation of populations.

Based on this limited information, two stocks of North Pacific right whales are currently recognized: a Western North Pacific stock (feeding primarily in the Sea of Okhotsk) and an Eastern North Pacific stock (feeding primarily in the southeastern Bering Sea) (Rosenbaum et al. 2000, Brownell et al. 2001, LeDuc et al. 2012).~~ The former is believed to feed primarily in the Sea of Okhotsk.~~

In summary, the range of the right whale in the North Pacific was historically broad, with feeding grounds in the Bering Sea, Gulf of Alaska, Okhotsk Sea, and northwestern North Pacific; all of these areas remain inhabited today from May to December~~, but only by a remnant population in the east. The location of winter breeding and calving grounds remains unknown for either population~~.

POPULATION SIZE

The historical (pre-whaling) population size of the North Pacific right whale is unknown. However, Scarff (1991) estimated that 26,500 to 37,000 animals were killed during the period from 1839 to 1909, with the majority being taken in a single decade (1840 to 1849). The U.S.S.R. illegally killed an estimated 771 right whales in the eastern and western North Pacific, with the majority (662) killed between 1962 and 1968 (Ivashchenko et al. 2017). These takes severely impacted the two populations concerned, notably in the east (Ivashchenko and Clapham 2012, Ivashchenko et al. 2013). Of the 662 right whales killed in the 1960s, ~~There were~~ 517 ~~Soviet catches~~were taken in the eastern North Pacific, including 366 in the Gulf of Alaska, 31 in the Aleutian Islands, 116 in the Bering Sea, and 4 in unspecified pelagic waters (Ivashchenko et al. 2013).

Earlier estimates of population size were at best speculative. Based on sighting data, Wada (1973) estimated a total population of 100-200 right whales in the North Pacific in 1970. Rice (1974) stated that only a few individuals remained in the Eastern North Pacific stock and that for all practical purposes the stock was extinct because no sightings of a mature female with a calf had been confirmed since 1900. However, various sightings made since 1996 have invalidated this view (Wade et al. 2006, Zerbini et al. 2015, Ford et al. 2016, Matsuoka et al. 2017). Brownell et al. (2001) suggested from a review of sighting records that the abundance of this species in the western North Pacific was likely in the "low hundreds," including the population in the Sea of Okhotsk.

The North Pacific Right Whale Photo-identification Catalogue currently contains a minimum of ~~29~~26 individual whales from the eastern North Pacific. From 2008 to 2018, ~~29~~26 right whales were photographically identified, some repeatedly (Clapham et al. 2013~~,~~; Ford et al. 2016; Matsuoka et al. 2017, 2018). Including individuals observed more than once across years, this comprises 8 animals photographed in 2008 (all in the Bering Sea), 7 in 2009 (Bering Sea), 3 in 2010 (1 in the Bering Sea, 2 off Kodiak), 2 in 2011 (Bering Sea), 1 in 2012 (Gulf of Alaska), 2 in 2013 (both off British Columbia), 14 in 2017 (12 in the Bering Sea, 1 in Kodiak, 1 in the Channel Islands), and 3 in the Bering Sea in 2018. The number of unique right whales decreased from previous years as a result of obtaining better quality photographs that allowed for additional internal matches in the catalogue.

LeDuc et al. (2012) analyzed 49 biopsy samples from 24 individual right whales, all but one of which were from the eastern North Pacific. The analysis revealed a male-biased sex ratio and a loss of genetic diversity that appeared to be midway between that observed for right whales in the North Atlantic and the Southern Hemisphere. The analysis also suggested a degree of separation between eastern and western populations, a male:female ratio of 2:1, and a low effective population size for the Eastern North Pacific stock, which LeDuc et al. (2012) considered to be at "extreme risk" of extirpation. Six biopsy samples were obtained from right whales in the Bering Sea during the IWC POWER cruises (3 in 2017, 3 in 2018), all from individuals of previously unknown sex. None were obtained during the 2019 cruise. Of the six whales sample~~s~~d, ~~obtained from right whales biopsied during the IWC POWER cruises, the three from 2017 have been analyzed (two~~five were male~~,~~ and only one was female~~) and support the 2:1 male-biased ratio~~. This suggests that the sex ratio may in fact be more skewed toward males than previously believed, which would put the population at even greater risk. These samples have not yet been integrated into the overall sample for reanalysis~~,~~; ~~but~~while this may change the male:female ratio, it is unlikely to change the overall conclusions of LeDuc et al. (2012).

The only recent estimate of abundance comes from mark-recapture analyses of photo-identification and genetic data. Photographic (18 identified individuals) and genotype (21 identified individuals) data through 2008 were used to calculate the first mark-recapture estimates of abundance for right whales in the Bering Sea and Aleutian Islands, resulting in separate estimates of 31 (95% CL: 23-54; CV = 0.22) and 28 (95% CL: 24-42), respectively (Wade et al. 2011). The abundance estimates are for the last year of each study, corresponding to 2008 for the photo-identification estimate and 2004 for the genetic identification estimate. Wade et al. (2011) also estimated that the population consisted of 8 females (95% CL: 7-18) and 20 males (95% CL: 17-37).

The Wade et al. (2011) estimates may relate to a subpopulation that uses the Bering Sea; there is no estimate for right whales in the Gulf of Alaska, and to date there have been no photo-identification matches between the two regions. Consequently, the total size of the Eastern North Pacific population may be somewhat higher than the Wade et al. (2011) estimates.~~;~~ ~~h~~However, given the extreme paucity of recent sightings in the Gulf of Alaska, it seems unlikely that the overall abundance is significantly larger.

Minimum Population Estimate

The minimum estimate of abundance (N_{MIN}) of Eastern North Pacific right whales is 26 whales based on the 20th percentile of the photo-identification estimate of 31 whales (CV = 0.226: Wade et al. 2011). This estimate will be ~~11~~12 years old in ~~2019~~2020, and the 2016 guidelines for preparing Stock Assessment Reports (NMFS 2016) recommend that N_{MIN} be considered unknown if the abundance estimate is more than 8 years old; however, given the extremely low abundance of this stock and the very low calf production, it seems unlikely that the current abundance is significantly different.

Current Population Trend

Due to a low resighting rate and the extremely low population size, ~~N~~no estimate of trend in abundance is available for this stock.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Due to insufficient information, the default cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% is used for this stock (NMFS 2016). However, given the small apparent size, male bias, and very low calf production in this population, this rate is likely to be unrealistically high.

POTENTIAL BIOLOGICAL REMOVAL

Potential biological removal (PBR) is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock is 0.1, the recommended value for cetacean stocks which are listed as endangered (NMFS 2016). A reliable estimate of N_{MIN} for this stock is 26 whales based on the mark-recapture estimate of 31 whales (CV = 0.226: Wade et al. 2011). The calculated PBR level for this stock is therefore 0.05 (26 × 0.02 × 0.1), which would be equivalent to one take every 20 years. However, the male bias likely results in lower than expected calf production and, thus, this PBR could be overestimated.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals between ~~2013~~2014 and ~~2017~~2018 is listed, by marine mammal stock, in ~~Delean et al. (2020)~~Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. No human-caused mortality or serious injury of Eastern North Pacific right whales was reported between ~~2013~~2014 and ~~2017~~2018~~.~~; ~~A~~although, given the remote nature of the known and likely habitats of North Pacific right whales, it is very unlikely that any mortality or serious injury in this population would be observed. Consequently, it is possible that the current absence of reported mortality or serious injury due to entanglement in fishing gear, ship strikes, or other anthropogenic causes (e.g., oil spills) is not a reflection of the true situation.

Fisheries Information

Information ~~(including observer programs, observer coverage, and observed incidental takes of marine mammals)~~ for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is ~~presented~~available in Appendi~~ces~~x 3~~-6~~ of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

There are no historical reports of fisheries-caused mortality or serious injury of Eastern North Pacific right whales. However, given what we know about susceptibility of other large whales to fisheries-caused mortality and serious injury, we assume that the potential exists for North Pacific right whales. Mortality and serious injury of humpback whales and fin whales in trawl gear, gray whales in gillnet gear, and bowhead whales in pot gear (George et al. 2017) has been documented. While much of the trawl fleet has observer coverage, several gillnet fisheries and pot fisheries in the range of Eastern North Pacific right whales do not. Therefore, the potential for fisheries-caused mortality and serious injury may be greater than is reflected in existing observer data.

Right whales, presumably from the Western North Pacific population, have suffered fisheries-caused mortality or serious injury. Gillnets were implicated in the death of a right whale off the Kamchatka Peninsula

(Russia) in October of 1989 (Kornev 1994). The Marine Mammal Commission reported that in February 2015, a young right whale was found entangled in aquaculture gear in South Korea; much of the gear was cut off, but the whale's fate is unknown. In October 2016, an entangled right whale was reported to have died while being disentangled in Volcano Bay, Hokkaido, Japan. And in July 2018, fishermen in the Sea of Okhotsk took video of a right whale that was entangled in the rope of a crab pot but later freed itself. No other incidental takes of right whales are known to have occurred in the North Pacific, although two photographs from the North Pacific Right Whale Photo-identification Catalogue show ~~potential~~possible fishing gear entanglement (A. Kennedy, NMFS-AFSC-MML, pers. comm., 21 September 2011; Ford et al. 2016). The right whale photographed on 25 October 2013 off British Columbia and northern Washington State~~,~~ showed ~~potential~~evidence of probable fishing gear entanglement (Ford et al. 2016). Given the very small estimate of abundance, any mortality or serious injury incidental to commercial fisheries would be considered significant. Entanglement in fishing gear, including lobster pot and sink gillnet gear, is a significant source of mortality and serious injury for North Atlantic right whales (Waring et al. 2014).

~~Although there are no records of mortality or serious injury of Eastern North Pacific right whales in any U.S. fishery, given the remote nature of the known and likely habitats of North Pacific right whales, it is very unlikely that any mortality or serious injury in this population would be observed. Consequently, it is possible that the current absence of reported entanglement-related mortality or serious injury in this stock is not a reflection of the true situation.~~

Alaska Native Subsistence/Harvest Information

Subsistence hunters in Alaska and Russia do not hunt animals from this stock.

Other Mortality

Ship strikes are considered one of the primary sources of human-caused mortality and serious injury of right whales in the North Atlantic (Cole et al. 2005~~,~~; Henry et al. 2012, 2019; Hayes et al. 2018), and it is possible that right whales in the North Pacific are also vulnerable to this source of mortality. However, due to their rare occurrence and scattered distribution, it is impossible to assess the threat of ship strikes to the Eastern North Pacific stock of right whales. There is concern ~~regarding the effects of~~that increased shipping through Arctic waters and the Bering Sea, with retreating sea ice, ~~which~~ may increase the potential risk to right whales from shipping.

Overall, given the remote nature of the known and likely habitats of North Pacific right whales, it is very unlikely that any mortality or serious injury in this population would be observed. Consequently, it is possible that the current absence of reported ship-strike-related or other anthropogenic mortality or serious injury in this stock is not a reflection of the true situation.

STATUS OF STOCK

The right whale is listed as endangered under the Endangered Species Act of 1973, and therefore designated as depleted under the Marine Mammal Protection Act. In 2008, NMFS relisted the North Pacific right whale as endangered as a separate species (*Eubalaena japonica*) from the North Atlantic species, *E. glacialis* (73 FR 12024, 06 March 2008). As a result, the stock is classified as a strategic stock. The abundance of this stock is considered to represent only a small fraction of its pre-commercial whaling abundance, i.e., the stock is well below its Optimum Sustainable Population (OSP). The minimum estimated mean annual level of human-caused mortality and serious injury is unknown for this stock. The reason(s) for the apparent lack of recovery for this stock is (are) unknown. Brownell et al. (2001) and Ivashchenko and Clapham (2012) noted the devastating impact of extensive illegal Soviet catches in the eastern North Pacific in the 1960s, and both suggested that the prognosis for right whales in this area was poor. Biologists working aboard the Soviet factory ships that killed right whales in the eastern North Pacific in the 1960s considered that the fleets had caught close to 100% of the animals they encountered (Ivashchenko and Clapham 2012); accordingly, it is quite possible that the Soviets killed the great majority of the animals in the population at that time. In its review of the status of right whales worldwide, the IWC expressed "considerable concern" over the status of this population (IWC 2001), which is currently the most endangered stock of large whales in the world for which an abundance estimate is available. A genetic analysis of biopsy samples from North Pacific right whales found an apparent loss of genetic diversity, low frequencies of females and calves, extremely low effective population size, and possible isolation from conspecifics in the western Pacific indicating that right whales in the eastern North Pacific are in severe danger of immediate extirpation from the eastern North Pacific (LeDuc et al. 2012).

There are key uncertainties in the assessment of the Eastern North Pacific stock of North Pacific right whales. The abundance of this stock is critically low and migration patterns, calving grounds, and breeding grounds are not well known. There appear to be considerably more males than females in the population and calf production is very low. PBR is designed to allow stocks to recover to, or remain above, the maximum net productivity level (MNPL) (Wade 1998). An underlying assumption in the application of the PBR equation is that marine mammal stocks exhibit certain dynamics. Specifically, it is assumed that a depleted stock will naturally grow toward OSP, and that some surplus growth could be removed while still allowing recovery. However, the Eastern North Pacific right whale population is far below historical levels and at a very small population size, and small populations can have different dynamics than larger populations from Allee effects and stochastic dynamics. Although there is currently no known direct human-caused mortality, given the small number of animals estimated to be in the population, any human-caused mortality or serious injury from ship strikes or commercial fisheries is likely to have a serious population-level impact.

HABITAT CONCERNS

NMFS conducted an analysis of right whale distribution in historical times and in more recent years and stated that principal habitat requirements for right whales are dense concentrations of prey (Clapham et al. 2006) and, on this basis, proposed two areas of critical habitat: one in the southeastern Bering Sea and another south of Kodiak Island (70 FR 66332, 2 November 2005). In 2006, NMFS issued a final rule designating these two areas as northern right whale critical habitat, one in the Gulf of Alaska and one in the Bering Sea (71 FR 38277, 6 July 2006; Fig. 1). In 2008, NMFS redesignated the same two areas as Eastern North Pacific right whale critical habitat under the newly recognized species name, *E. japonica* (73 FR 19000, 8 April 2008; Fig. 1).

Potential threats to the habitat of this population derive primarily from commercial shipping and fishing vessel activity. There is considerable fishing activity within portions of the critical habitat of this species, increasing the risk of entanglement. However, photographs of right whales in the eastern North Pacific to date have shown little evidence of entanglement scars; the sole exception is the animal photographed in the Strait of Juan de Fuca in October 2013 (Ford et al. 2016). Unimak Pass is a choke-point for shipping traffic between North America and Asia, with shipping density and risk of an accidental spill highest in the summer (Renner and Kuletz 2015), a time when right whales are believed to be present (Wright et al. 2018). The high volume of large vessels transiting Unimak Pass (e.g., 1,961 making 4,615 transits in 2012: Nuka Research and Planning Group, LLC 2014a, 2014b), a subset of which continue north through the Bering Sea, increases both the risk of ship strikes and the risk of a large or very large oil spill in areas in which right whales may occur. The risk of accidents in Unimak Pass, specifically, is predicted to increase in the coming decades, and studies indicate that more accidents are likely to involve container vessels (Wolniakowski et al. 2011).

Past offshore oil and gas leasing has occurred in the Gulf of Alaska and Bering Sea in the northern areas of known right whale habitat. The Bureau of Ocean Energy Management (BOEM) proposed an Outer Continental Shelf leasing plan for 2007-2012 that prioritized lease sales for the North Aleutian Basin in 2010 and 2012 (Aplin and Elliott 2007), but it was later withdrawn by Presidential Executive Order. Therefore, the North Aleutian Basin was not included in the 2017-2022 national lease schedule by BOEM, and there are no residual active leases from past sales. However, BOEM has announced plans to replace the 2017-2022 OCS plan (with a new 2019-2024 leasing plan) and to reconsider all current moratoria on offshore oil and gas exploration and extraction (82 FR 30886, 3 July 2017). It is noteworthy that two tagged right whales were observed to briefly visit the North Aleutian Basin area, one in 2004 and one in 2009 (Zerbini et al. 2015). The development of oil fields off Sakhalin Island in Russia is occurring within habitat of the western North Pacific population of right whales (NMFS 2006). However, no oil exploration or production is currently underway in offshore areas of the Bering Sea or Gulf of Alaska, and no lease sales are currently scheduled to occur in those areas. The possibility remains that there will be lease sales in these areas in the future, even though no discoveries have yet been announced and most leases have not contained commercially viable deposits (NMFS 2006). However, in Cook Inlet, lease sales are planned (the next federal sale under the existing 2017-2022 leasing plan will occur in 2021 and state sales currently occur annually) and exploration activity is occurring in both state and federal waters. BOEM (2016) conducted an oil spill model for lower Cook Inlet that suggested if a very large oil spill occurs in offshore waters it will impact right whale habitat around Kodiak Island and along the Alaska Peninsula. Although there is currently no oil and gas activity in the Alaska Chukchi Sea, oil exploration and production is ongoing in the Beaufort Sea, and this will likely include an increased level of associated vessel traffic through the Bering Sea en route to and from the Arctic, which could increase risks to right whales from ship strikes.

CITATIONS

Aplin, D., and W. Elliott. 2007. Conservation concerns for cetaceans in the Bering Sea and adjacent waters: offshore oil development and other threats. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/59/E9). 14 p.

Braham, H. W., and D. W. Rice. 1984. The right whale, *Balaena glacialis*. Mar. Fish. Rev. 46(4):38-44.

Brownell, R. L., P. J. Clapham, T. Miyashita, and T. Kasuya. 2001. Conservation status of North Pacific right whales. J. Cetacean Res. Manage. (Special Issue 2):269-286.

Brueggeman, J. J., R. A. Grotefendt, and A. W. Erickson. 1984. Endangered whale abundance and distribution in the Navarin Basin of the Bering Sea during the ice-free period, p. 201-236. *In* B. R. Melteff and D. H. Rosenberg (eds.), Proceedings of the Workshop on Biological Interactions Among Marine Mammals and Commercial Fisheries in the Southeastern Bering Sea. University of Alaska Sea Grant Report 84-1.

Bureau of Ocean Energy Management (BOEM). 2016. Cook Inlet Planning Area Oil and Gas Lease Sale 244, in the Cook Inlet, Alaska - Final Environmental Impact Statement. Appendix A.

Clapham, P. J., C. Good, S. E. Quinn, R. R. Reeves, J. E. Scarff, and R. L. Brownell, Jr. 2004. Distribution of North Pacific right whales (*Eubalaena japonica*) as shown by 19th and 20th century whaling catch and sighting records. J. Cetacean Res. Manage. 6(1):1-6.

Clapham, P. J., K. E. W. Shelden, and P. R. Wade. 2006. Review of information relating to possible critical habitat for Eastern North Pacific right whales, p. 1-27. *In* P. J. Clapham, K. E. W. Shelden, and P. R. Wade (eds.), Habitat requirements and extinction risks of Eastern North Pacific right whales. AFSC Processed Report 2006-06. Available from Alaska Fisheries Science Center, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Clapham, P. J., A. S. Kennedy, B. K. Rone, A. N. Zerbini, J. L. Crance, and C. L. Berchok. 2013. North Pacific right whales in the southeastern Bering Sea: Final Report. U.S. Dep. Commer., OCS Study BOEM 2012-074. 175 p. Available from Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Cole, T. V. N., D. L. Hartley, and R. M. Merrick. 2005. Mortality and serious injury determinations for large whale stocks along the eastern seaboard of the United States, 1999-2003. U.S. Dep. Commer., NEFSC Ref. Doc. 05-08, 20 p. Available from National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026.

~~Delean, B. J., V. T. Helker, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, J. Jannot, and N. C. Young. 2020. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2013-2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-401, 86 p.~~

Dizon, A. E., C. Lockyer, W. F. Perrin, D. P. DeMaster, and J. Sisson. 1992. Rethinking the stock concept: a phylogeographic approach. Conserv. Biol. 6:24-36.

Doroshenko, N. V. 2000. Soviet whaling for blue, gray, bowhead and right whales in the North Pacific Ocean, 1961-1979, p. 96-103. *In* A. V. Yablokov and V. A. Zemsky (eds.), Soviet Whaling Data (1949-1979). Center for Russian Environmental Policy, Marine Mammal Council, Moscow.

Ford, J. K. B., J. F. Pilkington, B. Gisborne, T. R. Frasier, R. M. Abernethy, and G. M. Ellis. 2016. Recent observations of critically endangered North Pacific right whales (*Eubalaena japonica*) off the west coast of Canada. Marine Biodiversity Records 9:50. DOI: dx.doi.org/10.1186/s41200-016-0036-3 .

George, J. C., G. Sheffield, D. J. Reed, B. Tudor, R. Stimmelmayr, B. T. Person, T. Sformo, and R. Suydam. 2017. Frequency of injuries from line entanglements, killer whales, and ship strikes on Bering-Chukchi-Beaufort seas bowhead whales. Arctic 70(1):37-46.

Goddard, P. C., and D. J. Rugh. 1998. A group of right whales seen in the Bering Sea in July 1996. Mar. Mammal Sci. 14(2):344-349.

Hayes, S. A., S. Gardner, L. Garrison, A. Henry, and L. Leandro. 2018. North Atlantic right whales – evaluating their recovery challenges in 2018. U.S. Dep. Commer., NOAA Tech Memo NMFS-NE-247, 24 p.

Henry, A. G., T. V. N. Cole, M. Garron, L. Hall, W. Ledwell, and A. Reid. 2012. Mortality and serious injury determinations for baleen whale stocks along the Gulf of Mexico, United States east coast and Atlantic Canadian provinces, 2006-2010. U.S. Dep. Commer., NEFSC Reference Document 12-11, 24 p. Available from National Marine Fisheries Service, 166 Water Street, Woods Hole, MA 02543-1026.

Henry, A., M. Garron, A. Reid, D. Morin, W. Ledwell, and T. V. N. Cole. 2019. Serious injury and mortality determinations for baleen whale stocks along the Gulf of Mexico, United States east coast, and Atlantic Canadian Provinces, 2012-2016. U.S. Dep. Commer, Northeast Fisheries Science Center Reference Document 19-13, 54 p. Available online: http://www.nefsc.noaa.gov/publications . Accessed August 2020.

Herman, L. M., C. S. Baker, P. H. Forestell, and R. C. Antinoja. 1980. Right whale, *Balaena glacialis,* sightings near Hawaii: a clue to the wintering grounds? Mar. Ecol. Prog. Ser. 2:271-275.

International Whaling Commission (IWC). 2001. Report of the workshop on the comprehensive assessment of right whales: a worldwide comparison. J. Cetacean Res. Manage. (Special Issue 2):1-60.

Ivashchenko, Y. V., and P. J. Clapham. 2012. Soviet catches of right whales *Eubalaena japonica* and bowhead whales *Balaena mysticetus* in the North Pacific Ocean and the Okhotsk Sea. Endang. Species Res. 18:201-217.

Ivashchenko, Y. V., R. L. Brownell, Jr., and P. J. Clapham. 2013. Soviet whaling in the North Pacific: revised catch totals. J. Cetacean Res. Manage. 13:59-71.

Ivashchenko, Y. V., P. J. Clapham, and R. L. Brownell, Jr. 2017. New data on Soviet catches of blue (*Balaenoptera musculus*) and right whales (*Eubalaena japonica*) in the North Pacific. J. Cetacean Res. Manage. 17:15-22.

Josephson, E. A., T. D. Smith, and R. R. Reeves. 2008. Depletion within a decade: the American 19th-century North Pacific right whale fishery, p. 133-147. *In* D. J. Starkey, P. Holm, and M. Barnard (eds.), Oceans Past: Management Insights from the History of Marine Animal Populations. Earthscan, London.

Kennedy, A. S., D. R. Salden, and P. J. Clapham. 2011. First high- to low-latitude match of an Eastern North Pacific right whale (*Eubalaena japonica*). Mar. Mammal Sci. 28(4):E539-E544. DOI: dx.doi.org/10.1111/j.1748-7692.2011.00539.x .

Kornev, S. I. 1994. A note on the death of a right whale (*Eubalaena glacialis*) off Cape Lopakta (Kamchatka). Rep. Int. Whal. Comm. (Special Issue 15):443-444.

LeDuc, R. G., W. L. Perryman, J. W. Gilpatrick, Jr., J. Hyde, C. Stinchcomb, J. V. Carretta, and R. L. Brownell, Jr. 2001. A note on recent surveys for right whales in the southeastern Bering Sea. J. Cetacean Res. Manage. (Special Issue 2):287-289.

LeDuc, R. G., B. L. Taylor, K. Martien, K. M. Robertson, R. L. Pitman, J. C. Salinas, A. M. Burdin, A. S. Kennedy, P. R. Wade, P. J. Clapham, and R. L. Brownell, Jr. 2012. Genetic analysis of right whales in the eastern North Pacific confirms severe extinction risk. Endang. Species Res. 18:163-167.

Matsuoka, K., J. Taylor, I. Yoshimua, J. Crance, and H. Kasai. 2017. Cruise report of the 2017 IWC-Pacific Ocean Whale and Ecosystem Research (IWC-POWER). Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/67b/ASI/12). 46 p. Available from International Whaling Commission, Cambridge, UK, at https://iwc.int/power .

Matsuoka, K., J. Crance, A. James, I. Yoshimura, and H. Kasai. 2018. Cruise report of the 2018 IWC-Pacific Ocean Whale and Ecosystem Research (IWC-POWER). Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee SC/68a/ASI/04. Available from International Whaling Commission, Cambridge, UK, at https://iwc.int/power .

Matsuoka, K., J. Crance, J. W. Gilpatrick, Jr., I. Yoshimura, and C. Okoshi. 2020. Cruise report of the 2019 IWC-Pacific Ocean Whale and Ecosystem Research (IWC-POWER). Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee. Available from International Whaling Commission, Cambridge, UK, at https://iwc.int/power .

Mellinger, D. K., K. M. Stafford, S. E. Moore, L. Munger, and C. G. Fox. 2004. Detection of North Pacific right whale (*Eubalaena japonica*) calls in the Gulf of Alaska. Mar. Mammal Sci. 20:872-879.

Moore, S. E., J. M. Waite, L. L. Mazzuca, and R. C. Hobbs. 2000. Provisional estimates of mysticete whale abundance on the central Bering Sea shelf. J. Cetacean Res. Manage. 2(3):227-234.

Moore, S. E., J. M. Waite, N. A. Friday, and T. Honkalehto. 2002. Distribution and comparative estimates of cetacean abundance on the central and south-eastern Bering Sea shelf with observations on bathymetric and prey associations. Prog. Oceanogr. 55(1-2):249-262.

~~Munger, L. M., and J. A. Hildebrand. 2004. Final Report: Bering Sea right whales: acoustic recordings and public outreach. North Pacific Research Board Grant Report T-2100.~~

Munger, L. M., S. M. Wiggins, S. E. Moore, and J. A. Hildebrand. 2008. North Pacific right whale (*Eubalaena japonica*) seasonal and diel calling patterns from long-term acoustic recordings in the southeastern Bering Sea, 2000–2006. Mar. Mammal Sci. 24(4):795-814.

National Marine Fisheries Service (NMFS). 2006. Review of the status of the right whales in the North Atlantic and North Pacific Oceans. ~~68~~v + 62 p.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed ~~December 2019~~August 2020.

Nuka Research and Planning Group, LLC. 2014a. Aleutian Islands risk assessment project; recommending an optimal response system for the Aleutian Islands: summary report. 51 p.

Nuka Research and Planning Group, LLC. 2014b. Summary of large vessel transits of Unimak Pass in 2012. Aleutian Islands Risk Assessment Phase B.

Renner, M., and K. J. Kuletz. 2015. A spatial-seasonal analysis of the oiling risk from shipping traffic to seabirds in the Aleutian Archipelago. Mar. Pollut. Bull. 101(1):127-136.

Rice, D. W. 1974. Whales and whale research in the eastern North Pacific, p. 170-195. *In* W. E. Schevill (ed.), The Whale Problem: A Status Report. Harvard Press, Cambridge, MA.

Rone, B. K., C. L. Berchok, J. L. Crance, and P. J. Clapham. 2012. Using air-deployed passive sonobuoys to detect and locate critically endangered North Pacific right whales. Mar. Mammal Sci. 28:E528-E538.

Rone, B. K., A. B. Douglas, T. M. Yack, A. N. Zerbini, T. N. Norris, E. Ferguson, and J. Calambokidis. 2014. Report for the Gulf of Alaska Line-Transect Survey (GOALS) II: marine mammal occurrence in the Temporary Maritime Activities Area (TMAA). Submitted to Naval Facilities Engineering Command (NAVFAC) Pacific, Honolulu, Hawaii under Contract No. N62470-10-D-3011, Task Order 0022, issued to HDR Inc., San Diego, California. Prepared by Cascadia Research Collective, Olympia, WA; Alaska Fisheries Science Center, Seattle, WA; and Bio-Waves, Inc., Encinitas, CA. April 2014.

Rone, B. K., A. N. Zerbini, A. B. Douglas, D. W. Weller, and P. J. Clapham. 2017. Abundance and distribution of cetaceans in the Gulf of Alaska. Mar. Biol. 164:23. DOI: dx.doi.org/10.1007/s00227-016-3052-2 .

Rosenbaum, H. C., R. L. Brownell, M. W. Brown, C. Schaeff, V. Portway, B. N. White, S. Malik, L. A. Pastene, N. J. Patenaude, C. S. Baker, M. Goto, P. B. Best, P. J. Clapham, P. Hamilton, M. Moore, R. Payne, V. Rowntree, C. T. Tynan, J. L. Bannister, and R. DeSalle. 2000. World-wide genetic differentiation of *Eubalaena*: questioning the number of right whale species. Mol. Ecol. 9(11):1793-1802.

Rowntree, V., J. Darling, G. Silber, and M. Ferrari. 1980. Rare sighting of a right whale (*Eubalaena glacialis*) in Hawaii. Can. J. Zool. 58:308-312.

Salden, D. R., and J. Mickelsen. 1999. Rare sightings of a North Pacific right whale (*Eubalaena glacialis*) in Hawaii. Pac. Sci. 53:341-345.

Scarff, J. E. 1986. Historic and present distribution of the right whale (*Eubalaena glacialis*) in the eastern North Pacific south of 50°N and east of 180°W. Rep. Int. Whal. Comm. (Special Issue 10):43-63.

Scarff, J. E. 1991. Historic distribution and abundance of the right whale, *Eubalaena glacialis*, in the North Pacific, Bering Sea, Sea of Okhotsk and Sea of Japan from the Maury Whale Charts. Rep. Int. Whal. Comm. 41:467-487.

Širović, A., S. C. Johnson, L. K. Roche, L. M. Varga, S. M. Wiggins, and J. A. Hildebrand. 2015. North Pacific right whales (*Eubalaena japonica*) recorded in the northeastern Pacific Ocean in 2013. Mar. Mammal Sci. 31(2):800-807. DOI: dx.doi.org/10.1111/mms.12189 .

Stafford, K. M., and D. K. Mellinger. 2009. Analysis of acoustic and oceanographic data from the Bering Sea, May 2006 – April 2007. North Pacific Research Board Final Report, NPRB Project No. 719. 24 p.

Stafford, K. M., S. E. Moore, P. J. Stabeno, D. V. Holliday, J. M. Napp, and D. K. Mellinger. 2010. Biophysical ocean observation in the southeastern Bering Sea. Geophys. Res. Lett. 37(2). DOI: dx.doi.org/10.1029/2009GL040724 .

Townsend, C. H. 1935. The distribution of certain whales as shown by logbook records of American whaleships. Zoologica NY 19:1-50.

Wada, S. 1973. The ninth memorandum on the stock assessment of whales in the North Pacific. Rep. Int. Whal. Comm. 23:164-169.

Wade, P. R. 1998. Calculating limits to the allowable human-caused mortality of cetaceans and pinnipeds. Mar. Mammal Sci. 14:1-37. DOI: dx.doi.org/10.1111/j.1748-7692.1998.tb00688.x .

Wade, P. R., M. P. Heide-Jørgensen, K. Shelden, J. Barlow, J. Carretta, J. Durban, R. LeDuc, L. Munger, S. Rankin, A. Sauter, and C. Stinchcomb. 2006. Acoustic detection and satellite tracking leads to discovery of rare concentration of endangered North Pacific right whales. Biol. Lett. 2:417-419.

Wade, P. R., A. Kennedy, R. LeDuc, J. Barlow, J. Carretta, K. Shelden, W. Perryman, R. Pitman, K. Robertson, B. Rone, J. C. Salinas, A. Zerbini, R. L. Brownell, Jr., and P. Clapham. 2011. The world's smallest whale population. Biol. Lett. 7:83-85.

Waring, G. T., E. Josephson, K. Maze-Foley, and P. E. Rosel (eds.). 2014. U.S. Atlantic and Gulf of Mexico marine mammal stock assessments - 2013. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-NE-228, 464 p.

Wolniakowski, K. U., J. Wright, G. Folley, and M. R. Franklin. 2011. Aleutian Islands Risk Assessment Project. Phase A Summary Report. 58 p.

Wright, D. L. 2017. Passive acoustic monitoring of the critically endangered Eastern North Pacific right whale (*Eubalaena japonica*). Final Report to Marine Mammal Commission, 4340 East-West Highway, Suite 700, Bethesda, MD 20814. 58 p.

Wright, D. L., M. Castellote, C. L. Berchok, D. Ponirakis, J. L. Crance, and P. J. Clapham. 2018. Acoustic detection of North Pacific right whales in a high-traffic Aleutian Pass, 2009-2015. Endang. Species Res. 37:77-90. DOI: dx.doi.org/10.3354/esr00915 .

Wright, D. L., C. L. Berchok, J. L. Crance, and P. J. Clapham. 2019. Acoustic detection of the critically endangered North Pacific right whale in the northern Bering Sea. Mar. Mammal Sci. 35:311-326. DOI: dx.doi.org/10.1111/mms.12521 .

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX.

Zerbini, A. N., M. F. Baumgartner, A. S. Kennedy, B. K. Rone, P. R. Wade, and P. J. Clapham. 2015. Space use patterns of the endangered North Pacific right whale (*Eubalaena japonica*) in the Bering Sea. Mar. Ecol. Prog. Ser. 532:269-281. DOI: dx.doi.org/10.3354/meps11366 .

BOWHEAD WHALE (*Balaena mysticetus*): Western Arctic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

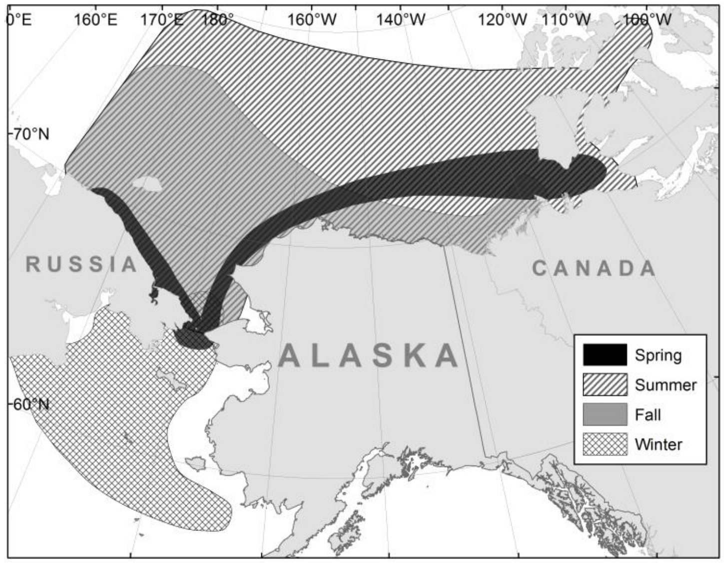

Figure 1. Annual range of the Western Arctic stock of bowhead whales by season from satellite tracking data, 2006-2017 (map based on Quakenbush et al. (2018): Fig. 2).

Western Arctic bowhead whales are distributed in seasonally ice-covered waters of the Arctic and near-Arctic, generally north of 60°N and south of 75°N in the western Arctic Basin (Braham 1984, Moore and Reeves 1993). For management purposes, four stocks of bowhead whales ~~have been~~are recognized worldwide by the International Whaling Commission (IWC 2010). Small stocks, comprising only a few hundred individuals, occur in the Sea of Okhotsk and the offshore waters of Spitsbergen (Zeh et al. 1993, Shelden and Rugh 1995, Wiig et al. 2009, Shpak et al. 2014, Boertmann et al. 2015). Bowhead whales occur in western Greenland (Hudson Bay and Foxe Basin) and eastern Canada (Baffin Bay and Davis Strait), and evidence suggests that these should be considered one stock based on genetics (Postma et al. 2006, Bachmann et al. 2010, Heide-Jørgensen et al. 2010, Wiig et al. 2010), aerial surveys (Cosens et al. 2006), and tagging data (Dueck et al. 2006; Heide-Jørgensen et al. 2006; IWC 2010, 2011). This stock, previously thought to include only a few hundred animals, may number over a thousand (Heide-Jørgensen et al. 2006, Wiig et al. 2011), and perhaps over 6,000 (IWC 2008, Doniol-Valcroze et al. 2015, Frasier et al. 2015). The only stock found within U.S. waters is the Western Arctic stock (Fig. 1), also known as the Bering-Chukchi-Beaufort stock (Rugh et al. 2003) or Bering Sea stock (Burns et al. 1993). The IWC Scientific Committee concluded, in several reviews of the extensive genetic and satellite telemetry data, that the weight-of-evidence is most consistent with one bowhead whale stock that migrates throughout waters of northern and western Alaska and northeastern Russia (IWC 2008, 2018).

The majority of the Western Arctic stock migrates annually from wintering areas ~~(December to March)~~ in the northern Bering and southern Chukchi ~~S~~seas (December to April), through the Chukchi Sea and Beaufort Sea in the spring (April through May), to the eastern Beaufort Sea (Fig. 1) where they spend much of the late spring and summer (~~June~~May through ~~early to mid-October~~September). During late summer and autumn (September through December), this stock migrates back ~~before returning again~~ to the Chukchi Sea and then to the Bering Sea (Fig. 1) ~~in the fall (September through December)~~ to overwinter (Braham et al. 1980; Moore and Reeves 1993; Quakenbush et al. 2010a, 2018; Citta et al. 2015). ~~Increasing numbers of bowhead whales are found in the western Beaufort and Chukchi seas in summer and fall, and these are thought to be a part of the expanding Western Arctic stock (Rugh et al. 2003, Citta et al. 2015, Clarke et al. 2017).~~

During winter and spring, bowhead whales are closely associated with sea ice (Moore and Reeves 1993, Quakenbush et al. 2010a, Citta et al. 2015, Druckenmiller et al. 2018). The bowhead whale spring migration follows fractures in the sea ice along the coast to Point Barrow, generally in the shear zone between the shorefast ice and the mobile pack ice, then continues offshore on a direct path to the Cape Bathurst polynya (Citta et al. 2015). In most years, during summer, ~~most~~a large proportion of the population is in the relatively ice-free waters of Amundsen Gulf in the eastern ~~Canadian~~ Beaufort Sea (Citta et al. 2015), an area often exposed to industrial activity related to petroleum exploration (e.g., Richardson et al. 1987, Davies 1997). However, summer aerial surveys conducted in the western Beaufort Sea during July and August of 2012-2017 have had relatively high sighting rates of bowhead whales, including cows with calves and feeding animals (Clarke et al. 2018a, 2018b), suggesting interannual variability in bowhead whale summer distribution. Additionally, data from a satellite tagging study conducted between 2006 and 2018 indicated that, although most tagged whales began to leave the Canadian

Beaufort Sea in September, the timing of their westward migration across the Beaufort Sea was highly variable; furthermore, all tagged whales observed in summer and fall in Beaufort and Chukchi waters near Point Barrow were known to have returned from Canada (Quakenbush and Citta 2019). Timing of the onset of the westward migration across the Beaufort Sea is associated with oceanographic conditions in the eastern Beaufort Sea (Citta et al. 2018, Clarke et al. 2018b). During the autumn migration~~ through the Beaufort Sea~~, bowhead whales generally ~~select~~inhabit shelf waters across the Beaufort Sea (Citta et al. 2015). ~~During t~~The autumn migration across the Chukchi Sea is more dispersed (Clarke et al. 2016); here, bowhead whales generally ~~select~~prefer cold, saline waters that are mostly of Bering Sea origin (Citta et al. ~~2017~~2018). ~~In~~During winter in the Bering Sea, bowhead whales often use areas ~~with~~covered by nearly 100% sea -ice~~ cover~~, even when polynyas are available (Quakenbush et al. 2010a, Citta et al. 2015).

Evidence from stomach contents and habitat associations suggests that Western Arctic bowhead whales feed on concentrations of zooplankton throughout their range. Likely or confirmed feeding areas include Amundsen Gulf and the eastern ~~Canadian~~ Beaufort Sea; the central and western ~~U.S.~~ Beaufort Sea; ~~Wrangel Island~~the Chukchi shelf break, especially Herald Valley and the Central Channel; and the coast of Chukotka between Wrangel Island and ~~the~~ Bering Strait (Lowry et al. 2004; Ashjian et al. 2010; Clarke and Ferguson 2010; Quakenbush et al. 2010a, 2010b; Okkonen et al. 2011; Fish et al. 2013; Citta et al. 2015, ~~2017~~2018; Clarke et al. 2017; Harwood et al. 2017). Citta et al. (2015) identified six core use areas for Western Arctic bowhead whales based on bowhead whale satellite telemetry, oceanography, sea ice, and winds. During spring in the Cape Bathurst polyna, whales are found in water <75 m deep where calanoid copepods are ascending after diapause. In summer and into fall, bowhead whales inhabit shelf waters in the Beaufort Sea, including the Tuktoyaktuk shelf and areas farther west, where episodic wind-driven upwelling and high river discharge results in high densities of zooplankton (Citta et al. 2015, Harwood et al. 2017, Okkonen et al. 2018, Clarke et al. 2018b).~~Bowhead whales have also been observed feeding during the summer in the northeastern Chukchi Sea (Clarke et al. 2016).~~ During summer and fall, Western Arctic bowhead whales may congregate on the shallow shelf east of Point Barrow, where variable wind dynamics promote large aggregations of zooplankton onto the shelf (Ashjian et al. 2010, Okkonen et al. 2011, Citta et al. 2015). In winter, dive behavior suggests that bowhead whales ~~are~~ feed~~ing~~ in shelf waters of the Bering Sea~~ shelf waters~~, from Bering Strait south through Anadyr Strait, and near the ~~entrance of~~seafloor in the Gulf of Anadyr (Citta et al. 2012, 2015). ~~Three o~~Of four bowhead whales harvested in ~~winter~~November (two in 2012) and December (two in ~~December~~ 2010 ~~and two in November 2012~~) near St. Lawrence Island, in the northern Bering Sea, three had been feeding (Sheffield and George 2013). Results from mercury and stable isotope analysis are consistent with year-round foraging and seasonal migration of bowhead whales (Pomerleau et al. 2018).

Clarke et al. (2015) evaluated biologically important areas (BIAs) for bowhead whales in the U.S. Arctic region and identified nine BIAs based on satellite telemetry and aerial survey data. The four reproductive BIAs encompass areas where the majority of bowhead whales identified as calves were observed each season. ~~In addition,~~The three feeding BIAs ~~for bowhead whales~~ were ~~identified~~ located in the western Beaufort Sea. In most years, the krill trap area (Ashjian et al. 2010) from Smith Bay to Point Barrow is the most consistent feeding area for bowhead whales from August to October (Clarke et al. 2015). In other areas of the western Beaufort Sea, bowhead whales may feed in ephemeral prey patches on the continental shelf, out to approximately the 50 m isobath, in September and October. These ephemeral foraging areas are also evident in satellite telemetry data (Quakenbush and Citta 2019).

POPULATION SIZE

All stocks of bowhead whales were severely depleted during intense commercial whaling, starting in the early 16th century near Labrador, Canada (Ross 1993), and spreading to the Bering Sea in the mid-19th century (Braham 1984, Bockstoce and Burns 1993, Bockstoce et al. 2007). Woodby and Botkin (1993) summarized previous efforts to estimate bowhead whale population size prior to the onset of commercial whaling. They reported a minimum worldwide population estimate of 50,000, with 10,400 to 23,000 in the Western Arctic stock (dropping to less than 3,000 at the end of commercial whaling). Brandon and Wade (2006) used Bayesian model averaging to estimate that the Western Arctic stock consisted of 10,960 bowhead whales (9,190 to 13,950; 5th and 95th percentiles, respectively) in 1848 at the start of commercial whaling.

The recently adopted Aboriginal Whaling Scheme (IWC 2018) requires that abundance estimates be conducted every 10 years as input into the Strike Limit Algorithm (SLA) that the IWC approved for estimating a safe strike limit for aboriginal subsistence hunting. Ice-based visual and acoustic counts have been conducted since 1978 (Krogman et al. 1989; Table 1). These counts have been corrected for whales missed due to distance offshore ~~(~~since the mid-1980s, using acoustic methods described in (Clark et al. 1994). ~~, whales missed when no watch was in effect (through interpolations from sampled periods), and whales missed during a watch (estimated as a function of visibility, number of observers, and distance offshore:~~ Correction factors were estimated for whales missed during a watch (due to visibility, number of observers, and offshore distance) and when no watch was in effect (through interpolations from sampled periods) (Zeh et al. 1993, Givens et al. 2016). The~~se~~ spring ice-based estimates of abundance have not been corrected for a small portion of the population that may not migrate past Point Barrow during the period when counts are made. According to Melnikov and Zeh (2007), 470 bowhead whales (95% CI: 332-665) likely migrated to Chukotka instead of Barrow in spring 2000 and 2001.

Table 1. Summary of abundance estimates for the Western Arctic stock of bowhead whales. The historical estimates were made by back-projecting using a simple recruitment model. All other estimates were developed by corrected ice-based census counts. Historical estimates are from Woodby and Botkin (1993); 1978-2001 estimates are from George et al. (2004) and Zeh and Punt (~~2004~~2005). The 2011 estimate is reported in Givens et al. (2016).

Year	Abundance range or estimate (CV)	Year	Abundance estimate (CV)
Historical	10,400-23,000	1985	5,762 (0.253)
End of commercial whaling	1,000-3,000	1986	8,917 (0.215)
1978	4,765 (0.305)	1987	5,298 (0.327)
1980	3,885 (0.343)	1988	6,928 (0.120)
1981	4,467 (0.273)	1993	8,167 (0.017)
1982	7,395 (0.281)	2001	10,545 (0.128)
1983	6,573 (0.345)	2011	16,820 (0.052)

Bowhead whales were identified from aerial photographs taken in 1985 and 1986, and again in 2003 and 2004, and the results were used in a sight-resight analysis (Table 2). These population estimates and their associated error are comparable to the estimates obtained from the combined ice-based visual and acoustic counts (Raftery and Zeh 1998, Schweder et al. 2009, Koski et al. 2010). An aerial photographic survey was conducted near Point Barrow concurrently with the ice-based spring census in 2011, which, in addition to an abundance estimate based on sight-resight data, also provided a revised survival estimate for the population (Givens et al. 2018) (Table 2). However, because ~~of its~~ the 2011 ice-based estimate had a lower coefficient of variation (CV), the IWC Scientific Committee considered ~~the 2011 ice-based~~this estimate the most appropriate for management and use in the SLA (IWC 2018).

Table 2. Summary of abundance estimates for the Western Arctic stock of bowhead whales from aerial sight-resight surveys. Estimates are reported in da Silva et al. 2000, 2007 (1986 estimate), Koski et al. 2010 (2004 estimate), and Givens et al. 2018 (2011 estimate). LB = lower bound of 95% confidence interval.

Year	Abundance range or estimate (CV)	Survival estimate (LB)
1986	4,719 - 7,331	0.985 (0.958)
2004	12,631 (0.2442)	
2011	27,133 (0.217)	0.996 (0.976)

Minimum Population Estimate

The minimum population estimate (N_{MIN}) for ~~this~~the Western Arctic stock is calculated from Equation 1 from the potential biological removal (PBR) guidelines (NMFS 2016): $N_{MIN} = N/\exp(0.842\times[\ln(1+[CV(N)]^2)]^{½})$. Using the 2011 population estimate (N) from the ice-based survey of 16,820 and its associated CV(N) of 0.052 (Table 1), N_{MIN} for ~~the Western Arctic~~this stock of bowhead whales is 16,100 whales.

Current Population Trend

Based on concurrent passive acoustic and ice-based visual surveys, Givens et al. (2013) reported that the Western Arctic stock of bowhead whales increased at a rate of 3.7% (95% CI = 2.9-4.6%) from 1978 to 2011, during which time abundance tripled from approximately 5,000 to approximately 16,820 whales (Givens et al. 2016) (Fig. 2). Schweder et al. (2009) estimated the yearly growth rate to be 3.2% (95% CI = 0.5-4.8%) between 1984 and 2003 using a sight-resight analysis of aerial photographs.

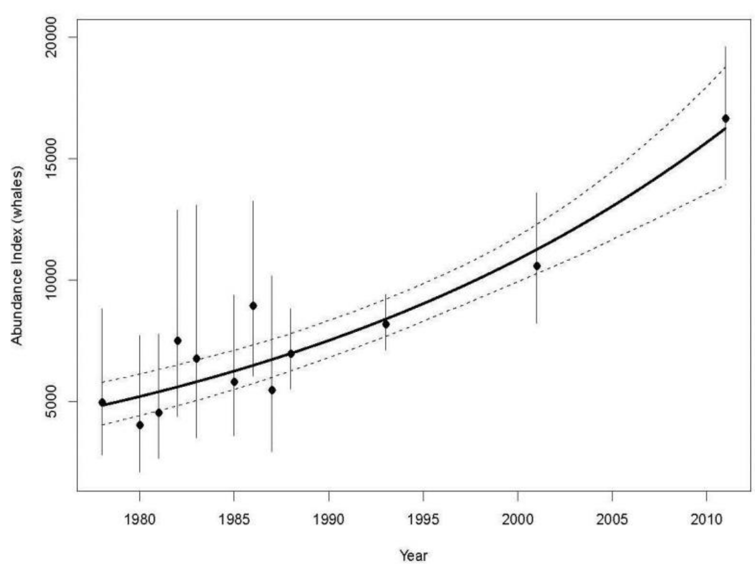

Figure 2. Abundance estimates (points with confidence interval lines) and trend (black line with confidence range) for the Western Arctic stock of bowhead whales, 1978-2011 (Givens et al. 2013), as computed from ice-based counts and acoustic data collected during bowhead whale spring migrations past Point Barrow, Alaska.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

The current estimate for the rate of increase for ~~this~~the Western Arctic stock of bowhead whales (3.7%: 95% CI = 2.9-4.6%) should not be used as an estimate of the maximum net productivity rate (R_{MAX}) because the population is currently being harvested and the population has been estimated to be at a substantial fraction of its carrying capacity (Brandon and Wade 2006) ~~and so~~; therefore, this stock may not be growing at its maximum rate. ~~Therefore, t~~The cetacean maximum theoretical net productivity rate of 4% will be used for the Western Arctic stock of bowhead whales (NMFS 2016).

POTENTIAL BIOLOGICAL REMOVAL

PBR is defined as the product of the minimum population estimate, one-half the maximum theoretical net productivity rate, and a recovery factor: PBR = $N_{MIN} \times 0.5R_{MAX} \times F_R$. The recovery factor ($F_R$) for this stock has been set at 0.5 rather than the default value of 0.1 for endangered species because population levels are increasing in the presence of a known take (NMFS 2016). Thus, PBR ~~=~~is 161 whales (16,100 × 0.02 × 0.5). The calculation of a PBR level for the Western Arctic bowhead whale stock is required by the MMPA even though the subsistence harvest quota is established under the authority of the IWC based on an extensively tested SLA (IWC 2003). The quota is based on subsistence need or the ability of the bowhead whale population to sustain a harvest, whichever is smaller. The IWC bowhead whale quota takes precedence over the PBR estimate for the purpose of managing the Alaska Native subsistence harvest from this stock. ~~For~~From 2013 to 2018, the IWC established a block quota of ~~306~~336 landed bowhead whales. Because some whales are struck and lost, the IWC set a strike limit of 67 (plus up to 15 previously unused strikes) per year. In recent years, an arrangement between the United States and the Russian Federation ensures that the total quota of bowhead whales struck will not exceed the limits set by the IWC. Under this arrangement, the Chukotka Natives in Russia may use no more than seven strikes, and ~~the~~ Alaska ~~Eskimos~~Natives may use no more than 75 strikes. The total block quota for 2019 to 2025 is 392 whales, with no more than 67 strikes per year~~ plus up to 33 previously unused strikes~~, except that any unused portion of a strike quota from the three prior quota blocks can be carried forward and added to the strike quotas of subsequent years, provided that no more than 50% of the annual strike limit is added to the strike quota for any one year.

ANNUAL HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed Alaska marine mammals between ~~2013~~2014 and ~~2017~~2018 is listed, by marine mammal stock, in ~~Delean et al. (2020)~~Young et al. (in press); however, only the mortality and serious injury data are included in the Stock Assessment Reports. The minimum estimated mean annual level of human-caused mortality and serious injury for Western Arctic bowhead whales between ~~2013~~2014 and ~~2017~~2018 is ~~53~~56 whales: 0.2 in U.S. commercial fisheries (Table 3) and ~~53~~56 in subsistence takes by Natives of Alaska (number landed + struck and lost mortality) and Russia (number landed, struck and lost not reported). Potential threats most likely to result in direct human-caused mortality or serious injury of individuals in this stock include entanglement in fishing gear and ship strikes due to increased vessel traffic (from increased commercial shipping in the Chukchi and Beaufort seas) (Smith and Stephenson 2013).

Fisheries Information

Information ~~(including observer programs, observer coverage, and observed incidental takes of marine mammals)~~ for federally-managed and state-managed U.S. commercial fisheries in Alaska waters is ~~presented~~available in Appendi~~ces~~x 3~~-6~~ of the Alaska Stock Assessment Reports (observer coverage) and in the NMFS List of Fisheries (LOF) and the fact sheets linked to fishery names in the LOF (observer coverage and reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed August 2020).

While there are no observer program records of bowhead whale mortality or serious injury incidental to U.S. commercial fisheries in Alaska, Citta et al. (2014) found that the distribution of satellite-tagged bowhead whales in the Bering Sea spatially, but not temporally, overlapped areas where commercial pot fisheries occurred and noted the potential risk of entanglement in lost gear. ~~Several cases of~~Approximately 12% of the bowhead whales taken in the subsistence hunt between 1990 and 2012 showed evidence of entanglement in line or net ~~entanglement have been reported from whales taken in the subsistence hunt~~ (Philo et al. 1993). George et al. (2017) examined 904 records ~~for 904~~of bowhead whales harvested between 1990 and 2012. Of these, 514 records were examined for at least one of the three types of scars indicating injuries from line entanglement wounds (514 records examined), attacks by killer whales (377 records examined), or ship strikes (and/or propeller injuries) (504 records examined). Their best estimate of the occurrence of entanglement scars was approximately 12.2% (59/485; ~~an additional~~ 29 records with possible entanglement scars were excluded from the analysis) with the cause most likely from fishing/crab pot gear in the Bering Sea. Most entanglement injuries occurred on the peduncle and were rarely observed on smaller subadult and juvenile whales (<10 m), possibly because young whales are less likely to survive entanglements (George et al. 2017) and have presumably had fewer years during which to acquire entanglement scars. A review of the photo-identification catalogue from 1985 to 2011 found the probability of scarring due to entanglement at about 2.2% per year (95% CI: 1.1-3.3%), with 12.4% of living bowhead whales photographed in 2011 showing evidence of entanglement (George et al. 2019).

One dead bowhead whale was found floating in Kotzebue Sound in early July 2010, entangled in crab pot gear similar to that used by commercial crabbers in the Bering Sea (Suydam et al. 2011), and one entangled bowhead whale was photographed during the 2011 spring aerial photographic survey of bowhead whales near Point Barrow (Mocklin et al. 2012)~~,~~ but it was not considered to be seriously injured. In July 2015, a dead adult female bowhead whale drifting near Saint Lawrence Island in the Bering Strait was ~~found~~ entangled in commercial fishing gear (Suydam et al. 2016), which included lines, two floats, and an attached color coded/numbered permit tag for the 2012/2013 winter commercial blue king crab fishery located in Saint Matthew Island waters of the northern Bering Sea (Sheffield and Savoonga Whaling Captains Association 2015) (Table 3). Two of the bowhead whales taken in the Alaska Native subsistence hunt in 2017 were seriously injured due to entanglement in pot gear suspected (but not confirmed) to be from Bering Sea commercial pot fisheries (~~Delean et al. 2020~~Young et al. in press) and a third whale taken during the subsistence hunt on 5 May 2017 was reported as "lethargic" and was later found to have 84 m of 19-mm rope attached to the baleen rack, left pectoral flipper, and peduncle, penetrating up to 10 cm through the epidermis (Rolland et al. 2019); however, because these whales are included in the Alaska Native subsistence harvest for 2017 (Table 4), they are not listed in Table 3. Thus, the minimum estimated average annual mortality and serious injury rate in U.S. commercial fisheries between ~~2013~~2014 and ~~2017~~2018 is 0.2 bowhead whales (Table 3; ~~Delean et al. 2020~~Young et al. in press), although, the actual rate is currently unknown. This mortality and serious injury estimate results from an actual count of verified human-caused deaths and serious injuries and is a minimum because not all entangled animals are found, reported, or have the cause of death determined.

Table 3. Summary of mortality and serious injury of Western Arctic bowhead whales, by year and type, reported to the NMFS Alaska Region marine mammal stranding network between ~~2013~~2014 and ~~2017~~2018 (~~Delean et al. 2020~~Young et al. in press).

Cause of injury	~~2013~~	2014	2015	2016	2017	2018	Mean annual mortality
Entangled in Bering Sea/Aleutian Is. commercial blue king crab pot gear	~~0~~	0	1	0	0	0	0.2
Total in commercial fisheries							0.2

Alaska Native Subsistence/Harvest Information

NMFS signed an agreement with the Alaska Eskimo Whaling Commission (in 1998, as last amended in 2019) to protect the bowhead whale and the Eskimo culture. This co-management agreement promotes full and equal participation by Alaska Natives in decisions affecting the subsistence management of marine mammals (to the maximum extent allowed by law) as a tool for conserving marine mammal populations in Alaska (https://www.fisheries.noaa.gov/alaska/marine-mammal-protection/co-management-marine-mammals-alaska, accessed August 2020).

~~Eskimos~~Alaska Natives have been taking bowhead whales for subsistence purposes for at least 2,000 years (Marquette and Bockstoce 1980, Stoker and Krupnik 1993). Subsistence takes have been regulated by a quota system under the authority of the IWC since 1977. Alaska Native subsistence hunters, primarily from 11 Alaska communities, take approximately 0.1-0.5% of the Western Arctic bowhead whale stock per annum (Philo et al. 1993, Suydam et al. 2011). Under this quota, the ~~total~~ number of bowhead whales landed by Alaska Natives between 1974 and ~~2017~~2018 ranged from 8 to 55 whales per year (Suydam and George 2012; Suydam et al. 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019; George and Suydam 2014). The maximum number of strikes per year is set by a quota which is determined by subsistence needs and bowhead whale abundance and trend estimates (Stoker and Krupnik 1993). Suydam and George (2012) summarized Alaska subsistence harvests of bowhead whales from 1974 to 2011 and reported a total of 1,149 whales landed by hunters from 12 villages, with Utqiaġvik (formerly Barrow) landing the most whales (n = 590) and Shaktoolik landing only one. Alaska Natives landed ~~220~~221 bowhead whales between ~~2013~~2014 and ~~2017~~2018 and ~~41~~52 of the ~~55~~65 whales that were struck and lost were determined to have died or had a poor chance of survival, resulting in an average annual take of ~~52~~55 whales (Table 4). Unlike the NMFS process for determining serious injuries (described in NMFS 2012), these estimates of struck and lost mortality are based on the Whaling Captains' assessment of the likelihood of survival (see criteria described in Suydam et al. 1995). The number of whales landed at each village varies greatly from year to year, as success is influenced by village size and ice and weather conditions. The efficiency of the hunt (the percent of whales struck that are retrieved) has increased since the implementation of the bowhead whale quota in 1978. In 1978, the efficiency was about 50%. In ~~2017~~2018, ~~50~~47 of ~~57~~68 whales struck were landed, resulting in an efficiency of

~~88~~69% ~~(Suydam et al. 2018). Suydam et al. (2018) reported that~~and the mean efficiency for ~~2007~~2008 to ~~2016~~2017 was ~~75~~77% (Suydam et al. 2019).

Canadian and Russian Natives also take whales from this stock. No catches of Western Arctic bowhead whales were reported by Canadian hunters between ~~2013~~2014 and ~~2017~~2018; however, ~~one~~two bowhead whales ~~was~~were landed in Russia ~~in 2013 (Ilyashenko and Zharikov 2014), two~~ in 2016 (Ilyashenko and Zharikov 2017), ~~and~~ one in 2017 (Zharikov 2018), and none in 2018 (Zharikov et al. 2019), resulting in an average annual take of ~~0.8~~0.6 (landed) whales.

The total average annual ~~total~~ subsistence take for ~~2013~~2014 to ~~2017~~2018 is ~~53~~56 bowhead whales, which includes the number landed (plus the struck and lost mortality) by Alaska Natives and the number landed (struck and lost not reported) by Russian Natives.

Table 4. Summary of the Alaska Native subsistence harvest of Western Arctic bowhead whales between ~~2013~~2014 and ~~2017~~2018.

Year	Landed	Struck and lost	Struck and lost mortality	Total (landed + struck and lost mortality)
~~2013[a]~~	~~46~~	~~11~~	~~6~~	~~52~~
2014~~[b]~~[a]	38	15	12	50
2015~~[c]~~[b]	39	10	6	45
2016~~[d]~~[c]	47	12	12	59
2017~~[e]~~[d]	50	7	5	55
2018[e]	47	21	17	64
Mean annual number taken (landed + struck and lost mortality)				~~52~~55

~~[a]George and Suydam (2014), Suydam et al. (2014) - A total mortality of 51 bowhead whales in 2013 is reported in Suydam et al. (2014), however, the number landed + the struck and lost mortality equals 52 whales;~~ [b]Suydam et al. (2015); ~~[c]~~[b]Suydam et al. (2016); ~~[d]~~[c]Suydam et al. (2017); ~~[e]~~[d]Suydam et al. (2018); [e]Suydam et al. (2019).

Other Mortality

Pelagic commercial whaling for bowhead whales was conducted from 1849 to 1914 in the Bering, Chukchi, and Beaufort seas (Bockstoce et al. 2007). During the first two decades of the fishery (1850-1870), over 60% of the estimated pre-whaling population was killed, and effort remained high into the 20th century (Braham 1984). Woodby and Botkin (1993) estimated that the pelagic whaling industry harvested 18,684 whales from this stock. From 1848 to 1919, shore-based whaling operations (including landings as well as struck and lost estimates from the U.S., Canada, and Russia) took an additional 1,527 whales (Woodby and Botkin 1993). An unknown percentage of the whales taken by the shore-based operations were harvested for subsistence ~~and not commercial~~ purposes. Historical harvest estimates likely underestimate the actual harvest as a result of under-reporting of the Soviet catches (Yablokov 1994) and incomplete reporting of struck and lost whales.

Transient killer whales are known to prey on bowhead whales. In a study of marks on bowhead whales taken in the subsistence harvest between spring 1976 and fall 1992, 4.1% to 7.9% had scars indicating that they had survived attacks by killer whales (George et al. 1994). Of 377 complete records for killer whale scars collected from 1990 to 2012, 29 whales (7.9%) had scarring "rake marks" consistent with killer whale injuries and another 10 had possible injuries (George et al. 2017). A higher rate of killer whale rake mark scars occurred from 2002 to 2012 than in the previous decade. George et al. (2017) noted this may be due to better reporting and/or sampling bias, an increase in killer whale population size, an increase in occurrence of killer whales at high latitudes (Clarke et al. 2013), or a longer open water period offering more opportunities to attack bowhead whales. The Aerial Surveys of Arctic Marine Mammals (ASAMM) project photo-documented bowhead whale carcasses that had injuries consistent with killer whale predation in 2012 (two carcasses), 2013 (two), 2015 (two), 2016 (three), and 2017 (one) and three of these carcasses (one each in 2013, 2015, and 2017) were likely calves or yearlings (Willoughby et al. 2018).

With increasing ship traffic and oil and gas exploration and development activities in the Chukchi and Beaufort seas, ship strikes may pose a greater risk to bowhead whales~~ may become increasingly at risk from ship strikes~~. Currently, ship-strike injuries on bowhead whales in Alaska ~~appear~~are thought to be uncommon (George et al. 2017, 2019). Only 10 whales harvested between 1990 and 2012 (approximately 2% of the records examined) showed clear evidence of scarring from ship propellers~~ injuries~~, while only seven whales from the photo-identification catalogue from 1985 to 2011 (1% of the sample) had evidence of ship-inflicted scars.

STATUS OF STOCK

Based on currently available data, the minimum estimated mean annual mortality and serious injury rate incidental to U.S. commercial fisheries (0.2 whales) is not known to exceed 10% of the PBR (10% of PBR = 16) and, therefore, can be considered insignificant and approaching a zero mortality and serious injury rate. The minimum estimated mean annual level of human-caused mortality and serious injury (~~53~~56 whales) is not known to exceed the PBR (161) nor the IWC annual maximum strike limit (67 + up to 15 previously unused strikes). The Western Arctic bowhead whale stock has been increasing; the estimate of 16,820 whales from 2011 is between 31% and 168% of the pre-exploitation abundance of 10,000 to 55,000 whales estimated by Brandon and Wade (2004, 2006). However, the stock is classified as a strategic stock because the bowhead whale is listed as endangered under the U.S. Endangered Species Act and is, therefore, also designated as depleted under the MMPA.

There are key uncertainties in the assessment of the Western Arctic stock of bowhead whales. Although there are few records of bowhead whales being killed or seriously injured incidental to commercial fishing, about 12.2% of harvested bowhead whales examined for scarring (59/485 records) had scars indicating line entanglement wounds (George et al. 2017) and the southern range of the population overlaps with commercial pot fisheries (Citta et al. 2014). The stock may be particularly sensitive to anthropogenic sound; under some circumstances, the stock changes either distribution or calling behavior in response to levels of anthropogenic sounds that are slightly above ambient (Blackwell et al. 2015). The reduction in sea ice may lead to increased predation of bowhead whales by killer whales.

HABITAT CONCERNS

Vessel traffic in arctic waters is increasing, largely due to an increase in commercial shipping facilitated by the lack of sea ice. This increase in vessel traffic could result in an increased number of vessel collisions with bowhead whales (Huntington et al. 2015). Oil and gas development in the Arctic imposes risks of various forms of pollution, including oil spills, in bowhead whale habitat, and the technology for effectively recovering spilled oil in icy conditions is lacking (Wilkinson et al. 2017).

Also of concern is noise produced by seismic surveys and vessel traffic resulting from shipping and offshore energy exploration, development, and production operations. Evidence indicates that bowhead whales are sensitive to noise from offshore drilling platforms and seismic survey operations (Richardson and Malme 1993, Richardson 1995, Davies 1997, Robertson et al. 2013, Blackwell et al. 2017). Bowhead whales often avoid sound sources associated with active drilling (Schick and Urban 2000) and seismic operations (Miller et al. 1999). Exposure to seismic operations resulted in subtle changes to dive, surfacing, and respiration behaviors (Robertson et al. 2013). Source levels, time of year, and whale behavior (migrating, feeding, etc.) all affect the extent of displacement or changes in behavior (e.g., Richardson et al. 1986, 1999; Ljungblad et al. 1988; Miller et al. 2005; Harris et al. 2007; MMS 2008; Funk et al. 2010) and impacts on bowhead calling rates (Greene et al. 1998~~,~~; Blackwell et al. 2013, 2015).

~~Climate change is resulting in warming of northern latitudes at about twice the rate of more temperate latitudes, increasing the immediacy of this threat for bowhead whales and other arctic species.~~ Global climate model projections for the next 50 to 100 years consistently show pronounced warming over the Arctic, accelerated sea-ice loss, and continued permafrost degradation (~~IPCC 2007,~~ USGS 2011, IPCC 2013, Jeffries et al. 2015). Within the Arctic, some of the largest changes are projected to occur in the Bering, Beaufort, and Chukchi seas (Chapman and

Walsh 2007, Walsh 2008). Ice-associated animals, including the bowhead whale, may be sensitive to changes in arctic weather, sea surface temperatures, sea-ice extent, and the concomitant effect on prey availability. Based on an analysis of various life-history features, Laidre et al. (2008) concluded that, on a worldwide basis, bowhead whales were likely to be moderately sensitive to climate change~~, based on an analysis of various life-history features that could be affected by climate~~. ~~Currently, there are insufficient data to make reliable projections of the effects of arctic climate change on bowhead whales.~~Using statistical models, Chambault et al. (2018) found that bowhead whales in Baffin Bay, Greenland, targeted a narrow range of temperatures (-0.5 to 2° C) and may be exposed to thermal stress as a result of warming temperatures. However, thermal stress resulting from increased sea surface temperatures has not been observed in the Western Arctic stock of bowhead whales. ~~George et al. (2006) showed that~~On the contrary, landed Western Arctic bowhead whales had better body condition during years of light ice cover (George et al. 2006). ~~Similarly, George et al. (2015) found an overall improvement in bowhead whale body condition and~~In addition, a positive correlation between body condition of Western Arctic bowhead whales and summer sea-ice loss has been observed over the last 2.5 decades in the Pacific Arctic (George et al. 2015). ~~George et al. (2015) speculated that sea-ice loss has positive effects on secondary trophic production in the short term within the Western Arctic bowhead whales' summer feeding region.~~Ice-free areas along the shelf break are thought to create increased upwelling and likely more feeding opportunities for foraging whales. The movement and foraging behavior of bowhead whales is becoming more variable as feeding areas are altered in response to retreating sea ice. Additionally, Hannay et al. (2013) found that a large fraction of bowhead whale acoustic detections in the northeast Chukchi Sea occurred just in advance of the progression of sea ice formation during the fall migration, suggesting that an increase in ice-free days may lead to a delayed migration out of the Chukchi Sea during fall. Sheffield and George (2013) presented evidence that the occurrence of fish has become more prevalent in the diets of Western Arctic bowhead whales near Utqiaġvik in the autumn~~ may be increasing~~. However, there are insufficient data to make reliable projections about whether arctic climate change will result in negative (thermal stress, habitat loss) or positive (prey abundance) effects on this population.

~~Another concern~~Ocean acidification, driven primarily by the production of carbon dioxide (CO_2) emissions into the atmosphere, is ~~the modification of habitat by ocean acidification, which may alter~~also a concern due to potential effects on prey~~ populations and other important aspects of the marine ecosystem~~. ~~Ocean acidification, a result of increased CO_2 in the atmosphere, may affect bowhead whale survival and recruitment b~~Because their primary prey are small crustaceans~~,~~ (especially calanoid copepods, euphausiids, gammarid and hyperid amphipods, and mysids ~~(Lowry et al. 2004),~~ that have exoskeletons composed of chitin and calcium carbonate), ~~which can be weakened by ocean acidification~~bowhead whale survival and recruitment may be impacted by increased ocean acidification (Lowry et al. 2004). The nature and timing of impacts to bowhead whales from ocean acidification are extremely uncertain and will depend partially on the whales' ability to switch to alternate prey species. Ecosystem responses may have very long lags as they propagate through trophic webs.

CITATIONS

Ashjian, C. J., S. R. Braund, R. G. Campbell, J. C. George, J. Kruse, W. Maslowski, S. E. Moore, C. R. Nicolson, S. R. Okkonen, B. F. Sherr, E. B. Sherr, and Y. H. Spitz. 2010. Climate variability, oceanography, bowhead whale distribution, and Iñupiat subsistence whaling near Barrow, Alaska. Arctic 63(2):179-194.

Bachmann, L., Ø. Wiig, M. P. Heide-Jørgensen, K. L. Laidre, L. D. Postma, L. Dueck, and P. J. Palsbøl. 2010. Genetic diversity in Eastern Canadian and Western Greenland bowhead whales (*Balaena mysticetus*). Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/62/BRG26). 6 p.

Blackwell S. B., C. S. Nations, T. L. McDonald, C. R. Greene, A. M. Thode, M. Guerra, and A. M. Macrander. 2013. Effects of airgun sounds on bowhead whale calling rates in the Alaskan Beaufort Sea. Mar. Mammal Sci. 29(4):E342-E365. DOI: dx.doi.org/10.1111/mms.12001 .

Blackwell S. B., C. S. Nations, T. L. McDonald, A. M. Thode, D. Mathias, K. H. Kim, C. R. Greene, Jr., and A. M. Macrander. 2015. Effects of airgun sounds on bowhead whale calling rates: evidence for two behavioral thresholds. PLoS ONE 10(6):e0125720. DOI: dx.doi.org/10.1371/journal.pone.0125720 .

Blackwell S. B., C. S. Nations, A. M. Thode, M. E. Kauffman, A. S. Conrad, R. G. Norman, and K. H. Kim. 2017. Effects of tones associated with drilling activities on bowhead whales calling rates. PLoS ONE 12(11):e0188459. DOI: dx.doi.org/10.1371/journal.pone.0188459 .

Bockstoce, J. R., and J. J. Burns. 1993. Commercial whaling in the North Pacific sector, p. 563-577. *In* J. J. Burns, J. J. Montague, and C. J. Cowles (eds.), The Bowhead Whale. Soc. Mar. Mammal., Spec. Publ. No. 2.

Bockstoce, J. R., D. B. Botkin, A. Philp, B. W. Collins, and J. C. George. 2007. The geographic distribution of bowhead whales (*Balaena mysticetus*) in the Bering, Chukchi, and Beaufort seas: evidence from whaleship records, 1849-1914. Mar. Fish. Rev. 67(3):1-43.

Boertmann, D., L. A. Kyhn, L. Witting, and M. P. Heide-Jorgensen. 2015. A hidden getaway for bowhead whales in the Greenland Sea. Polar Biol. 38(8):1315-1319. DOI: dx.doi.org/10.1007/s00300-015-1695-y .

Braham, H. W. 1984. The bowhead whale, *Balaena mysticetus*. Mar. Fish. Rev. 46(4):45-53.

Braham, H. W., M. A. Fraker, and B. D. Krogman. 1980. Spring migration of the Western Arctic population of bowhead whales. Mar. Fish. Rev. 42(9-10):36-46.

Brandon, J., and P. R. Wade. 2004. Assessment of the Bering-Chukchi-Beaufort Seas stock of bowhead whales. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/56/BRG20). 32 p.

Brandon, J., and P. R. Wade. 2006. Assessment of the Bering-Chukchi-Beaufort Seas stock of bowhead whales using Bayesian model averaging. J. Cetacean Res. Manage. 8(3):225-239.

Burns, J. J., J. J. Montague, and C. J. Cowles (eds.). 1993. The Bowhead Whale. Soc. Mar. Mammal., Spec. Publ. No. 2. 787 p.

Chambault, P., C. M. Albertsen, T. A. Patterson, R. G. Hansen, O. Tervo, K. L. Laidre, and M. P. Heide-Jørgensen. 2018. Sea surface temperature predicts the movements of an Arctic cetacean: the bowhead whale. Scientific Reports 8(1):9658. DOI: dx.doi.org/10.1038/s41598-018-27966-1 .

Chapman, W. L., and J. E. Walsh. 2007. Simulations of arctic temperature and pressure by global coupled models. J. Climate 20:609-632.

Citta, J. J., L. T. Quakenbush, J. C. George, R. J. Small, M P. Heide-Jørgensen, H. Brower, B. Adams, and L. Brower. 2012. Winter movements of bowhead whales (*Balaena mysticetus*) in the Bering Sea. Arctic 65(1):13-34.

Citta, J. J., J. J. Burns, L. T. Quakenbush, V. Vanek, J. C. George, R. J. Small, M. P. Heide-Jørgensen, and H. Brower. 2014. Potential for bowhead whale entanglement in cod and crab pot gear in the Bering Sea. Mar. Mammal Sci. 30(2):445-459. DOI: dx.doi.org/10.1111/mms.12047 .

Citta, J. J., L. T. Quakenbush, S. R. Okkonen, M. L. Druckenmiller, W. Maslowski, J. Clement-Kinney, J. C. George, H. Brower, R. J. Small, C. J. Ashjian, L. A. Harwood, and M. P. Heide-Jørgensen. 2015. Ecological characteristics of core-use areas used by Bering-Chukchi-Beaufort (BCB) bowhead whales, 2006-2012. Prog. Oceanogr. 136:201-222. DOI: dx.doi.org/10.1016/j.pocean.2014.08.012 .

Citta, J. J., S. R. Okkonen, L. T. Quakenbush, W. Maslowski, R. Osinski, J. C. George, R. J. Small, H. Brower, Jr., M. P. Heide-Jørgensen, and L. A. Harwood. ~~2017~~2018. Oceanographic characteristics associated with autumn movements of bowhead whales in the Chukchi Sea. Deep Sea Research II 152:121-131. DOI: dx.doi.org/10.1016/j.dsr2.2017.03.009 .

Clark, C. W., S. Mitchell, and R. Charif. 1994. Distribution and behavior of the bowhead whale, *Balaena mysticetus*, based on preliminary analysis of acoustic data collected during the 1993 spring migration off Point Barrow, Alaska. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/46/AS19). 24 p.

Clarke, J. T., and M. C. Ferguson. 2010. Aerial surveys for bowhead whales in the Alaskan Beaufort Sea: BWASP update 2000-2009 with comparisons to historical data. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/62/BRG14). 11 p.

Clarke, J., K. Stafford, S. E. Moore, B. Rone, L. Aerts, and J. Crance. 2013. Subarctic cetaceans in the southern Chukchi Sea: evidence of recovery or response to a changing ecosystem. Oceanography 26(4):136-149. DOI: dx.doi.org/10.5670/oceanog.2013.81 .

Clarke, J. T., M. C. Ferguson, C. Curtice, and J. Harrison. 2015. Biologically important areas for cetaceans within US waters - Arctic region. Aquat. Mamm. (Special Issue) 41(1):94-103.

Clarke, J. T., A. S. Kennedy, and M. C. Ferguson. 2016. Bowhead and gray whale distributions, sighting rates, and habitat associations in the eastern Chukchi Sea, summer and fall 2009-15, with a retrospective comparison to 1982-91. Arctic 69(4):359-377.

Clarke, J. T., A. A. Brower, M. C. Ferguson, and A. L. Willoughby. 2017. Distribution and relative abundance of marine mammals in the eastern Chukchi and western Beaufort seas, 2016. Annual Report, OCS Study BOEM 2017-078. Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.

Clarke, J. T., M. C. Ferguson, A. A. Brower, and A. L. Willoughby. 2018a. Bowhead whale calves in the western Beaufort Sea, 2012-2017. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/67b/AWMP3). 11 p.

Clarke, J. T., M. C. Ferguson, A. L. Willoughby, and A. A. Brower. 2018b. Bowhead and beluga whale distributions, sighting rates, and habitat associations in the western Beaufort Sea in summer and fall 2009-16, with comparison to 1982-91. Arctic 71(2):115-138.

Cosens, S. E., H. Cleator, and P. Richard. 2006. Numbers of bowhead whales (*Balaena mysticetus*) in the eastern Canadian Arctic, based on aerial surveys in August 2002, 2003 and 2004. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/58/BRG7). 19 p.

da Silva, C. Q., J. Zeh, D. Madigan, J. Laake, D. Rugh, L. Baraff, W. Koski, and G. Miller. 2000. Capture-recapture estimation of bowhead whale population size using photo-identification data. J. Cetacean Res. Manage. 2(1):45-61.

da Silva, C. Q., P. V. S. Gomes, and M. A. Stradioto. 2007. Bayesian estimation of survival and capture probabilities using logit link and photoidentification data. Comput. Stat. Data Anal. 51:6521-6534.

Davies, J. R. 1997. The impact of an offshore drilling platform on the fall migration path of bowhead whales: a GIS-based assessment. Unpubl. MS Thesis, Western Washington University, Bellingham, WA. 51 p.

~~Delean, B. J., V. T. Helker, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, J. Jannot, and N. C. Young. 2020. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2013-2017. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-401, 86 p.~~

Doniol-Valcroze, T., J. -F. Gosselin, D. Pike, J. Lawson, N. Asselin, K. Hedges, and S. Ferguson. 2015. Abundance estimate of the Eastern Canada – West Greenland bowhead whale population based on the 2013 High Arctic Cetacean Survey. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/058. v + 27 p.

Dueck, L. P., M. P. Heide-Jørgensen, M. V. Jensen, and L. D. Postma. 2006. Update on investigations of bowhead whale (*Balaena mysticetus*) movements in the eastern Arctic, 2003-2005, based on satellite-linked telemetry. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/58/BRG5). 17 p.

Druckenmiller, M. L., J. J. Citta, M. C. Ferguson, J. T. Clarke, J. C. George., and L. Quakenbush. 2018. Trends in sea-ice cover within bowhead whale habitats in the Pacific Arctic. Deep Sea Research II 152:95-107. DOI: dx.doi.org/10.1016/j.dsr2.2017.10.017 .

Fish, F. E., K. T. Goetz, D. J. Rugh, and L. Vate Brattström. 2013. Hydrodynamic patterns associated with echelon formation swimming by feeding bowhead whales (*Balaena mysticetus*). Mar. Mammal Sci. 29(4):E498-E507. DOI: dx.doi.org/10.1111/mms.12004 .

Frasier, T. R., S. D. Petersen, L. Postma, L. Johnson, M P. Heide-Jørgensen, and S. H. Ferguson. 2015. Abundance estimates of the Eastern Canada-West Greenland bowhead whale (*Balaena mysticetus*) population based on genetic capture-mark-recapture analyses. DFO Can. Sci. Advis. Sec. Res. Doc. 2015/008. iv + 21 p.

Funk, D. W., R. Rodrigues, D. S. Ireland, and W. R. Koski. 2010. Summary and assessment of potential effects on marine mammals, Chapter 11. *In* D. W. Funk, D. S. Ireland, R. Rodrigues, and W. R. Koski (eds.), Joint monitoring program in the Chukchi and Beaufort seas, open water seasons, 2006–2008. LGL Alaska Report P1050-2, Report from LGL Alaska Research Associates, Inc., LGL, Ltd., Greeneridge Sciences, Inc., and JASCO Research, Ltd., for Shell Offshore, Inc., and Other Industry Contributors, and National Marine Fisheries Service, U.S. Fish and Wildlife Service. 506 p. + appendices.

George, J. C., and R. S. Suydam. 2014. Update on characteristics of bowhead whale (*Balaena mysticetus*) calves. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/65b/BRG20Rev). 7 p.

George, J. C., L. Philo, K. Hazard, D. Withrow, G. Carroll, and R. Suydam. 1994. Frequency of killer whale (*Orcinus orca*) attacks and ship collisions based on scarring on bowhead whales (*Balaena mysticetus*) of the Bering-Chukchi-Beaufort Seas stock. Arctic 47(3):247-55.

George, J. C., J. Zeh, R. Suydam, and C. Clark. 2004. Abundance and population trend (1978-2001) of Western Arctic bowhead whales surveyed near Barrow, Alaska. Mar. Mammal Sci. 20:755-773.

George, J. C., C. Nicolson, S. Drobot, J. Maslanik, and R. Suydam. 2006. Sea ice density and bowhead whale body condition preliminary findings. Poster presented to the Society for Marine Mammalogy, San Diego, CA.

George, J. C., M. L. Druckenmiller, K. L. Laidre, R. Suydam, and B. Person. 2015. Bowhead whale body condition and links to summer sea ice and upwelling in the Beaufort Sea. Prog. Oceanogr. 136:250-262.

George, J. C., G. Sheffield, D. J. Reed, B. Tudor, R. Stimmelmayr, B. T. Person, T. Sformo, and R. Suydam. 2017. Frequency of injuries from line entanglements, killer whales, and ship strikes on Bering-Chukchi-Beaufort Sea bowhead whales. Arctic 70(1):37-46. DOI: dx.doi.org/10.14430/arctic4631 .

George, J. C., B. Tudor, G. H. Givens, J. Mocklin, and L. Vate Brattström. 2019. Entanglement-scar acquisition rates and scar frequency for Bering-Chukchi-Beaufort Seas bowhead whales using aerial photography. Mar. Mammal Sci. 35(4):1304-1321. DOI: dx.doi.org/10.1111/mms.12597 .

Givens, G. H., S. L. Edmondson, J. C. George, R. Suydam, R. A. Charif, A. Rahaman, D. Hawthorne, B. Tudor, R. A. DeLong, and C. W. Clark. 2013. Estimate of 2011 abundance of the Bering-Chukchi-Beaufort Seas bowhead whale population. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/65a/BRG1). 30 p.

Givens, G. H., S. L. Edmondson, J. C. George, R. Suydam, R. A. Charif, A. Rahaman, D. Hawthorne, B. Tudor, R. A. DeLong, and C. W. Clark. 2016. Horvitz-Thompson whale abundance estimation adjusting for uncertain recapture, temporal availability variation, and intermittent effort. Environmetrics 27:134-146. DOI: dx.doi.org/10.1002/env.2379 .

Givens, G. H., J. A. Mocklin, L. Vate Brattström, B. J. Tudor, W. R. Koski, J. E. Zeh, R. Suydam, and J. C. George. 2018. Adult sSurvival rate and 2011 abundance of Bering-Chukchi-Beaufort Seas bowhead whales from photo-identification data over three decades. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/67b/AWMP/01 Rev1). 24 p.

Greene, C. R., Jr., W. J. Richardson, and N. S. Altman. 1998. Bowhead whale call detection rates versus distance from airguns operating in the Alaskan Beaufort Sea during fall migration, 1996. J. Acoust. Soc. Am. 104:1826. DOI: dx.doi.org/10.1121/1.423473 .

Hannay, D. E., J. Delarue, X. Mouy, B. S. Martin, D. Leary, J. N. Oswald, and J. Vallarta. 2013. Marine mammal acoustic detections in the northeastern Chukchi Sea, September 2007–July 2011. Continental Shelf Research 67:127-46. DOI: dx.doi.org/10.1016/j.csr.2013.07.009 .

Harris, R. E., T. Elliot, and R. A. Davis. 2007. Results of mitigation and monitoring program, Beaufort Span 2-D marine seismic program, open water season 2006. LGL, Ltd., LGL Report TA4319-1, Report from LGL, Ltd., King City, Ont., for GX Technol., Houston, TX. 48 p.

Harwood, L. A., L. T. Quakenbush, R. J. Small, C. J. George, J. Pokiak, C. Pokiak, M. P. Heide-Jørgensen, E. V. Lea, and H. Brower. 2017. Movements and inferred foraging by bowhead whales in the Canadian Beaufort Sea during August and September, 2006–12. Arctic 70(2):161-76. DOI: dx.doi.org/10.14430/arctic4648 .

Heide-Jørgensen, M. P., K. L. Laidre, M. V. Jensen, L. Dueck, and L. D. Postma. 2006. Dissolving stock discreteness with satellite tracking: bowhead whales in Baffin Bay. Mar. Mammal Sci. 22:34-45.

Heide-Jørgensen, M. P., K. L. Laidre, Ø. Wiig, and L. Dueck. 2010. Large scale sexual segregation of bowhead whales. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/62/BRG23). 13 p.

Huntington, H. P., R. Daniel, A. Hartsig, K. Harun, M. Heiman, R. Meehan, G. Noongwook, L. Pearson, M. Prior-Parks, M. Robards, and G. Stetson. 2015. Vessels, risks, and rules: planning for safe shipping in Bering Strait. Marine Policy 51:119-127.

Ilyashenko, V., and K. Zharikov. 2014. Aboriginal harvest of gray and bowhead whales in the Russian federation in 2013. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/65b/BRG3). 1 p.

Ilyashenko, V., and K. Zharikov. 2017. Aboriginal subsistence whaling in the Russian federation in 2016. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/67a/AWMP03). 2 p.

Intergovernmental Panel on Climate Change (IPCC). 2007. Summary for policymakers. *In* S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K. B. Averyt, M. Tignor, and H. L. Miller (eds.), Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the IPCC. Cambridge University Press, Cambridge, UK and New York, NY. Available online: https://www.ipcc.ch/report/ar4/wg1/. Accessed December 2019.

Intergovernmental Panel on Climate Change (IPCC). 2013. Summary for policymakers. *In* T. Stocker, D. Qin, G. Plattner, M. Tignor, S. Allen, J. Boschung, A. Nauels, Y. Xia, V. Bex and P. Midgley (eds.), Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the IPCC. Cambridge University Press, Cambridge, UK, and New York, NY. Available online: https://www.ipcc.ch/site/assets/uploads/2018/02/WG1AR5_SPM_FINAL.pdf . Accessed August 2020.

International Whaling Commission (IWC). 2003. Report of the fourth workshop on the development of an Aboriginal Subsistence Whaling Management Procedure (AWMP). J. Cetacean Res. Manage. 5(Suppl.):489-497.

International Whaling Commission (IWC). 2008. Annex F: Report of the sub-committee on bowhead, right and gray whales. J. Cetacean Res. Manage. 10(Suppl.):150-166.

International Whaling Commission (IWC). 2010. Annex F: Report of the sub-committee on bowhead, right and gray whales. J. Cetacean Res. Manage. 11(Suppl. 2):154-179.

International Whaling Commission (IWC). 2011. Annex F: Report of the sub-committee on bowhead, right and gray whales. J. Cetacean Res. Manage. 12(Suppl.):168-184.

International Whaling Commission (IWC). 2018. Report of the Scientific Committee. Unpubl. doc. IWC/67/Rep01. Available online: www.iwc.int . Accessed December 2019August 2020.

Jeffries, M. O., J. Richter-Menge, and J. E. Overland (eds.). 2015. Arctic report card 2015. Available online: http://www.arctic.noaa.gov/reportcard . Accessed December 2019August 2020.

Koski, W., J. Zeh, J. Mocklin, A. R. Davis, D. J. Rugh, J. C. George, and R. Suydam. 2010. Abundance of Bering-Chukchi-Beaufort bowhead whales (*Balaena mysticetus*) in 2004 estimated from photo-identification data. J. Cetacean Res. Manage. 11(2):89-99.

Krogman, B., D. Rugh, R. Sonntag, J. Zeh, and D. Ko. 1989. Ice-based census of bowhead whales migrating past Point Barrow, Alaska, 1978-1983. Mar. Mammal Sci. 5:116-138.

Laidre, K. L., I. Stirling, L. Lowry, Ø. Wiig, M. P. Heide-Jørgensen, and S. Ferguson. 2008. Quantifying the sensitivity of arctic marine mammals to climate-induced habitat change. Ecol. Appl. 18(2)Suppl.:S97-S125.

Ljungblad, D. K., B. Würsig, S. L. Swartz, and J. M. Keene. 1988. Observations on the behavioral responses of bowhead whales (*Balaena mysticetus*) to active geophysical vessels in the Alaskan Beaufort Sea. Arctic 41(3):183-194.

Lowry, L. F., G. Sheffield, and J. C. George. 2004. Bowhead whale feeding in the Alaskan Beaufort Sea, based on stomach contents analyses. J. Cetacean Res. Manage. 6(3):215-223.

Marquette, W. M., and J. R. Bockstoce. 1980. Historical shore-based catch of bowhead whales in the Bering, Chukchi, and Beaufort seas. Mar. Fish. Rev. 42(9-10):5-19.

Melnikov, V. V., and J. E. Zeh. 2007. Chukotka Peninsula counts and estimates of the number of migrating bowhead whales (*Balaena mysticetus*). J. Cetacean Res. Manage. 9(1):29-35.

Miller, G. W., R. E. Elliott, W. R. Koski, V. D. Moulton, and W. J. Richardson. 1999. Whales, p. 5-1 to 5-109. *In* W. J. Richardson (ed.), Marine mammal and acoustical monitoring of Western Geophysical's open-water seismic program in the Alaskan Beaufort Sea, 1998. LGL Report TA2230–3. Report from LGL Ltd., King City, Ont., and Greeneridge Sciences Inc., Santa Barbara, CA, for Western Geophysical, Houston, TX, and National Marine Fisheries Service, Anchorage, AK, and Silver Spring, MD. 390 p.

Miller, G. W., V. D. Moulton, R. A. Davis, M. Holst, P. Millman, A. MacGillivray, and D. Hannay. 2005. Monitoring seismic effects on marine mammals—southeastern Beaufort Sea, 2001-2002, p. 511-542. *In* S. L. Armsworthy, P. J. Cranford, and K. Lee (eds.), Offshore Oil and Gas Development Effects Monitoring/Approaches and Technologies. Battelle Press, Columbus, OH.

Minerals Management Service (MMS). 2008. Beaufort Sea and Chukchi Sea Planning Areas, Oil and Gas Lease Sales 209, 212, 217, and 221, Draft Environmental Impact Statement: U.S. Department of the Interior, Minerals Management Service, Alaska OCS Region, MMS 2008-0055, November 2008. Available online: http://www.boem.gov/uploadedFiles/BOEM/About_BOEM/BOEM_Regions/Alaska_Region/Environment/Environmental_Analysis/2008-055-vol2.pdfhttps://www.boem.gov/oil-gas-energy/leasing/beaufort-and-chukchi-sea-planning-areas-oil-and-gas-lease-sales-209-212-217 . Accessed December 2019August 2020.

Mocklin, J., J. C. George, M. Ferguson, L. Vate Brattström, V. Beaver, B. Rone, C. Christman, A. Brower, B. Shea, and C. Accardo. 2012. Aerial photography of bowhead whales near Barrow, Alaska, during the 2011 spring migration. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/64/BRG3). 9 p.

Moore, S. E., and R. R. Reeves. 1993. Distribution and movement, p. 313-386. *In* J. J. Burns, J. J. Montague, and C. J. Cowles (eds.), The Bowhead Whale. Soc. Mar. Mammal., Spec. Publ. No. 2.

National Marine Fisheries Service (NMFS). 2012. Process for distinguishing serious from non-serious injury of marine mammals. 42 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-policies-guidance-and-regulations . Accessed December 2019August 2020.

National Marine Fisheries Service (NMFS). 2016. Guidelines for preparing stock assessment reports pursuant to the 1994 amendments to the Marine Mammal Protection Act. 23 p. Available online: https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks . Accessed December 2019August 2020.

Okkonen, S. R., C. J. Ashjian, R. G. Campbell, J. Clarke, S. E. Moore, and K. D. Taylor. 2011. Satellite observations of circulation features associated with the Barrow area bowhead whale feeding hotspot. Remote Sens. Environ. 115:2168-2174.

Okkonen, S. R., J. T. Clarke, and R. A. Potter. 2018. Relationships among high river discharges, upwelling events, and bowhead whale (*Balaena mysticetus*) occurrence in the central Alaskan Beaufort Sea. Deep Sea Research II 152:195-202. DOI: dx.doi.org/10.1016/j.dsr2.2016.11.015 .

Philo, L. M., E. B. Shotts, and J. C. George. 1993. Morbidity and mortality, p. 275-312. *In* J. J. Burns, J. J. Montague, and C. J. Cowles (eds.), The Bowhead Whale. Soc. Mar. Mammal., Spec. Publ. No. 2.

Pomerleau, C., C. J. Matthews, C. Gobeil, G. A. Stern, S. H. Ferguson, and R. W. Macdonald. 2018. Mercury and stable isotope cycles in baleen plates are consistent with year-round feeding in two bowhead whale (*Balaena mysticetus*) populations. Polar Biol. 41(9):1881-93. DOI: dx.doi.org/10.1007/s00300-018-2329-y .

Postma, L. D., L. P. Dueck, M. P. Heide-Jørgensen, and S. E. Cosens. 2006. Molecular genetic support of a single population of bowhead whales (*Balaena mysticetus*) in Eastern Canadian Arctic and Western Greenland waters. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/58/BRG4). 15 p.

Quakenbush, L. T., and J. J. Citta. 2019. Satellite tracking of bowhead whales: habitat use, passive acoustics and environmental monitoring. Final Report. U.S. Department of the Interior, Bureau of Ocean Energy Management, Alaska Outer Continental Shelf Region, Anchorage, AK. OCS Study BOEM 2019-076. 60 p. + appendices. Available online: https://www.boem.gov/sites/default/files/documents/regions/alaska-ocs-region/environment/BOEM%202019-076.pdf . Accessed August 2020.

Quakenbush, L. T., R. J. Small, and J. J. Citta. 2010a. Satellite tracking of Western Arctic bowhead whales. Unpubl. report submitted to the Bureau of Ocean Energy Management, Regulation and Enforcement (BOEMRE 2010-033).

Quakenbush, L. T., J. J. Citta, J. C. George, R. J. Small, and M. P. Heide-Jørgensen. 2010b. Fall and winter movements of bowhead whales (*Balaena mysticetus*) in the Chukchi Sea and within a potential petroleum development area. Arctic 63(3):289-307.

Quakenbush, L., J. Citta, J. C. George, M. P. Heide-Jørgensen, H. Brower, L. Harwood, B. Adams, C. Pokiak, J. Pokiak, and E. Lea. 2018. Bering-Chukchi-Beaufort stock of bowhead whales: 2006-2017 satellite telemetry results with some observations on stock sub-structure. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/67B/AWMP/04). 25 p.

Raftery, A., and J. Zeh. 1998. Estimating bowhead whale population size and rate of increase from the 1993 census. J. Am. Stat. Assoc. 93:451-463.

Richardson, W. J. 1995. Documented disturbance reactions, p. 241-324. *In* W. J. Richardson, C. R. Greene, C. I. Malme, and D. H. Thomson (eds.), Marine Mammals and Noise. Academic Press, San Diego, CA.

Richardson, W. J., and C. I. Malme. 1993. Man-made noise and behavioral responses, p. 631-700. *In* J. J. Burns, J. J. Montague, and C. J. Cowles (eds.), The Bowhead Whale. Soc. Mar. Mammal., Spec. Publ. No. 2.

Richardson, W. J., B. Würsig, and C. R. Greene, Jr. 1986. Reactions of bowhead whales, *Balaena mysticetus*, to seismic exploration in the Canadian Beaufort Sea. J. Acoust. Soc. Am. 79(4):1117-1128.

Richardson, W. J., R. A. Davis, C. R. Evans, D. K. Ljungblad, and P. Norton. 1987. Summer distribution of bowhead whales, *Balaena mysticetus*, relative to oil industry activities in the Canadian Beaufort Sea, 1980-84. Arctic 40(2):93-104.

Richardson, W. J., G. W. Miller, and C. R. Greene, Jr. 1999. Displacement of migrating bowhead whales by sounds from seismic surveys in shallow waters of the Beaufort Sea. J. Acoust. Soc. Am. 106(4, Pt. 2):2281.

Robertson, F. C., W. R. Koski, T. A. Thomas, W. J. Richardson, B. Würsig, and A. W. Trites. 2013. Seismic operations have variable effects on dive-cycle behavior of bowhead whales in the Beaufort Sea. Endang. Species Res. 21:143-160. DOI: dx.doi.org/10.3354/esr00515 .

Rolland, R. M., K. M. Graham, R. Stimmelmayr, R. S. Suydam, and J. C. George. 2019. Chronic stress from fishing gear entanglement is recorded in baleen from a bowhead whale (*Balaena mysticetus*). Mar. Mammal Sci. 35(4):1625-1642. DOI: dx.doi.org/10.1111/mms.12596 .

Ross, W. G. 1993. Commercial whaling in the North Atlantic sector, p. 511-561. *In* J. J. Burns, J. J. Montague, and C. J. Cowles (eds.), The Bowhead Whale. Soc. Mar. Mammal., Spec. Publ. No. 2.

Rugh, D., D. DeMaster, A. Rooney, J. Breiwick, K. Shelden, and S. Moore. 2003. A review of bowhead whale (*Balaena mysticetus*) stock identity. J. Cetacean Res. Manage. 5(3):267-279.

Schick, R. S., and D. L. Urban. 2000. Spatial components of bowhead whale (*Balaena mysticetus*) distribution in the Alaskan Beaufort Sea. Can. J. Fish. Aquat. Sci. 57:2193-2200.

Schweder, T., D. Sadykova, D. Rugh, and W. Koski. 2009. Population estimates from aerial photographic surveys of naturally and variably marked bowhead whales. J. Agric. Biol. Environ. Stat. 15(1):1-19.

Sheffield, G., and J. C. George. 2013. Section V – North Slope Borough research: B - diet studies, p. 253-277. *In* K. E. W. Shelden and J. A. Mocklin (eds.), Bowhead Whale Feeding Ecology Study (BOWFEST) in the western Beaufort Sea. Final Report, OCS Study BOEM 2013-0114. Marine Mammal Laboratory, AFSC, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115. Available online: https://www.afsc.noaa.gov/nmml/PDF/BOWFEST-2013-Final-Report.pdf . Accessed ~~December 2019~~August 2020.

Sheffield, G., and Savoonga Whaling Captains Association. 2015. Bowhead whale entangled in commercial crab pot gear recovered near Saint Lawrence Island, Bering Strait. UAF Alaska Sea Grant, Marine Advisory Program, Report to the North Slope Borough Department of Wildlife Management, Barrow, AK. 8 p.

Shelden, K. E. W., and D. J. Rugh. 1995. The bowhead whale (*Balaena mysticetus*): status review. Mar. Fish. Rev. 57(3-4):1-20.

Shpak, O. V., I. G. Meschersky, A. N. Chichkina, D. M. Kuznetsova, A. Y. Paramonov, and V. V. Rozhnov. 2014. New data on the Okhotsk Sea bowhead whales. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/65b/BRG17). 5 p.

Smith, L. C., and S. R. Stephenson. 2013. New trans-Arctic shipping routes navigable by midcentury. Proc. Nat. Acad. Sci. 110(13):-4871-4872. DOI: dx.doi.org/10.1073/pnas.1214212110 .

Stoker, S. W., and I. I. Krupnik. 1993. Subsistence whaling, p. 579-629. *In* J. J. Burns, J. J. Montague, and C. J. Cowles (eds.), The Bowhead Whale. Soc. Mar. Mammal., Spec. Publ. No. 2.

Suydam, R., and J. C. George. 2012. Preliminary analysis of subsistence harvest data concerning bowhead whales (*Balaena mysticetus*) taken by Alaskan Natives, 1974 to 2011. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/64/AWMP8). 13 p.

Suydam, R. S., R. P. Angliss, J. C. George, S. R. Braund, and D. P. DeMaster. 1995. Revised data on the subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaska Eskimos, 1973-1993. Rep. Int. Whal. Comm. 45:335-338.

Suydam, R., J. C. George, B. Person, C. Hanns, and G. Sheffield. 2011. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2010. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/63/BRG2). 7 p.

Suydam, R., J. C. George, B. Person, C. Hanns, R. Stimmelmayr, L. Pierce, and G. Sheffield. 2012. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2011. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/64/BRG2). 8 p.

Suydam R., J. C. George, B. Person, C. Hanns, R. Stimmelmayr, L. Pierce, and G. Sheffield. 2013. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2012. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/65a/BRG19). 7 p.

Suydam, R., J. C. George, B. Person, C. Hanns, R. Stimmelmayr, L. Pierce, and G. Sheffield. 2014. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2013. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/65b/BRG8). 10 p.

Suydam, R., J. C. George, B. Person, D. Ramey, C. Hanns, R. Stimmelmayr, L. Pierce, and G. Sheffield. 2015. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2014. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/66a/BRG6). 9 p.

Suydam, R., J. C. George, B. Person, D. Ramey, R. Stimmelmayr, T. Sformo, L. Pierce, and G. Sheffield. 2016. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2015 and other aspects of bowhead biology and science. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/66b/BRG3). 10 p.

Suydam, R., J. C. George, B. Person, D. Ramey, R. Stimmelmayr, T. Sformo, L. Pierce, and G. Sheffield. 2017. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Eskimos during 2016. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/67a/AWMP02rev). 8 p.

Suydam, R., J. C. George, B. Person, R. Stimmelmayr, T. Sformo, L. Pierce, A. VonDuyke, L. de Sousa, and G. Sheffield. 2018. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Natives during 2017. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/67b/AWMP/05). 8 p.

Suydam, R., J. C. George, B. T. Person, R. Stimmelmayr, T. L. Sformo, L. Pierce, A. VonDuyke, L. de Sousa, R. Acker, G. Sheffield, and A. Baird. 2019. Subsistence harvest of bowhead whales (*Balaena mysticetus*) by Alaskan Natives during 2018. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/68a/AWS02). 10 p.

U.S. Geological Survey (USGS). 2011. An evaluation of the science needs to inform decisions on Outer Continental Shelf energy development in the Chukchi and Beaufort seas. L. Holland-Bartels and B. Pierce (eds.), Alaska: U.S. Geological Survey Circular 1370. 278 p.

Walsh, J. E. 2008. Climate of the arctic marine environment. Ecol. Appl. 18(2)Suppl.:S3-S22. DOI: dx.doi.org/10.1890/06-0503.1 .

Wiig, Ø., L. Bachmann, N. Øien, K. M. Kovacs, and C. Lydersen. 2009. Observations of bowhead whales (*Balaena mysticetus*) in the Svalbard area 1940-2008. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/61/BRG2). 5 p.

Wiig, Ø., L. Bachmann, M. P. Heide-Jørgensen, K. L. Laidre, L. D. Postma, L. Dueck, and P. J. Palsbøl. 2010. Within and between stock re-identification of bowhead whales in Eastern Canada and West Greenland. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/62/BRG25). 7 p.

Wiig, Ø., M. P. Heide-Jørgensen, C. Lindqvist, K. L. Laidre, P. J. Palsbøll, and L. Bachmann. 2011. Population estimates of mark and recaptured genotyped bowhead whales (*Balaena mysticetus*) in Disko Bay, West Greenland. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/63/BRG18). 4 p.

Wilkinson, J., C. J. Beegle-Krause, K.-U. Evers, N. Hughes, A. Lewis, M. Reed, and P. Wadhams. 2017. Oil spill response capabilities and technologies for ice-covered Arctic marine waters: A review of recent developments and established practices. Ambio 46(Suppl. 3):S423–S441. DOI: dx.doi.org/10.1007/s13280-017-0958-y .

Willoughby, A. L., J. T. Clarke, M. C. Ferguson, R. Stimmelmayr, and A. B. Brower. 2018. Bowhead whale carcasses in the eastern Chukchi and western Beaufort seas, 2009-2017. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/67b/AWMP2). 10 p.

Woodby, D. A., and D. B. Botkin. 1993. Stock sizes prior to commercial whaling, p. 387-407. *In* J. J. Burns, J. J. Montague, and C. J. Cowles (eds.), The Bowhead Whale. Soc. Mar. Mammal., Spec. Publ. No. 2.

Yablokov, A. V. 1994. Validity of whaling data. Nature 367:108.

Young, N. C., B. J. Delean, V. T. Helker, J. C. Freed, M. M. Muto, K. Savage, S. Teerlink, L. A. Jemison, K. Wilkinson, and J. Jannot. In press. Human-caused mortality and injury of NMFS-managed Alaska marine mammal stocks, 2014-2018. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-XXX.

Zeh, J. E., and A. E. Punt. ~~2004~~2005. Updated 1978-2001 abundance estimates and their correlations for the Bering-Chukchi-Beaufort Seas stock of bowhead whales. ~~Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/56/BRG1). 10 p.~~J. Cetacean Res. Manage. 7(2):169-175.

Zeh, J. E., C. W. Clark, J. C. George, D. E. Withrow, G. M. Carroll, and W. R. Koski. 1993. Current population size and dynamics, p. 409-489. *In* J. J. Burns, J. J. Montague, and C. J. Cowles (eds.), The Bowhead Whale. Soc. Mar. Mammal., Spec. Publ. No. 2.

Zharikov, K. 2018. Aboriginal subsistence whaling in the Russian Federation in 2017. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/67b/AWMP/WP/02). 2 p.

Zharikov, K. A., D. I. Litovka, and E. V. Vereshagin. 2019. Aboriginal subsistence whaling in the Russian Federation during 2018. Unpubl. doc. submitted to Int. Whal. Comm. Scientific Committee (SC/68a/ASW03). 3 p.

Appendix 1. Summary of substantial changes to the text and/or values in the ~~2019~~2020 stock assessments (last revised ~~12/30/2019~~8/14/2020). An 'X' indicates sections where the information presented has been updated since the ~~2018~~2019 stock assessments were released. Stock Assessment Reports for those stocks in boldface were updated in ~~2019~~2020.

Stock	Stock definition	Population size	PBR	Fishery mortality	Subsistence mortality	Status
Steller sea lion (Western U.S.)	X	X	X	X	X	X
Steller sea lion (Eastern U.S.)	~~X~~	~~X~~	~~X~~	~~X~~		~~X~~
Northern fur seal (Eastern Pacific)		X	X	X	X	X
Harbor seal (Aleutian Islands)	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~
Harbor seal (Pribilof Islands)	~~X~~	~~X~~	~~X~~		~~X~~	~~X~~
Harbor seal (Bristol Bay)	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~
Harbor seal (North Kodiak)	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~
Harbor seal (South Kodiak)	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~
Harbor seal (Prince William Sound)	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~
Harbor seal (Cook Inlet/Shelikof Strait)	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~
Harbor seal (Glacier Bay/Icy Strait)	~~X~~	~~X~~	~~X~~		~~X~~	~~X~~
Harbor seal (Lynn Canal/Stephens Passage)	~~X~~	~~X~~	~~X~~		~~X~~	~~X~~
Harbor seal (Sitka/Chatham Strait)	~~X~~	~~X~~	~~X~~		~~X~~	~~X~~
Harbor seal (Dixon/Cape Decision)	~~X~~	~~X~~	~~X~~		~~X~~	~~X~~
Harbor seal (Clarence Strait)	~~X~~	~~X~~	~~X~~		~~X~~	~~X~~
Spotted seal (~~Alaska~~Bering)	X	X	X	X	X	X
Bearded seal (~~Alaska~~Beringia)	X	X	X	X	X	X
Ringed seal (~~Alaska~~Arctic)	X	X	X	X	X	X
Ribbon seal ~~(Alaska)~~	X	X	X	X	X	X
Beluga whale (Beaufort Sea)	X	X	X	X	X	X
Beluga whale (Eastern Chukchi Sea)	X	X	X	X	X	X
Beluga whale (Eastern Bering Sea)	X	X	X	X	X	X
Beluga whale (Bristol Bay)	X	X	X	X	X	X
Beluga whale (Cook Inlet)	X	X	X	X	X	X
Narwhal (Unidentified)						
Killer whale (ENP Alaska Resident)						
Killer whale (ENP Northern Resident)	~~X~~	~~X~~	~~X~~	~~X~~		~~X~~
Killer whale (ENP Gulf of Alaska, Aleutian Islands, and Bering Sea Transient)	X		X	X	X	X
Killer whale (AT1 Transient)	X	X		X	X	~~X~~
Killer whale (West Coast Transient)	X	X	X	X	X	X
Pacific white-sided dolphin (North Pacific)						
Harbor porpoise (Southeast Alaska)	X	X	~~X~~	X		~~X~~
Harbor porpoise (Gulf of Alaska)	X	~~X~~		X		~~X~~
Harbor porpoise (Bering Sea)	X	X		X		X
Dall's porpoise (Alaska)						
Sperm whale (North Pacific)	~~X~~	~~X~~		X		X
Baird's beaked whale (Alaska)						
Cuvier's beaked whale (Alaska)						
Stejneger's beaked whale (Alaska)						
Humpback whale (Western North Pacific)				X	X	X
Humpback whale (Central North Pacific)	X			X	X	X
Fin whale (Northeast Pacific)	~~X~~	~~X~~		X		X
Minke whale (Alaska)						
North Pacific right whale (Eastern North Pacific)	X	X	X	X		
Bowhead whale (Western Arctic)	X	~~X~~	X	X	X	X

Appendix 2. Stock summary table (last revised ~~12/30/2019~~8/14/2020).~~ Stock Assessment Reports for those stocks in boldface were updated in 2019.~~ N/A indicates data are unknown. UNDET (undetermined) PBR indicates data are available to calculate a PBR level but a determination has been made that calculating a PBR level using those data is inappropriate (see Stock Assessment Report (SAR) for details). N_{EST} is the AFSC Marine Mammal Laboratory's best estimate of the size of the population; Strategic status: S = Strategic, NS = Not Strategic. NOTE: This summary table has been reformatted/revised to be consistent with the summary tables in the U.S. Pacific and Atlantic SARs.

Species	Stock name	SAR updated	N_{EST}	CV N_{EST}	N_{MIN}	R_{MAX}	F_R	PBR	Total annual mortality/ serious injury	Annual U.S. commercial fishery mortality/ serious injury	Annual Native subsistence mortality	Strategic status	SAR last revised	~~Year of l~~Last survey year(s) for estimating abundance	Comments
Steller sea lion	Western U.S.	Y	~~53,624[a]~~ 52,932		~~53,624~~ 52,932	0.12	0.1	~~322~~318	~~247~~255	~~36~~38	~~204~~209	S	2019	2018-2019	N_{EST} is best estimate of counts, which have not been corrected for animals at sea during abundance surveys.
Steller sea lion	Eastern U.S.	N	43,201[a]		43,201	0.12	1.0	2,592	112	24	11	NS	2019	2017	N_{EST} is best estimate of counts, which have not been corrected for animals at sea during abundance surveys.
Northern fur seal	Eastern Pacific	Y	~~620,660~~ 608,143	0.2	~~525,333~~ 514,738	0.086	0.5	~~11,295~~ 11,067	~~399~~387	~~2.2~~2.6	~~387~~373	S	2019	~~2016~~ 2014-2018	Survey years = Sea Lion Rock - 2014; St. Paul and St. George Is. – 2014, 2016, 2018; Bogoslav Is. - 2015
Harbor seal	Aleutian Islands	N	5,588		5,366	0.12	0.3	97	90	0.4	90	NS	2019	2018	
Harbor seal	Pribilof Islands	N	229[a]		229	0.12	0.5	7	0	0	0	NS	2019	2018	N_{EST} is best estimate of counts, which have not been corrected for animals at sea during abundance surveys.

Species	Stock name	SAR updated	N_{EST}	CV N_{EST}	N_{MIN}	R_{MAX}	F_R	PBR	Total annual mortality/ serious injury	Annual U.S. commercial fishery mortality/ serious injury	Annual Native subsistence mortality	Strategic status	SAR last revised	~~Year of l~~Last survey year(s) for estimating abundance	Comments
Harbor seal	Bristol Bay	N	44,781		38,254	0.12	0.7	1,607	20	3.8	15	NS	2019	2017	
Harbor seal	North Kodiak	N	8,677		7,609	0.12	0.5	228	38	0.3	37	NS	2019	2017	
Harbor seal	South Kodiak	N	26,448		22,351	0.12	0.7	939	127	1.2	126	NS	2019	2017	
Harbor seal	Prince William Sound	N	44,756		41,776	0.12	0.5	1,253	413	24	387	NS	2019	2015	
Harbor seal	Cook Inlet/Shelikof Strait	N	28,411		26,907	0.12	0.5	807	107	2.5	104	NS	2019	2018	
Harbor seal	Glacier Bay/Icy Strait	N	7,455		6,680	0.12	0.3	120	104	0	104	NS	2019	2017	
Harbor seal	Lynn Canal/Stephens Passage	N	13,388		11,867	0.12	0.3	214	50	0	50	NS	2019	2016	
Harbor seal	Sitka/Chatham Strait	N	13,289		11,883	0.12	0.5	356	77	0	77	NS	2019	2015	
Harbor seal	Dixon/Cape Decision	N	23,478		21,453	0.12	0.5	644	69	0	69	NS	2019	2015	
Harbor seal	Clarence Strait	N	27,659		24,854	0.12	0.5	746	40	0	40	NS	2019	2015	
Spotted seal	~~Alaska~~Bering	Y	461,625		423,237	0.12	~~0.5~~1.0	~~12,697~~ 25,394	~~329~~5,254	~~0.9~~1	~~328~~5,253	NS	2017	2012-2013	
Bearded seal	~~Alaska~~Beringia	Y	~~b~~		~~b~~	0.12	0.5	~~b~~	~~551~~6,709	~~1.6~~1.8	~~549~~6,707	S	2019	2012-2013	N_{EST}, N_{MIN}, and PBR have been calculated, however, important caveats exist; see SAR text for details.

Species	Stock name	SAR updated	N_{EST}	CV N_{EST}	N_{MIN}	R_{MAX}	F_R	PBR	Total annual mortality/ serious injury	Annual U.S. commercial fishery mortality/ serious injury	Annual Native subsistence mortality	Strategic status	SAR last revised	~~Year of l~~Last survey year(s) for estimating abundance	Comments
Ringed seal	~~Alaska~~Arctic	Y	[b]		[b]	0.12	0.5	[b]	~~700~~6,459	~~2.4~~5	~~697~~6,454	S	2019	2012-2013	N_{EST}, N_{MIN}, and PBR have been calculated, however, important caveats exist; see SAR text for details.
Ribbon seal	~~Alaska~~	Y	184,697		163,086	0.12	1.0	9,785	~~3.9~~163	~~1.1~~0.9	~~2.8~~162	NS	2018	2012-2013	
Beluga whale	Beaufort Sea	Y	39,258	0.229	N/A	0.04	1.0	UNDET	~~139~~102	0	~~139~~102	NS	2017	1992	
Beluga whale	Eastern Chukchi Sea	Y	~~20,752~~ 13,305	~~0.70~~ 0.51	~~12,194~~8,875	0.04	1.0	~~244~~178	~~67~~55	~~0.2~~0	~~67~~55	NS	2017	~~2012~~2017	
Beluga whale	Eastern Bering Sea	Y	~~6,994~~9,242	~~0.37~~ 0.12	~~N/A~~8,357	0.04	1.0	~~UNDET~~ 167	~~206~~198	~~0.2~~	~~206~~198	~~N~~S	2017	~~2000~~2017	
Beluga whale	Bristol Bay	Y	~~1,926~~2,040	~~0.25~~ 0.26	~~N/A~~1,645	~~0.048~~ 0.04	1.0	~~UNDET~~33	~~25~~18	~~0.2~~	~~25~~18	NS	2017	~~2005~~2016	
Beluga whale	Cook Inlet	Y	~~327~~ 279	~~0.06~~ 0.061	~~311~~ 267	0.04	0.1	[b]	0	0	0	S	2019	~~2016~~2014-2018	Survey years = 2014, 2016, and 2018. PBR has been calculated, however, important caveats exist; see SAR text for details.
Narwhal	Unidentified	N	N/A		N/A	0.04	0.5	N/A	0	0	0	NS	2016		
Killer whale	Eastern North Pacific Alaska Resident	N	2,347[e]	N/A	2,347	0.04	0.5	24	1	1	0	NS	2016	2012	N_{EST} is based on counts of individuals identified from photo-ID catalogues.
Killer whale	Eastern North Pacific Northern Resident (British Columbia)	N	302[e]	N/A	302	0.029	0.5	2.2	0.2	0	0	NS	2019	2018	N_{EST} is based on counts of individuals identified from photo-ID catalogues.

Species	Stock name	SAR updated	N_{EST}	CV N_{EST}	N_{MIN}	R_{MAX}	F_R	PBR	Total annual mortality/ serious injury	Annual U.S. commercial fishery mortality/ serious injury	Annual Native subsistence mortality	Strategic status	SAR last revised	~~Year of l~~Last survey year(s) for estimating abundance	Comments
Killer whale	Eastern North Pacific Gulf of Alaska, Aleutian Islands, and Bering Sea Transient	Y	587[e]	N/A	587	0.04	0.5	5.9	~~1~~0.8	~~1~~0.8	0	NS	2016	2012	N_{EST} is based on counts of individuals identified from photo-ID catalogues.
Killer whale	AT1 Transient	Y	7[e]	N/A	7	0.04	0.1	~~0.01~~	0	0	0	S	2019	~~2018~~2019	N_{EST} is based on counts of individuals identified from photo-ID catalogues. PBR has been calculated, however, important caveats exist; see SAR text for details.
Killer whale	West Coast Transient	Y	~~243[e]~~349	N/A	~~243~~349	0.04	0.5	~~2.4~~3.5	0.4	0.2	0	NS	2013	~~2009~~2018	N_{EST} is based on counts of individuals identified from photo-ID catalogues in an analysis of a subset of data from 1958 to 2018.
Pacific white-sided dolphin	North Pacific	N	26,880	N/A	N/A	0.04	0.5	UNDET	0	0	0	NS	2018	1990	
Harbor porpoise	Southeast Alaska	Y	~~[b]~~	~~[b]~~	~~[b]~~	0.04	0.5	~~[b]~~	34	34	0	S	2019	2010-2012	N_{EST}, N_{MIN}, and PBR have been calculated, however, important caveats exist; see SAR text for details.
Harbor porpoise	Gulf of Alaska	Y	31,046	0.21	N/A	0.04	0.5	UNDET	72	72	0	S	2019	1998	

Species	Stock name	SAR updated	N_{EST}	CV N_{EST}	N_{MIN}	R_{MAX}	F_R	PBR	Total annual mortality/ serious injury	Annual U.S. commercial fishery mortality/ serious injury	Annual Native subsistence mortality	Strategic status	SAR last revised	~~Year of l~~Last survey year(s) for estimating abundance	Comments
Harbor porpoise	Bering Sea	Y	~~48,215~~	~~0.22~~	N/A	0.04	0.5	UNDET	~~0.2~~0.4	~~0.2~~0	0	S	2019	~~1999~~2008	N_{EST} has been calculated, however, important caveats exist; see SAR text for details.
Dall's porpoise	Alaska	N	83,400	0.097	N/A	0.04	1.0	UNDET	38	38	0	NS	2018	1991	
Sperm whale	North Pacific	Y	~~b~~	~~b~~	~~b~~	0.04	0.1	~~b~~	~~4.9~~3.5	~~4.7~~3.3	0	S	2019	2015	N_{EST}, N_{MIN}, and PBR have been calculated, however, important caveats exist; see SAR text for details.
Baird's beaked whale	Alaska	N	N/A		N/A	0.04	0.5	N/A	0	0	0	NS	2013		
Cuvier's beaked whale	Alaska	N	N/A		N/A	0.04	0.5	N/A	0	0	0	NS	2013		
Stejneger's beaked whale	Alaska	N	N/A		N/A	0.04	0.5	N/A	0	0	0	NS	2013		
Humpback whale	Western North Pacific	Y	1,107	0.300	865	0.07	0.1	3.0	~~2.6~~2.8	~~0.7~~0.9	0	S	2019	2004-2006	
Humpback whale	Central North Pacific - entire stock	Y	10,103	0.300	7,891	0.07	0.3	83	~~25~~26	~~9.5~~9.8	0	S	2019	2004-2006	
Fin whale	Northeast Pacific	Y	~~b~~	~~b~~	~~b~~	0.04	0.1	~~b~~	~~0.4~~0.6	0	0	S	2019	2013	N_{EST}, N_{MIN}, and PBR have been calculated, however, important caveats exist; see SAR text for details.
Minke whale	Alaska	N	N/A		N/A	0.04	0.5	N/A	0	0	0	NS	2018		

Species	Stock name	SAR updated	N_{EST}	CV N_{EST}	N_{MIN}	R_{MAX}	F_R	PBR	Total annual mortality/ serious injury	Annual U.S. commercial fishery mortality/ serious injury	Annual Native subsistence mortality	Strategic status	SAR last revised	~~Year of l~~Last survey year(s) for estimating abundance	Comments
North Pacific right whale	Eastern North Pacific	Y	31	0.226	26	0.04	0.1	~~b~~	0	0	0	S	2019	~~2015~~2008	PBR has been calculated, however, important caveats exist; see SAR text for details.
Bowhead whale	Western Arctic	Y	16,820	0.052	16,100	0.04	0.5	161	~~53~~56	0.2	~~53~~56	S	2019	2011	

Appendix 3. Summary table for Alaska **Category 2** commercial fisheries (last updated 12/30/2019). Notice of continuing effect of list of fisheries.

Fishery (area, target species, and gear type)	Mngmt	Permits/Vessels[a]	Soak time	Landings per day	Sets per day	Season duration	Fishery trends (2012-2016)
AK Southeast salmon drift gillnet	State	474	20 min - 3 hrs; day/night	1	6 - 20	June 18 to Early Oct	# vessels stable but may vary with price of salmon; catch - high
AK Yakutat salmon set gillnet	State	168	continuous soak during opener; day/night	1	net picked every 2 - 4 hrs/day or continuous during peak	June 4 to mid-Oct	# sites fished stable; catch - variable
AK Prince William Sound salmon drift gillnet	State	537	15 min - 3 hrs; day/night	1 or 2	10 - 14	mid-May to end of Sept	# vessels stable; catch - stable
AK Cook Inlet salmon drift gillnet	State	569	15 min - 3 hrs or continuous; day only	1	6 - 18	June 25 to end of Aug	# vessels stable; catch - variable
AK Cook Inlet salmon set gillnet	State	736	continuous soak during opener, but net dry with low tide; upper CI - day/night lower CI - day only except during fishery extensions	1	upper CI - picked on slack tide lower CI - picked every 2 - 6 hrs/day	June 2 to mid-Sept	# sites fished stable; catch - up for sockeye and kings, down for pinks
AK Kodiak salmon set gillnet	State	188	continuous during opener; day only	1 or 2	picked 2 or more times	June 9 to end of Sept	# sites fished stable; catch - variable
AK Peninsula/Aleutian Islands salmon drift gillnet	State	162	2 -5 hrs; day/night	1	3 - 8	mid-June to mid-Sept	# vessels stable; catch up
AK Peninsula/Aleutian Islands salmon set gillnet	State	113	continuous during opener; day/night	1	every 2 hrs	June 18 to mid-Aug	# sites fished stable; catch - up since 90; down in 96
AK Bristol Bay salmon drift gillnet	State	1,862	continuous soaking of part of net while other parts picked; day/night	2	continuous	June 17 to end of Aug or mid-Sept	# vessels stable; catch - variable
AK Bristol Bay salmon set gillnet	State	979	continuous during opener, but net dry during low tide; day/night	1	2 or continuous	June 17 to end of Aug or mid-Sept	# sites fished stable; catch - variable
AK Bering Sea, Aleutian Islands flatfish trawl	Federal	32	near continuous, 3-4 hours; day/night	NA	~ 4 per day	Jan 20 to end of Dec	# of vessels stable; catch variable
AK Bering Sea, Aleutian Islands pollock trawl	Federal	102	near continuous, 3-4 hours; day/night	NA	~ 3 per day	Jan 20 to Nov 1	# of vessels stable; catch variable
AK Bering Sea, Aleutian Islands rockfish trawl	Federal	17	near continuous, 2-3 hours; day/night	NA	~ 3 per day	Jan 20 to end of Dec	# of vessels stable; catch variable
AK Bering Sea, Aleutian Islands Pacific cod longline	Federal	45	near continuous, 1-hours; day/night	1	~ 3 per day	Year-round	# of vessels stable; catch variable
AK Gulf of Alaska sablefish longline	Federal	295	near continuous, 2-3 hours; day/night	1	~ 3 per day	March-November	# of vessels stable; catch variable based on IFQ

[a]These numbers are from the 2019 List of Fisheries.

REFERENCES

National Marine Fisheries Service. 2019. List of Fisheries. Final Rule. U.S. Dep. Commer., NOAA 84 FR 22051. 23 p.

Appendix 4. Interaction table for Alaska **Category 2** commercial fisheries (last revised 12/30/2019). Notice of continuing effect of list of fisheries.

Fishery Name (area, target species, and gear type)	Mngmt	Permits/Vessels[a]	Observer data[b]	Species recorded as taken incidentally in this fishery (records dating back to 1988)	Data type
AK Southeast salmon drift gillnet	State	474	2012 - 2013	Steller sea lion, harbor seal, harbor porpoise, Dall's porpoise, Pacific white-sided dolphin, humpback whale, sea otter	logbook, observer, stranding data, self-reports
AK Yakutat salmon set gillnet	State	168	2007 - 2008	harbor seal, harbor porpoise (obs), humpback whale, gray whale (stranding)	logbook, observer, stranding
AK Prince William Sound salmon drift gillnet	State	537	1990 - 1991	Steller sea lion (obs), northern fur seal, harbor seal (obs), harbor porpoise (obs), Dall's porpoise, Pacific white-sided dolphin, sea otter	logbook, observer, stranding
AK Cook Inlet salmon drift gillnet	State	569	1999 - 2000	Steller sea lion, harbor seal, harbor porpoise, Dall's porpoise, Cook Inlet beluga whale (Note: observer program in 1999 and 2000 recorded one incidental mortality/serious injury of a harbor porpoise)	observer, logbook
AK Cook Inlet salmon set gillnet	State	736	1999 - 2000	harbor seal, harbor porpoise, Dall's porpoise, Cook Inlet beluga whale, humpback whale, Steller sea lion, sea otter (Note: observer program in 1999 and 2000 recorded one incidental mortality/serious injury of a harbor porpoise)	observer, logbook
AK Kodiak salmon set gillnet	State	188	2002, 2005	harbor seal, harbor porpoise, sea otter, Steller sea lion	observer, logbook
AK Peninsula/Aleutian Islands salmon drift gillnet	State	162	1990-1991	northern fur seal, harbor seal, harbor porpoise, Dall's porpoise (obs)	observer, logbook
AK Peninsula/Aleutian Islands salmon set gillnet	State	113	never observed	Steller sea lion, harbor porpoise, northern sea otter	logbook
AK Bristol Bay salmon drift gillnet	State	1,862	never observed	Steller sea lion, northern fur seal, harbor seal, spotted seal, Pacific white-sided dolphin, beluga whale, gray whale	logbook
AK Bristol Bay salmon set gillnet	State	979	never observed	northern fur seal, harbor seal, spotted seal, beluga whale, gray whale	logbook
AK Bering Sea, Aleutian Islands flatfish trawl	Federal	32	1976 - 2017	bearded seal, harbor porpoise (Bering Sea), harbor seal (Bering Sea), killer whale (Alaska Resident), killer whale (GOA, Aleutian Islands, and Bering Sea Transient), northern fur seal, spotted seal, ringed seal, ribbon seal, gray whale, Steller sea lion (Western U.S.), walrus, humpback whale	observer
AK Bering Sea, Aleutian Islands pollock trawl	Federal	102	1976 - 2017	Dall's porpoise, harbor seal, humpback whale (Central North Pacific), humpback whale (Western North Pacific), fin whale, killer whale (GOA, Aleutian Islands, and Bering Sea Transient), minke whale, ribbon seal, spotted seal, ringed seal, bearded seal, northern fur seal, Steller sea lion (Western U.S.), beluga whale	observer
AK Bering Sea, Aleutian Islands rockfish trawl	Federal	17	1976 - 2017	killer whale (Alaska Resident), killer whale (GOA, Aleutian Islands, and Bering Sea Transient)	observer
AK Bering Sea, Aleutian Islands Pacific cod longline	Federal	45	1976 - 2017	killer whale (Alaska Resident), killer whale (GOA, Aleutian Islands, and Bering Sea Transient), ribbon seal, northern fur seal, ringed seal, spotted seal, Steller sea lion (Western U.S.), Dall's porpoise	observer
AK Gulf of Alaska sablefish longline	Federal	295	2014	Steller sea lion, sperm whale	observer

[a]These numbers are from the 2019 List of Fisheries.
[b]Observer data indicates the years of observer data included in these reports.

Note: Only species with positive records of being taken incidentally in a fishery since 1988 (the first year of the Marine Mammal Protection Act interim exemption program) have been included in this table. A species' absence from this table does not necessarily mean it is not taken in a particular fishery. Rather, in most fisheries, only logbook or stranding data are available which resulted in many reports of unidentified or misidentified marine mammals. Observer program indicates most recent year of observer data included in these reports.

REFERENCES

Manly, B. F. J. 2006. Incidental catch and interactions of marine mammals and birds in the Cook Inlet salmon driftnet and setnet fisheries, 1999-2000. Final Report to NMFS Alaska Region. 98 p.

Manly, B. F. J. 2007. Incidental take and interactions of marine mammals and birds in the Kodiak Island salmon set gillnet fishery, 2002 and 2005. Final Report to NMFS Alaska Region. 221 p.

Manly, B. F. J. 2009. Incidental catch of marine mammals and birds in the Yakutat salmon set gillnet fishery, 2007 and 2008. Final report to NMFS Alaska Region. 96 p.

Manly, B. F. J. 2015. Incidental takes and interactions of marine mammals and birds in district 6, 7 and 8 of the Southeast Alaska salmon drift gillnet fishery, 2012 and 2013. Final Report to NMFS Alaska Region. 52 p.

Manly, B. F. J., A. S. Van Atten, K. J. Kuletz, and C. Nations. 2003. Incidental catch of marine mammals and birds in the Kodiak Island set gillnet fishery in 2002. Final report to NMFS Alaska Region. 91 p.

National Marine Fisheries Service. 2011. U.S. National Bycatch Report [W. A. Karp, L. L. Desfosse, S. G. Brooke, Editors]. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-117E, 508 p.

National Marine Fisheries Service. 2013. U.S. National Bycatch Report First Edition Update 1 [L. R. Benaka, C. Rilling, E. E. Seney, and H. Winarsoo, Editors]. U.S. Dep. Commer., 57 p.

National Marine Fisheries Service. 2016a. U.S. National Bycatch Report First Edition Update 2 [L. R. Benaka, D. Bullock, J. Davis, E. E. Seney, and H. Winarsoo, Editors]. U.S. Dep. Commer., 90 p.

National Marine Fisheries Service. 2016b. Protected Resource Division, Alaska Region Marine Mammal Stranding Database. Accessed 8/15/2016.

National Marine Fisheries Service. 2016c. Catch Accounting System. Accessed 8/24/2016.

National Marine Fisheries Service. 2019. List of Fisheries. Final Rule. U.S. Dep. Commer., NOAA 84 FR 22051. 23 p.

Perez, M. A. 2006. Analysis of marine mammal bycatch data from the trawl, longline, and pot groundfish fisheries of Alaska, 1998-2004, defined by geographic area, gear type, and target groundfish catch species. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-167, 194 p.

Appendix 5. Interaction table for Alaska **Category 3** commercial fisheries (last revised 12/30/2019). Notice of continuing effect of list of fisheries.

Fishery name (area, target species, and gear type)	Mngmt	Permits/Vessels[a]	Observer data[b]	Species recorded as taken incidentally in this fishery (records dating back to 1990)	Data type
AK Prince William Sound salmon set gillnet	State	29	1990-1991 only	Steller sea lion, harbor seal, sea otter	logbook
AK Kuskokwim, Yukon, Norton Sound, Kotzebue salmon gillnet	State	1,778	never observed	harbor porpoise	n/a
AK roe herring and food/bait herring gillnet	State	920	never observed	none documented	none
AK salmon purse seine (Prince William Sound, Chignik, Alaska Peninsula	State	936	never observed	harbor seal, gray whale (Eastern North Pacific)	logbook
AK salmon beach seine	State	31	never observed	none documented	none
AK roe herring and food/bait herring purse seine	State	356	never observed	none documented	none
AK roe herring and food/bait herring beach seine	State	10	never observed	none documented	none
AK Metlakatla salmon purse seine	Tribal	10	never observed	none documented	none
AK Cook Inlet salmon purse seine	State	83	never observed	humpback whale	stranding
AK Kodiak salmon purse seine	State	376	never observed	humpback whale	stranding
AK Southeast salmon purse seine	State	315	never observed	none documented	none
AK salmon troll	State	1,908	never observed	Steller sea lion (Western U.S.), Steller sea lion (Eastern U.S.)	logbook
AK Bering Sea, Aleutian Islands groundfish hand troll and dinglebar troll	Federal		never observed		
AK Gulf of Alaska groundfish hand troll and dinglebar troll	Federal		never observed		
AK state waters longline /setline (incl. sablefish, rockfish, lingcod, and misc. finfish)	State	464	never observed	none documented	none
AK Gulf of Alaska halibut longline	Federal	855	2017	none documented	observer
AK Gulf of Alaska Pacific cod longline	Federal	92	2017	Steller sea lion (Western U.S.)	observer
AK Bering Sea, Aleutian Islands Greenland turbot longline	Federal	4	2017	killer whale (Eastern North Pacific Resident), killer whale (Eastern North Pacific Transient), killer whale (Alaska Resident), killer whale (GOA, Aleutian Islands, and Bering Sea Transient)	observer
AK Bering Sea, Aleutian Islands sablefish longline	Federal	22	2017	none documented	observer
AK Bering Sea, Aleutian Islands halibut longline	State	127	2017	Steller sea lion	self-reports
AK octopus/squid longline	State	3	never observed	none documented	none
AK shrimp otter trawl and beam trawl	State	38	never observed	none documented	none
AK Gulf of Alaska flatfish trawl	Federal	36	2017	northern elephant seal, harbor seal	observer
AK Gulf of Alaska Pacific cod trawl	Federal	55	2017	Steller sea lion (Western U.S.), harbor seal	observer
AK Gulf of Alaska pollock trawl	Federal	67	2017	Steller sea lion (Western U.S.), fin whale, northern elephant seal, Dall's porpoise	observer
AK Gulf of Alaska rockfish trawl	Federal	43	2017	none documented	observer
AK Bering Sea, Aleutian Islands Atka mackerel trawl	Federal	13	2017	ribbon seal, Steller sea lion (Western U.S.), northern elephant seal	observer
AK Bering Sea, Aleutian Islands Pacific cod trawl	Federal	72	2017	harbor seal, Steller sea lion (Western U.S.), ringed seal, bearded seal	observer
AK State-managed waters of Prince William Sound groundfish trawl	State	2	never observed	none documented	none
AK Kodiak food/bait herring trawl	State	4	never observed	none documented	none
AK Bering Sea, Aleutian Islands Pacific cod pot	Federal	59	2017	possible harbor seal	observer
AK Bering Sea, Aleutian Islands crab pot	State	540	1998-current[c]	gray whale (Eastern North Pacific)	stranding
AK Gulf of Alaska crab pot	State	271	never observed	humpback whale	stranding
AK Gulf of Alaska Pacific cod pot	Federal	271	2017	harbor seal, gray whale (Eastern North Pacific)	observer, stranding
AK Southeast Alaska crab pot	State	375	never observed	humpback whale	stranding

Fishery name (area, target species, and gear type)	Mngmt	Permits/Vessels[a]	Observer data[b]	Species recorded as taken incidentally in this fishery (records dating back to 1990)	Data type
AK Southeast Alaska shrimp pot	State	99	never observed	humpback whale	stranding
AK octopus/squid pot	State	15	never observed	none documented	none
AK Bering Sea, Aleutian Islands sablefish pot	Federal	6	2017	humpback whale	observer
AK Gulf of Alaska sablefish pot	Federal		2017		
AK shrimp pot, except Southeast	State	141	never observed	none documented	none
AK halibut jig	State	71	never observed	none documented	none
AK Bering Sea, Aleutian Islands groundfish jig	Federal	2	never observed		
AK Gulf of Alaska groundfish jig	Federal	214	never observed		
AK herring spawn on kelp pound net	State	291	never observed	none documented	none
AK Southeast herring roe/food/bait pound net	State	2	never observed	none documented	none
AK scallop dredge	State	5	never observed	none documented	none
AK Dungeness crab (hand pick/dive)	State	2	never observed	none documented	none
AK herring spawn-on-kelp (hand pick/dive)	State	266	never observed	none documented	none
AK miscellaneous invertebrates (hand pick/dive)	State	214	never observed	none documented	none
AK commercial passenger fishing vessel	State	1,006	never observed	killer whale (stock unknown), Steller sea lion (Western U.S.), Steller sea lion (Eastern U.S.)	n/a
AK clam	State	130	never observed	none documented	none

[a]These numbers are from the 2019 List of Fisheries.

[b]Observer data indicates most recent year of observer data included in these reports. Prior to 2013, there were no observer data from vessels less than 60 feet in length, regardless of fishery. Also prior to 2013, there were no observer data for the halibut Individual Fishing Quota (IFQ) fishery, regardless of vessel size.

[c]While this fishery is observed, the program is not tailored to monitoring crab pot gear interactions with marine mammals as many such interactions are thought to more often occur during the times that the fishery is not tended or observed.

Note: Only species with positive records of being taken incidentally in a fishery since 1990 (the first year of the MMPA interim exemption logbook program) have been included in this table. A species' absence from this table does not necessarily mean it is not taken in a particular fishery. Rather, in most fisheries, only logbook or stranding data are available which resulted in many reports of unidentified or misidentified marine mammals.

REFERENCES

National Marine Fisheries Service. 2011. U.S. National Bycatch Report [W. A. Karp, L. L. Desfosse, S. G. Brooke, Editors]. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-F/SPO-117E, 508 p.

National Marine Fisheries Service. 2013. U.S. National Bycatch Report First Edition Update 1 [L. R. Benaka, C. Rilling, E. E. Seney, and H. Winarsoo, Editors]. U.S. Dep. Commer., 57 p.

National Marine Fisheries Service. 2016a. U.S. National Bycatch Report First Edition Update 2 [L. R. Benaka, D. Bullock, J. Davis, E. E. Seney, and H. Winarsoo, Editors]. U.S. Dep. Commer., 90 p.

National Marine Fisheries Service. 2016b. Protected Resource Division, Alaska Region Marine Mammal Stranding Database. Accessed 8/15/2016.

National Marine Fisheries Service. 2016c. Catch Accounting System. Accessed 8/24/2016.

National Marine Fisheries Service. 2019. List of Fisheries. Final Rule. U.S. Dep. Commer., NOAA 84 FR 22051. 23 p.

Perez, M. A. 2006. Analysis of marine mammal bycatch data from the trawl, longline, and pot groundfish fisheries of Alaska, 1998-2004, defined by geographic area, gear type, and target groundfish catch species. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-167, 194 p.

Powers, B., and D. Sigurdsson. 2016. Participation, effort, and harvest in the sport fish business/guide licensing and logbook programs, 2014. Alaska Department of Fish and Game, Fishery Data Series No. 16-02, Anchorage, AK.

Appendix ~~6~~3. Percent observer coverage in Alaska commercial fisheries 1990-~~2017~~2018 (last revised ~~12/30/2019~~8/14/2020).

Fishery name[a]	Method for calculating observer coverage[b]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Gulf of Alaska (GOA) groundfish trawl	% of observed biomass	55	38	41	37	33	44	37	33	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
GOA flatfish trawl	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	39.2	35.8	36.8	40.5	35.9	40.6	76.9	29.2	24.2	31	28	22	26	31	42	46	47	54	39	56	34
GOA Pacific cod trawl	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	20.6	16.4	13.5	20.3	23.2	27.0	82.5	21.4	22.8	25	24	38	31	41	25	10	12	13	13	11	25
GOA pollock trawl	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	37.5	31.7	27.5	17.6	26.0	31.4	96.1	24.2	26.5	27	34	43			27	15	14	23	27	19	21
GOA rockfish trawl	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	51.4	49.8	50.2	51.0	37.2	48.4	74.1	51.4	49.1	88	87	91			95	95	96	93	98	98	95
GOA longline	% of observed biomass	21	15	13	13	8	18	16	15	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
GOA Pacific cod longline	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.8	5.7	6.1	4.9	11.4	12.6	21.4	3.7	10.2	45	32	43	29	30	13	29	31	36	30	40	29
GOA halibut longline	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	51.3	47.1	51.1	43.0	41.4	9.6	36.4	6.5	2.8	N/A	N/A	N/A		2.3	0.6	4.2	11	9.4	9.5	4.6	6.4
GOA rockfish longline	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.0	1.4	0.2	1.3	4.9	2.5	0	0	3.1	N/A	N/A	83			0	0	3.2	10	6.7	12	0
GOA sablefish longline	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	16.9	14.0	15.2	12.4	13.7	9.4	37.7	10.4	11.2	37	35	38	15	14	14	14	19	20	14	12	9.8
GOA finfish pots	% of observed biomass	13	9	9	7	7	7	5	4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
GOA Pacific cod pot	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.7	5.7	7.0	5.8	7.0	4.0	40.6	3.8	2.9	14	18	13			9.6	8.4	8.7	14	8.3	2.9	8.8
Bering Sea/Aleutian Islands (BSAI) finfish pots	% of observed biomass	43	36	34	41	27	20	17	18	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Fishery name[a]	Method for calculating observer coverage[b]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
BSAI Pacific cod pot	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	14.6	16.2	8.5	14.7	12.1	12.4	33.1	14.4	12.4	30	23	29	21	20	19	18	21	27	21	13	21
BS sablefish pot	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	42.1	44.1	62.6	38.7	40.6	21.4	72.5	44.3	35.3	N/A	N/A	N/A			39	13	11	9	23	19	33
AI sablefish pot	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	100	50.3	68.2	60.6	69.4	47.5	51.2	64.4	18.7	N/A	N/A	N/A			40	0	0	86	88	33	55
BSAI groundfish trawl	% of observed biomass	74	53	63	66	64	67	66	64	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BSAI Atka mackerel trawl	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	65.0	77.2	86.3	82.4	98.3	95.4	96.6	97.8	96.7	94	100	99	100	99	100	99	100	100	98	100	100
BSAI flatfish trawl	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	59.4	66.3	64.5	57.6	58.4	63.9	68.2	68.3	67.8	72	100	100	99	99	100	100	100	100	99	100	100
BSAI Pacific cod trawl	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	55.3	50.6	51.7	57.8	47.4	49.9	75.1	52.8	46.8	52	56	64	66	60	68	80	80	72	68	68	73
BSAI pollock trawl	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	66.9	75.2	76.2	79.0	80.0	82.2	92.8	77.3	73.0	85	85	86	86	98	98	98	98	99	99	99	99
BSAI rockfish trawl	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	85.4	85.6	85.1	65.3	79.9	82.6	94.1	71.0	80.6	88	98	99	99	99	100	100	100	100	100	100	100
BSAI longline	% of observed biomass	80	54	35	30	27	28	29	33	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
BSAI Greenland turbot longline	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	31.6	30.8	52.8	33.5	37.3	40.9	39.3	33.7	36.2	64	74	74	59	59	57	52	56	52	60	56	62
BSAI Pacific cod longline	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	34.4	31.8	35.2	29.5	29.6	29.8	25.7	24.6	26.3	63	63	61	64	57	51	66	64	62	57	58	55
BSAI halibut longline	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	38.9	48.4	55.3	67.2	57.4	20.3	44.5	27.9	26.4	N/A	N/A	N/A		16	1.8	13	11	13	10	6.9	8.2
BSAI rockfish longline	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	41.5	21.4	53.0	26.9	36.0	74.9	37.9	36.3	46.8	88	N/A	100			34	49	100	70	53	0	83

Fishery name[a]	Method for calculating observer coverage[b]	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
BSAI sablefish longline	% of observed biomass	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	19.5	28.4	24.4	18.9	30.3	10.4	50.9	19.3	11.2	48	49	56			27	42	35	34	22	6.9	7.7
Prince William Sound salmon drift gillnet	% of estimated sets observed	4	5	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.
Prince William Sound salmon set gillnet	% of estimated sets observed	3	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.
Alaska Peninsula/Aleutian Islands salmon drift gillnet (South Unimak area only)	% of estimated sets observed	4	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.
Cook Inlet salmon drift gillnet	% of fishing days observed	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	1.6	3.6	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.
Cook Inlet salmon set gillnet	% of fishing days observed	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	0.16-1.1	0.34-2.7	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.
Kodiak Island salmon set gillnet	% of fishing days observed	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	6.0	not obs.	not obs.	4.9	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.
Yakutat salmon set gillnet	% of fishing days observed	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	5.3	7.6	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.
Southeast Alaska salmon drift gillnet (Districts 6, 7, and 8)	% of fishing days observed	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	not obs.	6.4	6.6	not obs.	not obs.	not obs.	not obs.	not obs.

[a]From 1990 to 1997, most federally-regulated commercial fisheries in Alaska were named using gear type and fishing location. In 2003, the naming convention changed to define fisheries based on gear type, fishing location, and target fish species. Bycatch data collected from 1998 to present are analyzed using these fishery definitions. The use of "N/A" for either pooled or separated fisheries indicates that we do not have effort data for a particular fishery for that year.

[b]Observer coverage in the groundfish fisheries (trawl, longline, and pots) was determined by the percentage of tons caught which were observed. Observer coverage in the groundfish fisheries is assigned according to vessel length; where vessels greater than 125 feet have 100% coverage, vessels 60-125 feet have 30% coverage, and vessels less than 60 feet are not observed. Observer coverage in the groundfish fisheries varies by statistical area; the pooled percent coverage for all areas is provided here. Observer coverage in the drift gillnet fisheries was calculated as the percentage of the estimated sets that were observed. Observer coverage in the set gillnet fishery was calculated as the percentage of estimated setnet hours (determined by number of permit holders and the available fishing time) that were observed.

REFERENCES

Breiwick, J. M. 2013. North Pacific marine mammal bycatch estimation methodology and results, 2007-2011. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-260, 40 p.

Manly, B. F. J. 2006. Incidental catch and interactions of marine mammals and birds in the Cook Inlet salmon driftnet and setnet fisheries, 1999-2000. Final Report to NMFS Alaska Region. 98 p.

Manly, B. F. J. 2007. Incidental take and interactions of marine mammals and birds in the Kodiak Island salmon set gillnet fishery, 2002 and 2005. Final Report to NMFS Alaska Region. 221 p.

Manly, B. F. J. 2009. Incidental catch of marine mammals and birds in the Yakutat salmon set gillnet fishery, 2007 and 2008. Final Report to NMFS Alaska Region. 96 p.

Manly, B. F. J. 2015. Incidental takes and interactions of marine mammals and birds in districts 6, 7, and 8 of the Southeast Alaska salmon drift gillnet fishery, 2012 and 2013. Final Report to NMFS Alaska Region. 52 p.

Perez, M. A. 2006. Analysis of marine mammal bycatch data from the trawl, longline, and pot groundfish fisheries of Alaska, 1998-2004, defined by geographic area, gear type, and target groundfish catch species. U.S. Dep. Commer., NOAA Tech. Memo. NMFS-AFSC-167, 194 p.

Perez, M. A. Unpubl. ms. Bycatch of marine mammals by the groundfish fisheries in the U.S. EEZ of Alaska, 2005. 67 p. Available from Marine Mammal Laboratory, AFSC, 7600 Sand Point Way NE, Seattle, WA 98115.

Wynne, K. M., D. Hicks, and N. Munro. 1991. 1990 salmon gillnet fisheries observer programs in Prince William Sound and South Unimak Alaska. Annual Report NMFS/NOAA Contract 50ABNF000036. 65 p. Available from NMFS Alaska Region, Office of Marine Mammals, P.O. Box 21668, Juneau, AK 99802.

Wynne, K. M., D. Hicks, and N. Munro. 1992. 1991 marine mammal observer program for the salmon driftnet fishery of Prince William Sound Alaska. Annual Report NMFS/NOAA Contract 50ABNF000036. 53 p. Available from NMFS Alaska Region, Office of Marine Mammals, P.O. Box 21668, Juneau, AK 99802.

Appendix 7. Self-reported fisheries information.

The Marine Mammal Exemption Program (MMEP) was initiated in mid-1989 as a result of the 1988 amendments to the Marine Mammal Protection Act (MMPA). The MMEP required fishers involved in Category I and II fisheries to register with NMFS and to complete annual logbooks detailing each day's fishing activity, including: date fished, hours fished, area fished, marine mammal species involved, injured and killed due to gear interactions, and marine mammal species harassed, injured and killed due to deterrence from gear or catch. If the marine mammal was deterred, the method of deterrence was required, as well as indication of its effectiveness. Fishers were also required to report whether there were any losses of catch or gear due to marine mammals. These logbooks were submitted to NMFS on an annual basis, as a prerequisite to renewing their registration. Fishers participating in Category III fisheries were not required to submit complete logbooks, but only to report mortalities of marine mammals incidental to fishing operations. Logbook data are available for part of 1989 and for the period covering 1990-1993. Logbook data received during the period covering part of 1994 and all of 1995 was not entered into the MMEP logbook database in order for NMFS personnel to focus their efforts on implementing the 1994 amendments to the MMPA. Thus, aside from a few scattered reports from the Alaska Region, self-reported fisheries information is not available for 1994 and 1995.

In 1994, the MMPA was amended again to implement a long-term regime for managing mammal interactions with commercial fisheries (the Marine Mammal Authorization Program, or MMAP). Logbooks are no longer required. Instead, vessel owners/operators in any commercial fishery (Category I, II, or III) are required to submit one-page pre-printed reports for all interactions resulting in an injury or mortality to a marine mammal. The report must include the owner/operator's name and address, vessel name and ID, where and when the interaction occurred, the fishery, species involved, and type of injury (if animal was released alive). These postage-paid report forms are mailed to all Category I and II fishery participants that have registered with NMFS, and must be completed and returned to NMFS within 48 hours of returning to port for trips in which a marine mammal injury or mortality occurred. This reporting requirement was implemented in April 1996. During 1996, only 5 mortality/injury reports were received by fishers participating in all of Alaska's commercial fisheries. This level of reporting was a drastic drop in the number of reports compared to the numbers of interactions reported in the annual logbooks. As a result, the Alaska Scientific Review Group (SRG) considers the MMAP reports unreliable and has recommended that NMFS not utilize the reports to estimate marine mammal mortality (see June 1998 Alaska SRG meeting minutes; DeMaster 1998). As of the stock assessment reports for 2006, these records are no longer used to estimate annual fishery-related mortalities.

Fishery	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**Minimum estimated mortality**
Steller sea lion (Western U.S. stock)																
Alaska Peninsula/Aleutian Islands salmon set gillnet	0	1	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.75
Bristol Bay salmon drift gillnet	0	4	2	8	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.5
Prince William Sound set gillnet	0	0	2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5
Alaska miscellaneous finfish set gillnet	0	1	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
Alaska halibut longline (state and federal waters)	0	0	0	0	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.2
Kodiak salmon set gillnet	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	2	2
Steller sea lion (Eastern U. S. stock)																
Southeast Alaska salmon drift gillnet	0	1	2	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.25
Northern fur seal (Eastern Pacific stock)																
Prince William Sound salmon drift gillnet	1	1	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5
Alaska Peninsula/Aleutian Islands salmon drift gillnet	2	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5
Bristol Bay salmon drift gillnet	5	0	49	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	13.5
Alaska misc. finfish pair trawl	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1
Harbor seal (Southeast Alaska stock)																
Southeast Alaska salmon drift gillnet	8	1	4	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	3.2
Yakutat salmon set gillnet	0	18	31	61	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	27.5

Fishery	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	Minimum estimated mortality
Harbor seal (Gulf of Alaska stock)																
Cook Inlet salmon set gillnet	6	0	1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.75
Prince William Sound set gillnet	0	0	0	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
Kodiak salmon set gillnet	3	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.75
Alaska salmon purse seine (except for Southeast)	0	0	0	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5
Alaska Peninsula/Aleutian Islands salmon drift gillnet	9	2	12	5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	7
Harbor seal (Bering Sea stock)																
Bristol Bay salmon drift gillnet	38	23	2	42	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	26.25
Bristol Bay salmon set gillnet	0	0	1	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5
AK misc. finfish pair trawl	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	1
Spotted seal (Alaska stock)																
Bristol Bay salmon drift gillnet	5	1	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.5
Beluga whale (Bristol Bay stock)																
Bristol Bay salmon drift gillnet	0	1	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
Bristol Bay salmon set gillnet	1	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
Pacific white-sided dolphin (North Pacific stock)																
Prince William Sound salmon drift gillnet	1	4	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1.25
Southeast Alaska salmon drift gillnet	0	0	1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.25
Bristol Bay salmon drift gillnet	3	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.75
Harbor porpoise (Southeast Alaska stock)																
Southeast Alaska salmon drift gillnet	2	2	7	2	N/A	N/A	2	N/A	1	N/A	N/A	N/A	N/A	N/A	N/A	2.7
Harbor porpoise (Gulf of Alaska stock)																
Cook Inlet salmon drift and set gillnet fisheries	3	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	0.8
AK Peninsula/Aleutian Island salmon drift gillnet	2	0	1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.75
Kodiak salmon set gillnet	8	4	2	1	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	N/A	N/A	N/A	3.2
Harbor porpoise (Bering Sea stock)																
AK Peninsula/Aleutian Island salmon set gillnet	0	0	2	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5
Bristol Bay salmon drift gillnet	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
Bristol Bay salmon set gillnet	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
AK Kuskokwim, Yukon, Norton Sound, Kotzebue salmon gillnet	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
Dall's porpoise (Alaska stock)																
Prince William Sound salmon drift gillnet	0	2	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5
Southeast Alaska salmon drift gillnet	6	6	4	6	N/A	N/A	N/A	1	N/A	1	N/A	1	N/A	?	N/A	3.6
Cook Inlet set and drift gillnet fisheries	1	0	1	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5
Eastern North Pacific gray whale																
Bristol Bay salmon drift and set gillnet fisheries	2	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.5
WA/OR/CA crab pot	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A	N/A	N/A	0.5
Humpback whale (Central North Pacific stock)																
Southeast Alaska salmon drift gillnet	0	0	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0
Southeast Alaska salmon purse seine	0	0	0	0	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.2

REFERENCES

DeMaster, D. P. 1998. Minutes from the sixth meeting of the Alaska Scientific Review Group, 21-23 October 1997, Seattle, Washington. 40 p. Available from Alaska Fisheries Science Center, NMFS, 7600 Sand Point Way NE, Seattle, WA 98115.