Alaska Marine Mammal
Stock Assessments, ~~2021~~2022

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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 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), 2018 (Muto et al. 2019), 2019 (Muto et al. 2020), ~~and~~ 2020 (Muto et al. 2021), and 2021 (Muto et al. in press). 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 new information for ~~19~~35 existing stocks (including all of the strategic stocks) in the Alaska Region ~~in 2020-2021~~for the 2022 Stock Assessment Report cycle and ~~revised~~updated information or developed new reports for 9 stocks contained in ~~5~~7 Stock Assessment Reports under NMFS' jurisdiction: 4 strategic stocks (~~Eastern Pacific northern fur seals, Cook Inlet beluga whales,~~ Southern Southeast Alaska Inland Waters harbor porpoise, Western North Pacific humpback whales, Mexico-North Pacific humpback whales, and Western Arctic bowhead whales) and ~~1~~5 non-strategic stocks (~~Alaska Dall's porpoise~~Eastern Bering Sea beluga whales, Eastern North Pacific Alaska Resident killer whales, Northern Southeast Alaska Inland Waters harbor porpoise, Yakutat/Southeast Alaska Offshore Waters harbor porpoise, and Hawai'i humpback whales). The Stock Assessment Reports for all of the Alaska stocks, however, are included in the final document to provide a complete reference. Those sections of each Stock Assessment Report containing substantial changes in ~~2021~~2022 are listed in Appendix 1. The authors solicit any new information or comments which would improve future Stock Assessment Reports.

In the 2022 Stock Assessment Reports, stock structure was revised for the Southeast Alaska harbor porpoise stock, which was split into three stocks in one report: the Northern Southeast Alaska Inland Waters, Southern Southeast Alaska Inland Waters, and Yakutat/Southeast Alaska Offshore Waters harbor porpoise stocks. Stock structure was also revised for all North Pacific humpback whale stocks. The three existing North Pacific humpback whale stocks (Central North Pacific and Western North Pacific stocks contained in the Alaska SAR and the CA/OR/WA stock contained in the Pacific SAR) were replaced by five stocks (Western North Pacific, Hawai'i, and Mexico-North Pacific stocks contained in the Alaska SAR and the Central America/Southern Mexico-CA/OR/WA and Mainland Mexico-CA/OR/WA stocks contained in the Pacific SAR).

New abundance estimates were calculated for the following Alaska stocks in the ~~2021~~2022 Stock Assessment Reports. For explanations of why estimates have changed, see the individual report for each stock:

- ~~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 Bogoslof Island in 2015 and 2019, is 626,618 northern fur seals. This is an increase from the previous estimate of 608,143.~~
- Eastern Bering Sea beluga whales: The updated best estimate of abundance, derived from a 2017 aerial line-transect survey and corrected for various biases, is 12,269 beluga whales. This is an increase from the 2000 estimate of 6,994, which was considered to be an underestimate. Other sources of potential negative bias may still affect the estimate for 2017 but additional information is necessary for further refinement.
- Eastern North Pacific Alaska Resident killer whales: The updated best estimate of abundance, derived from photo-identifications from 2005 to 2019, is 1,920 killer whales. This is considered an underestimate because

some of the pods have not been photo-identified since 2005-2012 and researchers continue to encounter new whales.

- Northern Southeast Alaska Inland Waters and Southern Southeast Alaska Inland Waters harbor porpoise: The updated best estimates of abundance (uncorrected for animals missed on the trackline), derived from a vessel survey in 2019, isare 1,3021,619 and 890 harbor porpoise, respectively. This estimate is not statistically different from the previous (uncorrected) estimate of 975 in 2010-2012. However, the estimates for both 2010-2012 and 2019 are for the inland waters of Southeast Alaska, which is only a portion of the range of this stock. A current estimate of abundance is not available for the Yakutat/Southeast Alaska Offshore Waters stock.
- Alaska Dall's porpoise: An abundance estimate for Dall's porpoise in the northwestern Gulf of Alaska, derived from a vessel survey in 2015, is 13,110 porpoise. However, this estimate is for only a small portion of the stock's range and is not considered a reliable estimate for the entire stock.
- Western North Pacific humpback whales: The best estimates of abundance for the stock (1,084) and the portion of the stock migrating to summering areas in U.S. waters (127) were derived from a reanalysis of the 2004-2006 SPLASH data (Wade 2021). Although these data are more than eight years old, the estimates are still considered valid minimum population estimates.
- Hawai'i humpback whales: The best estimate of abundance, 11,278, was derived from a species distribution model and represents the peak abundance of humpback whales around the main Hawaiian Islands during 2020., Because the estimate is derived from the model output for a specific one-month time period, this may under-represent the full abundance of whales that overwinter in the region because individual whales may not have a very long residence time in Hawai'i.
- Western Arctic bowhead whales: The updated best estimate of abundance, derived from ice-based counts in 2019, is 14,025 bowhead whales. This is a decrease from the previous estimate of 16,820; however, it is considered to be an underestimate and not a true decline in abundance due to the abnormal ice conditions and migration route during the 2019 survey

The U.S. Fish and Wildlife Service (USFWS) has management authority for polar bears, sea otters, and walruses. The stock assessments for these species are published separately by USFWS and are available online at https://www.fws.gov/library/collections/marine-mammal-stock-assessment-reports.

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, Donna Hauser, Nicole Kanayurak, Mike Miller, Greg O'Corry-Crowe (Co-Chair in 2019-20212022), Lorrie Rea, Megan Peterson Williams (Co-Chair in 2019-20212022), 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 is from a variety of sources. Where feasible, we have attempted to use only published material. When citing information contained in this document, authors are reminded to cite the original publications, when possible.

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*NMFS Stock Assessment Reports and Appendices revised in ~~2021~~2022 are in boldface.

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

~~**NOTE – April 2022: Following consultation with the Alaska Beluga Whale Committee, NMFS withdrew the final 2020 Eastern Bering Sea beluga whale Stock Assessment Report. It is replaced here with the most recently published final Stock Assessment Report for this stock, last revised in 2017.**~~

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 (i.e., Kotzebue Sound, Kasegaluk Lagoon), and Beaufort Sea (Mackenzie River Delta) (Hazard 1988;~~,~~ O'Corry-Crowe et al. ~~1997~~2018, 2021) (Fig. 1). Seasonal distribution is affected by ice cover, tidal conditions, access to prey, temperature, and human interaction (Frost and Lowry ~~1985~~1990). 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 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).

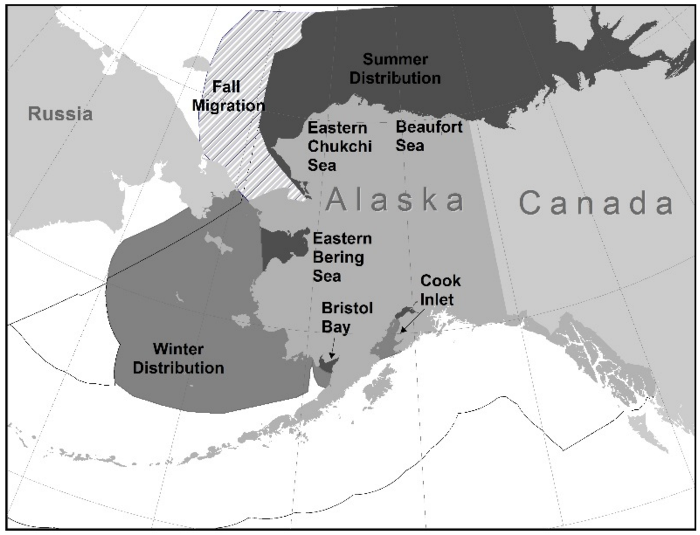

Figure 1. Approximate distribution for all five beluga whale stocks. Summering areas are dark gray, wintering areas are lighter gray, and the hashed area is a region used by the Eastern Chukchi Sea and Beaufort Sea stocks for autumn migration. The U.S. Exclusive Economic Zone is delineated by a black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

New genetic analyses have further defined six of the summering aggregations in the Bering, Chukchi, and Beaufort seas as follows: Bristol Bay, eastern Bering Sea (Norton Sound), Kotzebue Sound, Kasegaluk Lagoon/eastern Chukchi Sea, eastern Beaufort Sea (Mackenzie-Amundsen), and Gulf of Anadyr (Anadyr Bay) (O'Corry-Crowe et al. 2018, 2021). 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, 2021).

The Beaufort Sea and Eastern Chukchi Sea stocks of beluga whales migrate between the Bering, Chukchi, 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 before migrating back to the Chukchi Sea in the~~and~~ fall, returning to the Bering Sea in late fall (Hauser et al. 2014). 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 northern Chukchi and 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.

In general, 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 (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. A beluga tagged near Stebbins in May 2019 traveled north into the southern Chukchi Sea during November to mid-December, then back south into the Bering Sea where it swam west of St. Lawrence Island and continued south of Nunivak Island (ABWC unpubl. data).

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 summer (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 in Alaska (O'Corry-Crowe et al. 1997) and among stocks in Alaska and the Gulf of Anadyr (O'Corry-Crowe et al. 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)~~. The extent to which the beluga whales seen in Kotzebue Sound during summer may represent a separate stock is currently unclear and under review.

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 and yearlings). 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 multiple covariates distance-sampling ~~line-transect~~ model in a geographically stratified analysis. The resulting~~Results~~ estimate of beluga whales present at the surface in the study area was~~indicate~~ 3,497 beluga whales (coefficient of variation (CV) = 0.37) ~~were seen at the surface in the study area~~ (Lowry et al. 2017). Lowry et al. (2017) applied a correction factor for availability bias (Marsh and Sinclair 1989) of 2.0 (Reeves et al. 2011) ~~If this estimate were doubled~~ to correct for the proportion of whales that were diving~~,~~ and thus not visible at the surface, resulting in an estimate of ~~the~~ total abundance for the Eastern Bering Sea stock of~~would be~~ 6,994 beluga whales (95% CI: 3,162-15,472). The 2000 abundance estimate was likely an underestimate for the following reasons: 1) it did not include a correction factor for the probability of detecting belugas on the trackline (known as transect detection probability), 2) it did not account for dark-colored neonates and yearlings that were not seen, and 3) some beluga whales from this population could have been outside the study area (e.g., in the Yukon River) during the survey period.

In 2017, ABWC and NMFS collaborated on an aerial line-transect survey for beluga whales in the Norton Sound/Yukon River Delta region. To estimate the number of beluga whales present at the surface throughout the entire 2017 survey area, Ferguson et al. (in prep.) used a line transect analysis analogous to Lowry et al. (2017); the resulting estimate was 4,621 beluga whales (CV = 0.117, 95% CI: 3,635-5,873). As noted above, an additional four factors need to be taken into account to produce a total abundance estimate of the of Eastern Bering Sea stock of beluga whales: 1) availability bias (to correct for beluga whales not visible at the surface and not within the observers' field of view), 2) transect detection probability (to correct for beluga whales that are available to be seen but not detected), 3) lower detection probability of small or dark-colored individuals (to correct for such beluga whales that are not seen), and 4) survey area boundaries (to account for beluga whales that may have been outside the survey area).

To account for availability bias, Ferguson et al. (in prep.) calculated a correction factor of 2.0 based on: 1) beluga surface interval and dive interval data reported in Frost and Lowry (1995), and 2) an estimate of the amount of time that an aerial observer during the 2017 Eastern Bering Sea beluga survey had to detect a beluga within their field of view. Because aerial observers aboard the survey aircraft had an unobstructed field of view within the 180° arc on each side of the aircraft, Ferguson et al. (in prep) computed this time-in-view estimate based on the survey speed of the aircraft and the 95th percentile of perpendicular distances at which belugas were detected during the 2017 aerial line-transect surveys. The estimated time-in-view was 15.9 sec. Transect detection probability can be another large source of negative bias in aerial line-transect abundance estimates when it is incorrectly assumed to be equal to 1.0. This source of perception bias can be estimated using a double-platform set-up during surveys. However, data were not collected during the 2017 Eastern Bering Sea beluga whale aerial survey to estimate a correction factor for transect detection probability that was specific to the survey. Therefore, Ferguson et al. (in prep.) used imagery and marine mammal observer data collected during aerial line-transect surveys for marine mammals in the eastern Chukchi and western Beaufort seas during July through October 2018 (Clarke et al. 2019) and 2019 (Clarke et al. 2020) to estimate transect detection probability, resulting in a value of 0.753.

Applying an availability bias correction factor of 2.0 and a transect detection probability of 0.753 to the estimated 4,621 belugas at the surface results in a total abundance estimate for the Eastern Bering Sea beluga whale stock in 2017 of 12,269 (CV = 0.118) (Ferguson et al. in prep.). The estimated CV for the corrected abundance estimate is negatively biased (i.e., the uncertainty is underestimated) because the availability bias correction factor had no associated CV. Additional potential sources of negative bias that may still affect this estimate of Eastern Bering Sea beluga abundance in 2017 include: 1) the possibility that belugas from this stock may not have been present in the survey area during the survey period, and 2) lower detectability of small, dark gray belugas (neonates and yearlings), which are harder to detect than large white belugas.

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~~ 12,269 whales and an associated CV(N) of 0.118, N_{MIN} for ~~this~~the Eastern Bering Sea stock is ~~5,173~~ 11,112 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 ~~Norton Sound~~ the 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 comparable abundance estimates (that were not corrected for transect detection probability) from the surveys conducted in 2000 (6,994 beluga whales) and 2017 (9,242 beluga whales) were not statistically 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 specifically for the Eastern Bering Sea stock of beluga whales. The default value for the maximum theoretical net productivity rate for cetaceans is 4% (NMFS 2016). NMFS Guidelines suggest that, in general, substitution of other values for this default should be made with caution, and preferably when reliable stock-specific information is available on R_{MAX} (NMFS 2016). However, the Guidelines also state that for stocks subject to subsistence harvests, calculations of PBR will be determined from the analysis of scientific and other relevant information discussed during the co-management process. Co-management of the Eastern Bering Sea stock of beluga whales is conducted by the ABWC and NMFS. -Through the co-management process, ABWC and NMFS considered that the nearby Bristol Bay stock of beluga whales has similar environmental conditions and habitat to the Eastern Bering Sea stock, and has exhibited an ~~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 the~~a~~ 12-year period from 1993-2005 (Lowry et al. 2008). This 4.8% is not a theoretical R_{MAX}, but an actual realized value for the growth rate of the population at an intermediate density between zero and carrying capacity. For these reasons, NMFS considered 4.8% more appropriate than the default value, and therefore used an R_{MAX} of 4.8% for this stock. ~~However, until additional data become available specific to the Eastern Bering Sea stock, the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% will be used for this stock (Wade and Angliss 1997).~~

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 ($F_R$) used 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 267 beluga whales (11,112 × 0.024 × 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 2016 and 2020 is listed, by marine mammal stock, in ~~Helker et al. (2017)~~Freed et al. (2022); 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 2016 and 2020 is ~~206~~227 beluga whales (comprising intentional~~: 0.2 in U.S. commercial fisheries and 206~~ ~~in~~ subsistence takes by Alaska Natives and belugas incidentally taken in net fisheries – see below).~~; 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~~incidental 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 April 2022). ~~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 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 mortalities 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. In 2019, one dead beluga whale found entangled in an unknown fishing net was reported (Freed et al. 2022). 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 that all~~ Incidental beluga whale~~s~~ mortalities~~killed 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., Freed et al. 2022) as subsistence takes and are also 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 2016 and 2020 for this stock is estimated to be ~~0.2~~0.4 ~~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 has 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 April 2022).

Data on t~~T~~he subsistence take of Eastern Bering Sea beluga whales ~~from the Eastern Bering Sea stock~~ are collected annually from more than 20 Eastern Bering Sea villages and reported to NMFS ~~is provided~~ by the ABWC. The most recent subsistence harvest estimates for ~~the~~this stock are provided in Table ~~2~~1 ~~(ABWC, unpubl. data, 2016)~~. Beluga whales harvested in Kuskokwim villages are included in the total harvest for the Eastern Bering Sea beluga whale stock, but there are no genetics data indicating to what stock Kuskokwim belugas belong; those takes are included here for completeness. The annual subsistence take by Alaska Native ~~villages~~hunters between 2016 and 2020 averaged ~~206~~227 Eastern Bering Sea beluga whales landed, struck and lost, or caught incidentally in fisheries and subsequently used for subsistence purposes ~~from the Eastern Bering Sea stock in 2011-2015~~.

Table 21. Summary of Eastern Bering Sea beluga whales landed and struck and lost by Alaska Native subsistence hunters in 2011–2015between 2016 and 2020 (ABWC, unpubl. data, 20162021). These are minimum estimates of the total number of beluga whales taken, since struck and lost data are not consistently provided.

Year	Reported total nNumber landed	Number struck and lost	Total (landed + struck and lost)
2011	205		
2012	181		
2013	216		
2014	237		
2015	193		
2016	184	14*	198
2017	186	18*	204
2018	190	25	215
2019	225	21	246
2020	256	14*	270
Mean annual number landed	206208	18	227

* No data were reported for the number of struck and lost whales in Kuskokwim in 2016, 2017, and 2020.

STATUS OF STOCK

A minimum estimate of the mean annual mortality and serious injury rate incidental to U.S. commercial fisheries for the Eastern Bering Sea beluga stock of beluga whales between 2016 and 2020 is 0.20.4 whales. This figure is less than 10% of the PBR (10% of 267 = 26.7).. Because the PBR is undetermined, the mean annual U.S. commercial fishery-related mortality and serious injury rate that and, therefore, can be considered insignificant and approaching a zero mortality and serious injury rate is unknown. The totalminimum estimated mean annual level of human-caused mortality and serious injury 206(227 beluga whales) is less than the calculated PBR (267 beluga whales). The Eastern Bering Sea stock of beluga whales isare 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 not classified as a non-strategic stock.

There are some key uncertainties in the 2017 abundance estimateassessment of for the Eastern Bering Sea stock of beluga whales, including biases that warrant further attention as noted above. The abundance is based on a line-transect survey. The abundance estimate for this stock could be further refined with additional information about availability probability, transect detection probability, small/dark animal detection probability, and the uncertainties associated with these probabilities. The availability bias correction factor for aerial surveys is thought to range from 2 to 3 (Citta et al. 2021). Ferguson et al. (in prep.) derived an availability bias correction factor of 2.0 based on beluga surface and dive behavior from five belugas, but a more precise estimate of this correction factor and a reliable estimate of the associated CV are needed.; the resulting estimate is doubled to account for the proportion of whales that are diving and thus missed by the observers. It would be desirable to explore this key topic through field studies and analyses as soon as feasible. The estimate of transect detection probability that was used in the 2017 abundance estimate was derived from a similar aerial survey for cetaceans that was conducted in the eastern Chukchi and western Beaufort seas, where the surface waters are relatively clear. Vacquie-Garcia et al. (2020) found that the sightability of beluga whales is greatly reduced in turbid water like the nearshore habitat off the Yukon River Delta where the highest densities of belugas were found during the aerial survey in 2017. Therefore, the extent to which the water color and lack of clarity in this area affect transect detection probability requires further evaluation. Additionally, several studies have documented that large numbers of dark-colored neonates and young age classes of beluga whales are not seen in surveys (e.g., Brodie 1971, Richard et al. 1994, Kingsley and Gauthier 2002). Other analyses (e.g., Lowry et al. 1999) applied correction factors for the effects of beluga coloration on detectability; however, it is not known how or to what extent coloration or beluga size affected detectability during the 2017 surveys and the appropriate data needed to evaluate this issue do not exist. It is not known whether doubling the estimate accurately accounts for whales missed. The population rate of increase is unknown. Expanding the geographic area covered during the aerial surveys might also encompass a greater proportion of the habitat being used during the survey. For example, due to relatively high densities of belugas found at the southern boundary of the 2017 survey area and the lack of survey effort up the Yukon River where belugas are known to occur, it is possible that belugas from the Eastern Bering Sea stock were outside of the surveyed area at the time of the 2017 survey, resulting in a negative bias to the abundance estimate. Extending the boundary of future surveys farther south until beluga density diminishes considerably or gathering additional data from satellite telemetry or imagery could help address this question of stock range during the survey period. New analytical approaches (e.g., spatially explicit models) may offer improved methods for estimating abundance.

Beluga mortality associated with fisheries is also difficult to quantify. Coastal commercial fisheries that overlap with this stock have either never been observed or have not been observed recently. Therefore, ~~, so~~ mortality and serious injury of Eastern Bering Sea beluga whales in U.S. 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 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 (Hauser et al. 2017b, Bailleul et al. 2012). 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, Castellote et al. 2022). 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, diving behavior, and ~~winter~~summer-fall distribution may have occurred (Hauser et al. 2017a, 2018b). 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, commercial vessel activity, and increased nearshore development, has the potential to impact beluga whale habitat ~~for beluga whales~~ (Moore et al. 2000, Lowry et al. 2006, Halliday et al. 2019, Halliday et al. 2020, Hauser et al. 2018a)~~;~~. ~~h~~However, predicting the type and magnitude of these impacts is difficult.

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KILLER WHALE (*Orcinus orca*): Eastern North Pacific Alaska Resident Stock

NOTE – NMFS has ~~preliminary~~ genetic information on killer whales in Alaska ~~which~~that indicates ~~that~~ the current stock structure of killer whales in Alaska needs to be reassessed (Parsons et al. 2013). NMFS is evaluating th~~is~~e ~~new~~ genetic information, along with all other available data that inform stock structure (e.g., movements, tagging data, social association patterns, call types, etc.; see Martien et al. 2019). ~~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.~~Should the evaluation identify a different population structure than is currently reflected in the Alaska SARs, we will consider how best to revise stock designations in a future SAR following NMFS Procedure "Reviewing and Designating Stocks and Issuing Stock Assessment Reports under the Marine Mammal Protection Act" (NMFS 2019).

STOCK DEFINITION AND GEOGRAPHIC RANGE

Killer whales have been observed in all oceans and seas of the world (Leatherwood and Dahlheim 1978). Although reported occurring in~~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.~~ ~~and~~ ~~A~~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~~Killer whales from these areas have been labeled as "resident," "transient," ~~and~~ or "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 in photographs~~and pods~~, movements of whales and pods 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).

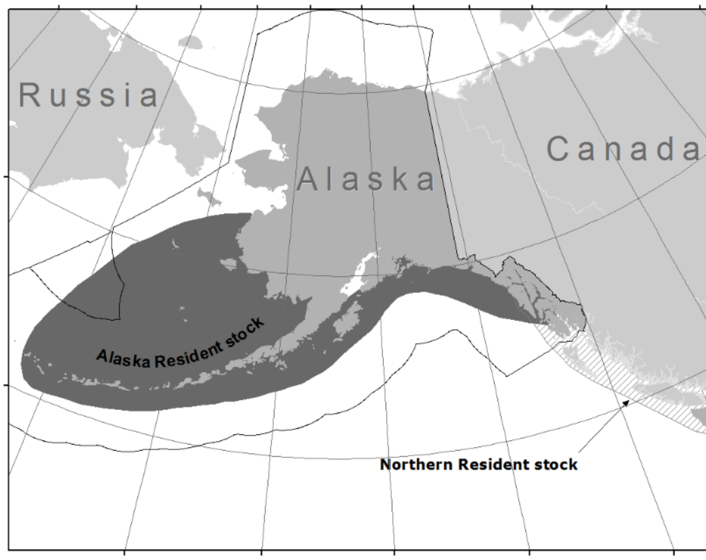

Figure 1. Approximate distribution of resident killer whales in the eastern North Pacific (shaded areas). The distribution of resident and transient killer whale stocks in the eastern North Pacific largely overlap (see text). The U.S. Exclusive Economic Zone is delineated by a black line.

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~~2021). 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.

~~Genetic differences have also been found between populations within the transient and resident ecotypes (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000). Within the resident ecotype, association data were used to describe three separate populations in the North Pacific: Southern Residents, Northern Residents, and Alaska Residents (Bigg et al. 1990; Ford et al. 1994, 2000; Dahlheim et al. 1997; Matkin et al. 1999). In previous stock assessment reports, the Alaska and Northern Resident populations were considered one stock. Acoustic data (Ford 1989, 1991; Yurk et al. 2002), and genetic data (Hoelzel et al. 1998, 2002; Barrett-Lennard 2000) have now confirmed that these three units represent discrete populations. The Southern Resident population is found in summer primarily in waters of Washington state and southern British Columbia and has never been seen to associate with other resident stocks. The Northern Resident population is found in summer primarily in central and northern British Columbia. Members of the Northern Resident population have been documented in southeastern Alaska; however, they have not been seen to intermix with Alaska Residents (Fig. 1). Alaska Resident whales are found from southeastern Alaska to the Aleutian Islands and Bering Sea. Intermixing of Alaska Residents have been documented among the three areas, at least as far west as the eastern Aleutian Islands.~~

Based on data regarding association patterns (Matkin et al. 2010), acoustics (Ford 1989, 1991; Yurk et al. 2002; Matkin et al. 2007), movements (Matkin et al. 2010), and genetic differences (Hoelzel and Dover 1991; Hoelzel et al. 1998, 2002; Barrett-Lennard 2000), 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 (Fig. 1), 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 ~~s~~Southeast~~ern~~ 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 ~~t~~Transient stock - occurring from California through ~~s~~Southeast~~ern~~ 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~~.

~~Resident killer whales ranging from Southeastern Alaska to Kodiak Island have been observed in regular association during multipod encounters since 1984 (Matkin et al. 2010). Tagging data also indicates the range of killer whales seen in these aggregations extends from Southeastern Alaska to south of Kodiak Island (Matkin et al. 2010). Although recent studies have documented movements of Alaska Resident killer whales from the Bering Sea into the Gulf of Alaska as far north as southern Kodiak Island, none of these whales have been photographed further north and east in the Gulf of Alaska where regular photo-identification studies have been conducted since 1984 (P. Wade, pers. comm., MML-AFSC, Seattle, WA, 10 December 2012; unpublished data; Matkin et al. 2010). The resident-type killer whales encountered in western Alaska possibly belong to groups that are distinct from the groups of resident killer whales in the Gulf of Alaska because no call syllables or call patterns (sequence of syllables) between groups were found to match (Matkin et al. 2007).~~

POPULATION SIZE

The Alaska Resident stock includes killer whales from ~~s~~Southeast~~ern~~ Alaska to the Aleutian Islands and Bering Sea.

Gulf of Alaska

~~Preliminary analysis of photographic data resulted in the following~~Long-term photo-identification studies by the North Gulf Oceanic Society (NGOS) and collaborators have provided minimum counts for resident killer whales belonging to the Alaska Resident stock in Prince William Sound, Kenai Fjords, Kodiak, and Southeast Alaska (e.g., Matkin et al. 1999, 2014)~~(Note: individual whales have been matched between geographical regions and missing animals likely to be dead have been subtracted)~~. For the time period 2005-2012, this resulted in a minimum count of

121 whales for Southeast Alaska and 751 whales for Prince William Sound, Kodiak, and Kenai Fjords (Table 1). NGOS has updated the counts for many of the pods seen most frequently in more recent years and has documented the most recent count for those pods on their website (https://www.whalesalaska.org/salmon-specialist-residents, accessed January 2022); most pods have continued to increase in size. Those updated counts result in revised minimum counts of 137 whales for Southeast Alaska and 784 whales for Prince William Sound, Kodiak, and Kenai Fjords, for a total of 921 for the Gulf of Alaska for the years 2005-2019 (years in parentheses in Table 1 represent the most recent year a count is available for each pod). In southeastern Alaska, 109 resident whales have been identified as of 2009 (MML and North Gulf Oceanic Society (NGOS), 3430 Main Street, Suite B1, Homer, Alaska; unpublished data). In Prince William Sound and Kenai Fjords, another 675 resident whales have been identified as of 2009 (Matkin et al. 2003; C. Matkin, North Gulf Oceanic Society, pers. comm.).

Aleutian Islands and Bering Sea

Beginning in 2001, dedicated killer whale studies were initiated by the NMFS Marine Mammal Laboratory (MML) in Alaska waters, west of Kodiak Island, including the Aleutian Islands and Bering Sea (e.g., Fearnbach et al. 2012, 2014; Zerbini et al. 2007), and by the NGOS in the eastern Aleutians. Between 2001 and 2009, using field assessments based on morphology, association data, and genetic analyses, additional resident whales were added to the Alaska Resident stock. Internal matches within the MML data set have been subtracted, resulting in a final count of western Alaska residents for 2001-2012 as 1,475 whales. Studies conducted in western Alaska by the NGOS have resulted in the collection of photographs of approximately 600 resident killer whales; however, the NGOS and MML data sets have not yet been matched so it is unknown how many of these 600 animals are included in the MML collection. Another 41 whales were identified off Kodiak between 2000 and 2003 by the NGOS. These whales are added to the total of western Alaska residents although they have not been matched to MML photographs. For the first 3 years (2001-2003), MML conducted killer whale line-transect surveys in July and August. These surveys covered an area from approximately Resurrection Bay in the Kenai Fjords area 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. A total of 9,053 km of tracklines were surveyed between the Kenai Peninsula (~150°W) and Amchitka Pass (~179ºW). A total of 41 on-effort sightings of killer whales were recorded, with an additional 16 sightings off-effort. Estimated abundance of resident killer whales from these surveys was 991 (CV = 0.52), with a 95% confidence interval of 380-2,585 (Zerbini et al. 2007). However, the first four strata of that survey overlap with the NGOS photo-identification study areas around Kodiak and Kenai Fjords. The estimated abundance for strata 1-4 was 208 (Zerbini et al. 2007: Table 4). Subtracting 208 from 991 leaves a line-transect abundance estimate of 783 for the areas from Kodiak to the west.

Identification photographs were collected on those and subsequent MML biopsy and tagging surveys from 2001 to 2010 and on NGOS surveys (2001-2005). These two data sets were matched and reconciled, with Fearnbach et al. (2014: Table 2, areas 4-8) reporting a total of 999 distinct individuals for the Aleutian Islands and Bering Sea from 2001 to 2010.

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. A total of 9,053 km of tracklines were surveyed between the Kenai Peninsula (~150°W) and Amchitka Pass (~179ºW). A total of 41 on-effort sightings of killer whales were recorded, with an additional 16 sightings off-effort. Estimated abundance of resident killer whale from these surveys was 991 (CV = 0.52), with a 95% confidence interval of 380-2,585 (Zerbini et al. 2007).

The line--transect surveys provide an "instantaneous" (across ~40 days) estimate of the number of resident killer whales in the survey area. It should be noted that the photographic catalogue encompasses a larger area, including some data from areas such as Prince William Sound and the Bering Sea that were outside the line-transect survey area. 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 resident 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.

Combining the counts of known resident whales gives a minimum number of 2,347 (Southeast Alaska + Prince William Sound + Western Alaska; 121 + 751 + 1,475) killer whales belonging to the Alaska Resident stock (Table 1).Using essentially the same combined dataset of photographs from MML and NGOS, Fearnbach (2014) used photographic mark-recapture methods to estimate abundance of resident killer whales in the coastal waters (typically within 30 km from the shore or continental shelf edge) around the central and eastern Aleutians (~160°W to 180°), and extending northwards up the Bering Sea shelf edge to the Pribilof Islands (~57°N). The yearly estimates ranged from 732 (95% highest density probability intervals = 493-1,561) to 2,260 individuals (95% highest density probability intervals = 1,255-4,112) using this area annually during summer sampling periods from 2001 to 2010. These estimates refer to the number of whales using (rather than necessarily resident in) these coastal waters during an annual May-September sampling period. Of these, the highest estimate is thought to be the best representation of summer abundance in this region, as it was obtained in the year (2002) when there was the greatest extent of survey effort (Fearnbach 2014).

In summary, for resident type killer whales in the areas west of Kodiak, primarily the Aleutian Islands and Bering Sea, there is a line-transect estimate of 783 (CV = 0.52) for the years 2001-2003 (Zerbini et al. 2007: Table 4, strata 5-16), mark-recapture estimates ranging from 732 to 2,260, with the highest estimate of 2,260 (CV = 0.32) occurring in the year 2002 (Fearnbach 2012), and a minimum count of unique identified individual whales of 999 whales for the years 2001-2010 (Fearnbach et al. 2014: Table 2, areas 4-8). These estimates are relatively consistent with one another. For the sake of consistency across areas, the minimum count of unique identified individuals (999) will be used for the Aleutian Islands and Bering Sea area.

Total for Alaska

The number of unique identified individual whales in the Gulf of Alaska is 921, with the estimates for different pods occurring in different years, ranging from 2005 to 2019 (Table 1). The only available number of unique identified individuals for the Aleutian Islands and Bering Sea is 999, for the years 2001 to 2010. Combining those two counts results in a total for Alaska of 1,920 resident killer whales (Table 1).

Table 1. Numbers of animals in each pod of killer whales belonging to the Alaska Resident stock of killer whales. A number followed by a "+" indicates a minimum count for that pod.

Pod ID	1999/2000 estimate (and source)	2001/2004 estimate (and source)	2005-2012 estimate (and source)	2005-2019 estimate
Southeast Alaska			33 (Matkin et al. in prep.)	Source: NGOS website https://www.whalesalaska.org/salmon-specialist-residents
AF22			33 (Matkin et al. 2013)	33 (2012)
AF5	49 (Dahlheim et al. 1997, Matkin et al. 1999)	61 (C. Matkin, NGOS, pers. comm.)	46 (Matkin et al. in prep.2013)	45 (2012)
AG	27 (Dahlheim et al. 1997, Matkin et al. 1999)	33 (C. Matkin, NGOS, pers. comm.)	42 (Matkin et al. in prep.2013)	59 (2017)
AZ	23+ (Dahlheim, AFSC-MML, pers. comm.)	23+ (Dahlheim et al. 1997)	Not seen since prior to 1997	
Total, Southeast Alaska	**99+**	**117+**	**121 (excluding AZ)**	**137 (excluding AZ)**
Prince William Sound	**Matkin et al. 1999**	**Matkin et al. 2003 and C. Matkin, NGOS, pers. comm.**	**Matkin et al. in prep.2013**	**NGOS website https://www.whalesalaska.org/salmon-specialist-residents**
AA1	—	8	8	8 (2005-2012)
AA30	—	—	24	24 (2005-2012)
AB	25	19	20	20 (2014)
AB25	—	10	19	25 (2018)
AD05	—	16	22	11 (2015)
AD08				9 (2019)
AD11				6 (2018)
AD16	7	4	9	12 (2017)
AE	16	19	17	19 (2019)
AH01		9	9	9 (2005-2012)
AH20		12	12	12 (2005-2012)

Pod ID	~~1999/2000 estimate (and source)~~	~~2001/2004 estimate (and source)~~	2005-2012 estimate (and source)	2005-2019 estimate
AI	~~7~~	~~7~~	8	8 (2019)
AJ (AJ+AJ8)	~~38~~	~~42~~	57	64 (2018-2019)
AK (AK2+AK6)	~~12~~	~~13~~	19	24 (2019)
AL	~~—~~	~~—~~	23	23 (2005-2012)
AN10	~~20~~	~~27~~	36	36 (2005-2012)
AN20	~~assume 9~~	~~33~~	30	30 (2005-2012)
AS2	~~assume 20~~	~~21~~	31	31 (2005-2012)
AS30		~~14~~	19	19 (2005-2012)
AW		~~24~~	27	27 (2005-2012)
AX01	~~21~~	~~20~~	33	33 (2005-2012)
AX27		~~24~~	26	26 (2005-2012)
AX32		~~15~~	18	18 (2005-2012)
AX40		~~14~~	16	16 (2005-2012)
AX48		~~20~~	23	31 (2015)
AY	~~assume 11~~	~~18~~	21	23 (2015)
Unassigned to pods	~~138 (C. Matkin, NGOS, pers. comm.)~~	~~112~~	220	220 (2005-2012)
Total, Prince William Sound/ Kenai Fjord/ Kodiak	~~**341**~~	~~**501**~~	**751**	**784**
Western Alaska	~~**Dahlheim et al. 1997 and MML unpublished data**[2]~~	~~**2001/2003 MML unpublished data**[2]~~	**2001-201~~2~~0 MML/NGOS total unique IDs (Fearnbach et al. 2014)~~unpublished catalog~~[2]**	**2001-2010 MML/NGOS total unique IDs (Fearnbach et al. 2014)**
Unassigned to pods (MML)	~~68+~~	464	999 ~~1,475 (H. Fearnbach, NOAA-SWFSC, pers. comm., April 2013)~~	999
Total, Western Alaska	~~**68+**~~	~~**505**~~	**999 ~~1,475~~**	**999**
Total, all areas	~~**507**~~	~~**1,123**~~	**1,871 ~~2,347~~**	**1,920**

~~[1]Although there is strong evidence (Matkin et al. 2003, 2010) the resident killer whale numbers have been increasing in the Gulf of Alaska, the bulk of the increase from the 2001-2004 counts to the 2005-2009 counts is believed to be due to the discovery of new animals, not recruitment. Animals reported here have been photographed in the 2001-2012 period. [2]Available from M. Dahlheim, Marine Mammal Laboratory, Alaska Fisheries Science Center, 7600 Sand Point Way NE, Seattle, WA 98115.~~

Minimum Population Estimate

For the Gulf of Alaska, a minimum count of photographically identified whales for Prince William Sound, Kodiak, Kenai Fjords, and Southeast Alaska results in a total of 921 whales for the years 2005-2019 (the years in parentheses in Table 1 represent the most recent years a count is available for each pod). Although some of the counts are fairly old, nearly all pods that have been recently counted have continued to increase, suggesting this number can still represent a conservative estimate of the minimum number of resident killer whales in the Gulf of Alaska. Therefore, we use this estimate even though parts of it are older than 8 years because there is reasonable assurance the population has not declined in the Gulf of Alaska.

For the Aleutian Islands and Bering Sea, the minimum count of photographically identified whales is 999 for the years 2001 to 2010. This is a minimum count over a 10-year period, so some identified whales could have died by the end of the study in 2010. However, there are two reasons to suggest this number can be used as a minimum abundance estimate. First, the great majority of whales in this study were only seen in one year, meaning that capture probability was relatively low, suggesting there are a large number of distinctive whales that have never been identified. This is supported by annual mark-recapture estimates for a portion of the area that are much higher than the number of identified individuals in each year (Fearnbach 2012). Second, Fearnbach (2012) used photo identification data to estimate that the proportion of the population that was distinctive was, on average, 0.67, with annual estimates ranging from 0.59 to 0.73. Therefore, the number of identified whales represents only about two-thirds of the total population, meaning that number should be re-scaled by ~1.5 to account for whales (mainly younger animals) that are not sufficiently marked to be distinctive and thus are unable to be re-identified. Therefore, we use this estimate as a minimum abundance for the Aleutians and Bering Sea even though it is older than 8 years, because there is reasonable assurance the true abundance of resident killer whales is much greater than the number counted.

Therefore, the minimum population estimate (N_{MIN}) for resident-type killer whales in Alaska is 1,920, based on adding 921 identified individuals from the Gulf of Alaska with 999 identified individuals from the Aleutian Islands and Bering Sea.

~~The survey technique utilized for obtaining the abundance estimate of killer whales is a direct count of individually identifiable animals. Thus the minimum population estimate (N_{MIN}) for the Alaska Resident stock of killer whales based on photo-identification studies conducted between 2005-2009 is 2,084 animals (Table 1). Other estimates of the overall population size (i.e., N_{BEST}) and associated CV(N) are not currently available. Given that researchers continue to identify new whales, the estimate of abundance based on the number of uniquely identified individuals known to be alive is likely conservative. However, the rate of discovering new resident whales within southeastern Alaska and Prince William Sound is relatively low (MML, unpublished data). Conversely, the rate of discovery of new whales in western Alaska was initially high (i.e., 2001 and 2002 field seasons). However, recent photographic data collected during 2003 and 2004 indicates that the rate of discovering new individual whales has decreased.~~

~~Using the line-transect estimate of 991 (CV = 0.52) results in an estimate of N_{MIN} (20th percentile) of 656. This is lower than the minimum number of individuals identified from photographs in recent years, so the photographic catalogue number is used for PBR calculations.~~

~~Some overlap of Northern Resident whales occur with the Alaska Resident stock in southeastern Alaska. However, information on the percentage of time that the Northern Resident stock spends in Alaska waters is unknown. However, as noted above, this minimum population estimate is considered conservative. This approach is consistent with the recommendations of the Alaska Scientific Review Group (DeMaster 1996).~~

Current Population Trend

Data from Matkin et al. (2003, 2014) indicate that the component of the Alaska Resident stock that summers in the Prince William Sound and Kenai Fjords area is increasing. With the exception of AB pod, which declined drastically after the *Exxon Valdez* oil spill and has not yet recovered, the component of the Alaska Resident stock in the Prince William Sound and Kenai Fjords area increased 3.2% (95% CI = 1.94 to 4.36%) per year from 1990 to 2005 (Matkin et al. 2008); the 10 pods seen most frequently increased by 3.4% per year from 1984 to 2005, with evidence of continued increase through 2010 by 7 of those pods (Matkin et al. 2014). ~~Although the current minimum population count of 2,084 is higher than the last population count of 1,123, examination of only count data does not provide a direct indication of the net recruitment into the population.~~ At present, reliable data on trends in population abundance for the entire Alaska Resident stock of killer whales are unavailable, due to a lack of trend data from the Aleutian Islands and Bering Sea.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for this 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)~~,~~ and 3.3% ~~over the period~~ from 1984 to ~~-~~2002 (Matkin et al. 2003). Until additional stock-specific data become available, ~~it is recommended that~~ the cetacean maximum theoretical net productivity rate (R_{MAX}) of 4% ~~be employed~~ is used for this stock (~~Wade and Angliss 1997~~NMFS 2016).

POTENTIAL BIOLOGICAL REMOVAL

~~Under the 1994 reauthorized Marine Mammal Protection Act (MMPA), the 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 (~~Wade and Angliss 1997~~NMFS 2016). Thus, for the Eastern North Pacific Alaska Resident killer whale stock, PBR = 19~~24~~ ~~animals~~whales (~~2,347~~1,920 × 0.02 × 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 2016 and 2020 is listed, by marine mammal stock, in Freed et al. (2022); 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 Alaska Resident killer whales between 2016 and 2020 is 1.3 killer whales: 1.1 in 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.

Fisheries Information

~~Detailed i~~Information ~~on~~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 (~~including observer programs,~~ observer coverage~~,~~ and ~~observed~~reported incidental takes of marine mammals: https://www.fisheries.noaa.gov/national/marine-mammal-protection/marine-mammal-protection-act-list-fisheries, accessed January 2022) ~~is presented in Appendices 3-6 of the Alaska Stock Assessment Reports~~.

Between 2016 and 2020, mortality and serious injury of killer whales occurred in ~~Three~~two of the federally-regulated U.S. commercial fisheries~~,~~ that are monitored for incidental mortality and serious injury of marine mammals by fishery observers~~, incurred mortality and serious injury of killer whales (unknown stock) between 2010 and 2014~~: the Bering Sea/Aleutian Islands flatfish trawl~~, Bering Sea/Aleutian Islands rockfish trawl,~~ and Bering Sea/Aleutian Islands Pacific cod longline fisheries (Table ~~1~~2; 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 fishery (n = 3) and Bering Sea/Aleutian Islands Pacific cod longline fisher~~ies~~y (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, 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~~vessel's propeller, the~~se~~ events are assigned to both the transient and resident killer whale stocks occurring in ~~that~~the area. Thus, ~~the~~an estimated mean annual mortality and serious injury rate of ~~one~~0.4 killer whales in the Bering Sea/Aleutian Islands flatfish trawl fishery between ~~2010-2014~~2016 and 2020 ~~will be~~is assigned to both the Alaska Resident and Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stocks of killer whales, while a mean annual mortality and serious injury rate of 0.4 killer whales in the Bering Sea/Aleutian Islands flatfish trawl fishery and 0.3 in the Bering Sea/Aleutian Islands Pacific cod longline fishery between 2016 and 2020 is assigned to the Alaska Resident stock (Table 2; Breiwick 2013; MML, unpubl. data).

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 the Bering Sea/Aleutian Islands trawl fisheries often occurs due to contact with the ~~ship~~vessel's propeller (e.g., the ~~2010~~2016 ~~mortality~~serious injury in the Bering Sea/Aleutian Islands ~~rockfish~~flatfish trawl fishery). Fisheries observers report that large groups of killer whales in the Bering Sea follow vessels for days at a time, actively consuming the processing waste (NMFS-AFSC, Fishery Observer Program, unpubl. data). On some vessels, the waste is discharged in the vicinity of the vessel's propeller (NMFS, unpubl. data); consumption of the processing waste in the vicinity of the propeller may be the cause of the propeller-caused mortalities of killer whales in the trawl fisheries.

Table 2. Summary of incidental mortality and serious injury of Alaska Resident killer whales due to U.S. commercial fisheries in ~~2010-2014~~2016-2020 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	~~2010~~ ~~2011~~ ~~2012~~ ~~2013~~ ~~2014~~ 2016 2017 2018 2019 2020	obs data	~~99~~ ~~100~~ ~~99~~ ~~99~~ ~~99~~ 99 100 100 100 100	~~0~~ ~~0~~ ~~0 (+1)[a]~~ ~~2~~ ~~0~~ 1[a] 0 1[a] 0 2	~~0~~ ~~0~~ ~~0 (+1)[b]~~ ~~2~~ ~~0~~ 1 (0) 0 1 (0.05) 0 2 (0.02)	~~0.4 (+0.2)[c]~~ ~~(CV = 0)~~ 0.8 (CV = 0.02)
~~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)~~
Bering Sea/Aleutian Is. Pacific cod longline	~~2010~~ ~~2011~~ ~~2012~~ ~~2013~~ ~~2014~~ 2016 2017 2018 2019 2020	obs data	~~64~~ ~~57~~ ~~51~~ ~~66~~ ~~64~~ 57 58 55 52 53	~~0~~ ~~0~~ ~~0 (+1)[d]~~ ~~0~~ ~~0~~ 1	~~0~~ ~~0~~ ~~0 (+1)[e]~~ ~~0~~ ~~0~~ 1.7 (0.64)	~~0 (+0.2)[f]~~ ~~(CV = N/A)~~ 0.3 (CV = 0.64)
Minimum total estimated annual mortality						~~1~~ 1.1 (CV = 0.19)

[a]~~Total mortality and serious injury observed in 2012: 0 whales in sampled hauls + 1 whale in an unsampled haul~~The mortality or serious injury was assigned to the Eastern North Pacific Alaska Resident and Eastern North Pacific Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stocks of killer whales because the stock is unknown and these two stocks overlap in the area where the event occurred..
[b]~~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).~~
[c]~~Mean annual mortality and serious injury for fishery: 0.4 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).~~

A minimum estimate of the mean annual mortality and serious injury rate incidental to U.S. commercial fisheries ~~in 2010-2014~~between 2016 and 2020, based on observer data, is ~~one~~1.1 Alaska Resident killer whales, ~~based on observer data~~ (Table 2).

Reports from the NMFS Alaska Region stranding network of killer whales entangled in fishing gear or with injuries caused by interactions with gear are another source of mortality and serious injury data. There was one report of a killer whale seriously injured by entanglement 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 fisheries between 2016 and 2020 (Table 3; Freed et al. 2022). Because the stock is unknown, this serious injury was assigned to the three killer whale stocks that occur in the area: the Eastern North Pacific Alaska Resident, Eastern North Pacific Northern Resident, and West Coast Transient stocks. 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 or reported.

Table 3. Summary of mortality and serious injury of Alaska Resident killer whales, by year and type, reported to the NMFS Alaska Region marine mammal stranding network between 2016 and 2020 (Freed et al. 2022).

Cause of injury	**2016**	**2017**	**2018**	**2019**	**2020**	**Mean annual mortality**
Entangled in Southeast Alaska pot gear*	1[a]	0	0	0	0	0.2
*Total in unknown (commercial, recreational, or subsistence) fisheries						0.2

[a]This serious injury was assigned to the Eastern North Pacific Alaska Resident, Eastern North Pacific Northern Resident, and West Coast Transient stocks of killer whales because the stock is unknown and these three stocks overlap in the area where the event occurred.

Subsistence/Native Harvest Information

There are no reports of a subsistence harvest of killer whales in Alaska.

Other Mortality

During the 1992 killer whale surveys conducted in the Bering Sea and western Gulf of Alaska, 9 of 182 (4.9%) individual whales in 7 of the 12 (58%) pods encountered had evidence of bullet wounds (Dahlheim and Waite 1993). The relationship between wounding due to shooting and survival is unknown. In Prince William Sound, the pod responsible for most of the fishery interactions experienced a high level of mortality: between 1986 and 1991, 22 whales out of a pod of 37 (59%) disappeared (Matkin et al. 1994). The cause of death for these whales is unknown, but it may be related to gunshot wounds or effects of the *Exxon Valdez* oil spill (Dahlheim and Matkin 1994). It is unknown who was responsible for shooting at the killer whales.

There have been no obvious bullet wounds observed on killer whales during surveys in the Bering Sea and western Gulf of Alaska (J. Durban, NMFS-SWFSC, pers. comm.). However, researchers have reported that killer whale pods in certain areas exhibit vessel avoidance behavior, which may indicate that shootings occur in some places.

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%. Resident killer whales are most likely to be involved in such fishery interactions since these whales are known to be fish eaters.

~~Fisheries observers report that large groups of killer whales in the Bering Sea follow vessels for days at a time, actively consuming the processing waste (NMFS-AFSC, Fishery Observer Program, unpubl. data). On some vessels, the waste is discharged in the vicinity of the vessel's propeller (NMFS, unpubl. data); consumption of the processing waste in the vicinity of the propeller may be the cause of the propeller-caused mortalities of killer whales in the trawl fisheries.~~

STATUS OF STOCK

The Eastern North Pacific Alaska Resident stock of killer whales is not designated as depleted under the MMPA or listed as threatened or endangered under the Endangered Species Act. The minimum abundance estimate for the Alaska Resident stock is likely underestimated because researchers continue to encounter new whales in the Gulf of Alaska and in western Alaska waters. Because the population estimate is likely to be conservative, the PBR is also conservative.

Based on currently available data, a minimum estimate of the mean annual mortality and serious injury rate due to U.S. commercial fisheries (1.1 killer whales) is less than 10% of the PBR (10% of PBR = 2.4) and, therefore, is 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 (1.3 killer whales) is not known to exceed the PBR (1924). Therefore, the Eastern North Pacific Alaska Resident 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 Alaska Resident stock of killer whales. Some of the pods have not been photographically identified since 2005-2012 and the population estimate and PBR are likely conservative because researchers continue to encounter new whales.

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HARBOR PORPOISE (*Phocoena phocoena*): Southeast Alaska Stocks: ~~(~~Northern Southeast Alaska Inland Waters, Southern Southeast Alaska Inland Waters, Yakutat/Southeast Alaska Offshore Waters~~)~~

~~**NOTE – July 2021: In areas outside of Alaska, studies of harbor porpoise distribution have indicated that population structure is likely more fine-scaled than is reflected in the Alaska Stock Assessment Reports (SARs). Data to evaluate population structure for harbor porpoise in Southeast Alaska have been collected and are currently being analyzed. Should the analysis identify different population structure than is currently reflected in the Alaska SARs, we will consider how best to revise stock designations in a future SAR following NMFS Procedure "Reviewing and Designating Stocks and Issuing Stock Assessment Reports under the Marine Mammal Protection Act" (NMFS 2019).**~~

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 the greatest densities observed in the Glacier Bay/Icy Strait region, near ~~Zarembo and~~ Wrangell and Zarembo Islands, and in 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 inland waters off Southeast Alaska (Glacier Bay and 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).

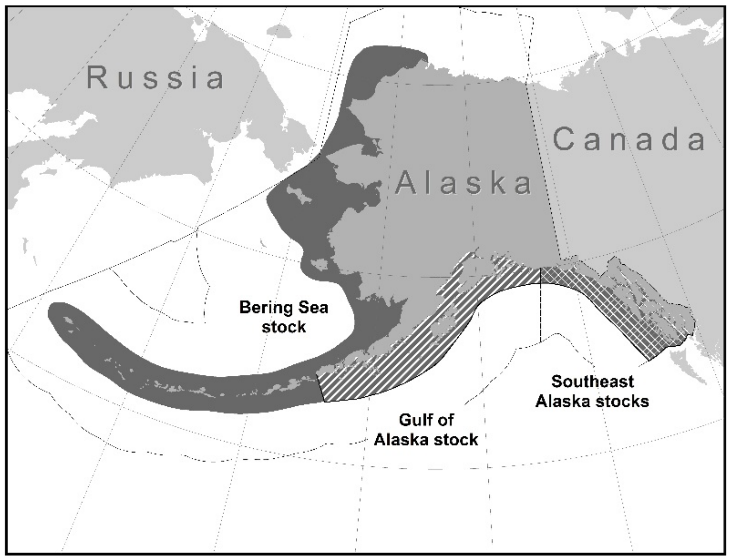

Figure 1. Approximate distribution of harbor porpoise in Alaska waters. See Figure 2 for boundaries of the three stocks in Southeast Alaska. The U.S. Exclusive Economic Zone is delineated by a black line.

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. Despite these two clades overlapping in latitude, the results suggest 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 eight additional samples from Alaska, revealed 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 revealed that harbor porpoise along the west coast of North America are not panmictic and that movement is sufficiently restricted to result in genetic differences between regions (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~~was 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~~were previously specified, recognizing that the boundaries ~~of these three stocks a~~were identified primarily based upon geography or perceived areas of low porpoise density: 1) the Southeast Alaska stock - occurring from Dixon Entrance to Cape Suckling, including offshore, coastal, and 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 west and 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.

Dahlheim et al. (2015) proposed that harbor porpoise in the northern and southern inland waters of Southeast Alaska potentially represented different populations due to differences in trends in abundance between the two regions. In addition, a possible hiatus in distribution between these two areas, south of Frederick Sound suggests the range of harbor porpoise from those two regions does not overlap. Results from analyses of environmental DNA (eDNA) from three areas in Southeast Alaska (Glacier Bay and Icy Strait, Keku Strait, and Wrangell and Zarembo Islands) suggested significant genetic differentiation between Wrangell and Zarembo Islands and the two other areas (Parsons et al. 2018), supporting the existence of two different populations within Southeast Alaska inland waters. Connectivity of harbor porpoise in these two regions with those in Gulf of Alaska waters offshore of Southeast Alaska and in the region around Yakutat is poorly understood.

Multiple lines of evidence (molecular genetics, trends in abundance, and discontinuous distribution) led NMFS to delineate two Demographically Independent Populations and one unit within the Southeast Alaska harbor porpoise stock (Zerbini et al. 2022), which is now divided into three stocks: 1) the Northern Southeast Alaska (N-SEAK) Inland Waters stock, which includes Cross Sound, Glacier Bay, Icy Strait, Chatham Strait, Frederick Sound, Stephens Passage, Lynn Canal, and adjacent inlets; 2) the Southern Southeast Alaska (S-SEAK) Inland Waters stock, which encompasses Sumner Strait, including areas around Wrangell and Zarembo Islands, Clarence Strait, and adjacent inlets and channels within the inland waters of Southeast Alaska north-northeast of Dixon Entrance; and 3) the Yakutat/Southeast Alaska (Y-SEAK) Offshore Waters stock, which includes offshore habitats in the Gulf of Alaska west of the Southeast Alaska inland waters and the areas around Yakutat Bay (Fig. 2). There is limited information to assess how harbor porpoise in the Y-SEAK Offshore Waters stock relate to animals in inland waters, but it is likely, based on what is known about harbor porpoise stock structure in other areas, that the Y-SEAK Offshore Waters stock includes more than one Demographically Independent Population. Therefore, refinement of the stock structure of Y-SEAK/Offshore Waters stock in future years is likely as new information becomes available in the future (Zerbini et al. 2022).~~Preliminary results from an analysis of environmental DNA (eDNA) samples suggest significant genetic differentiation between harbor porpoise concentrations in Glacier Bay/Icy Strait (northern region) and around Zarembo/Wrangell Islands (southern region) (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, because of differences in trends in abundance of porpoise between the northern and southern regions and because of a possible hiatus in distribution between these two areas. Because eDNA samples were only obtained in one area of the northern and southern regions as of 2016 (Parsons et al. 2018), additional samples are needed to better understand harbor porpoise substructure within Southeast Alaska, as well as connectivity of subpopulations in inland, coastal, and offshore waters of Alaska. 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 the southern region, e.g., Wrangell and Zarembo Islands area (Manly 2015), are of concern because of the potential impact on undefined localized stocks of harbor porpoise.~~

~~This stock assessment report primarily provides an assessment of Southeast Alaska harbor porpoise in the inland waters of Southeast Alaska, which represents a portion of the stock's geographic range, because current estimates of abundance are only available for this region. The stock was previously assessed across its entire range based on stock-wide estimates of abundance from surveys conducted in the 1990s (Hobbs and Waite 2010), but these estimates are now outdated. Human-caused mortality and serious injury is estimated for the stock's entire range, as well as for a specific subarea in the inland waters of Southeast Alaska; however, these are likely underestimates because the majority of the salmon and herring fisheries operating within the range of this stock are not observed.~~

POPULATION SIZE

Information on harbor porpoise abundance has been collected for coastal and inland waters of Southeast Alaska by the Alaska Fisheries Science Center's Marine Mammal Laboratory (MML), using both aerial and shipboard surveys between 1991 and 2012 (Hobbs and Waite 2010, Dahlheim et al. 2015). Estimates of abundance provided by these surveys are more than 8 years old and are no longer considered reliable for current management purposes. Further information on these surveys is available in previous stock assessment reports for Southeast Alaska harbor porpoise (e.g., Muto et al. 2021).~~Aerial surveys of this stock were conducted in June and July 1997 and resulted in an abundance estimate of 11,146 harbor porpoise in the coastal and inland waters of Southeast Alaska (Hobbs and Waite 2010).~~

~~Abundance of harbor porpoise was computed from shipboard 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 the size of the stock. Abundance was found to vary across the 22-year survey period with the estimate for 1991-1993 (N = 1,076; 95% CI = 910-1,272) being higher than the one 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 was insufficient information to estimate the probability of detection on the trackline (g[0]) for these surveys; therefore, the abundance estimates above assume a detection probability of 1 (perfect detection). This assumption is typically violated in harbor porpoise surveys because observers tend to miss animals on the survey trackline.~~

Northern and Southern Southeast Alaska Inland Waters Stocks

A line-transect vessel survey was conducted in the inland waters of Southeast Alaska in July/August 2019 using a combination of line-transect and strip-transect methods (Fig. 2) (Zerbini et al. ~~in prep.~~in review). Using the methods of Barlow (2015), an estimate of g(0) = 0.53 (CV = 0.11, 95% CI = 0.43-0.65) was computed for both inland waters stocks from apparent densities in different survey conditions. This parameter corrects for the fraction of animals missed directly on the survey transect line. ~~and harbor porpoise abundance was estimated at 1,302 porpoise (coefficient of variation (CV) = 0.21; 95% CI = 831-1,965). These surveys also assumed that detection probability on the trackline was perfect (i.e., g[0] = 1); work is underway on a corrected estimate with a calculated value for g(0). Preliminary results based on eDNA analysis show genetic differentiation between harbor porpoise in the northern and southern regions of the inland waters of Southeast Alaska, however, the geographic delineation between these regions is not yet known and separate subpopulations or stocks are currently not recognized (but see the NOTE above).~~ Estimates of abundance for the N-SEAK and S-SEAK Inland Waters stocks are, respectively, 1,619 (CV = 0.26, 95% CI = 944-2,529) and 890 (CV = 0.37, 95% CI = 385-1,708) harbor porpoise.

Yakutat/Southeast Alaska Offshore Waters Stock

A current estimate of abundance is not available for the Y-SEAK Offshore Waters stock.~~An estimate of abundance, based on the 2019 survey, of 332 harbor porpoise (CV = 0.37; 95% CI = 125-616) was computed for the region composed of the Alaska Department of Fish and Game (ADF&G) Districts 6, 7, and 8, where the salmon drift gillnet fishery was observed in 2012 and 2013 and mortality and serious injury was estimated (Manly 2015).~~

Minimum Population Estimate

Northern and Southern Southeast Alaska Inland Waters Stocks

~~For the Southeast Alaska stock of harbor porpoise, t~~The minimum population estimates (N_{MINs}) for the harbor porpoise stocks in Southeast Alaska inland waters, based on the 2019 vessel survey, ~~is 1,057 porpoise~~ were calculated as the 20th percentile of the distribution of the g(0)-corrected abundance estimates computed using bootstrap methods. The N_{MINs} for the N-SEAK and S-SEAK Inland Waters stocks are, respectively, 1,250 and 610 harbor porpoise. ~~Since this abundance estimate represents some portion of the total number of animals in the stock and is not corrected for animals missed on the trackline, using this estimate to calculate N_{MIN} results in a negatively-biased N_{MIN} for the stock. N_{MIN} for the area that overlaps ADF&G Districts 6, 7, and 8 in the southern region of the inland waters was computed as 224 individuals using the same method described above.~~

Yakutat/Southeast Alaska Offshore Waters Stock

A minimum population estimate is not available for the Y-SEAK Offshore Waters stock.

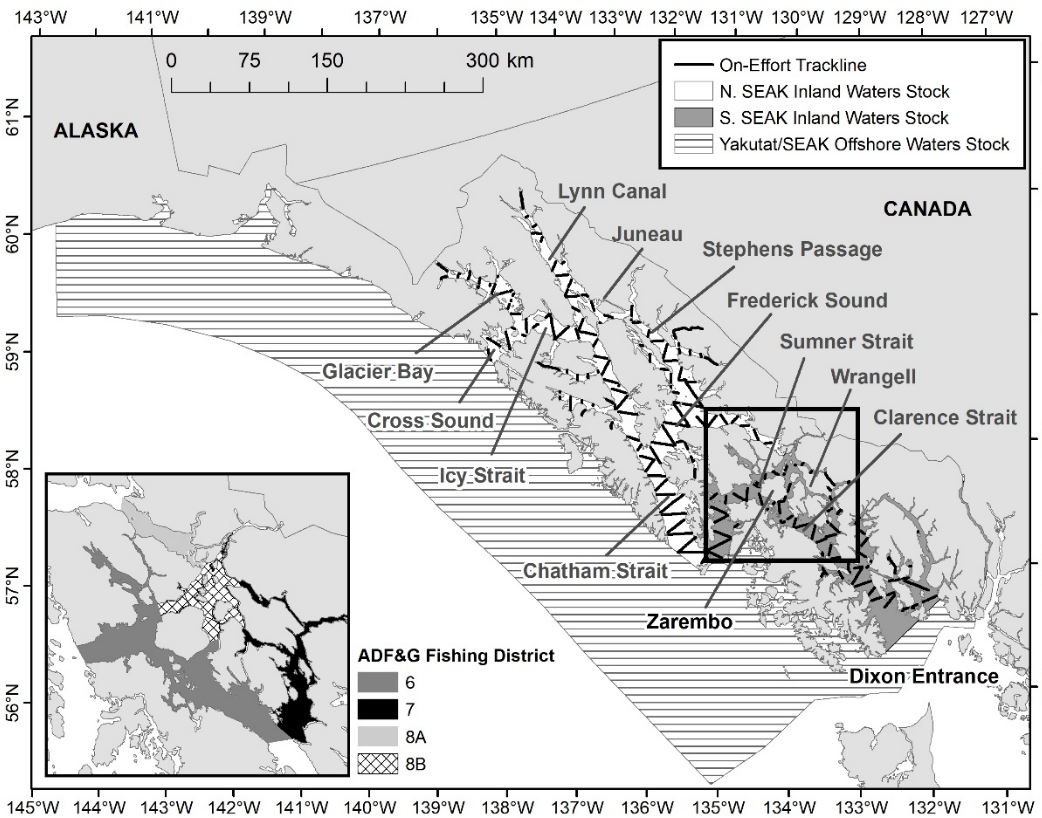

Figure 2. Boundaries for the three newly identified Southeast Alaska harbor porpoise stocks. The on-effort trackline for the 2019 ~~H~~harbor porpoise survey of the inland waters of Southeast Alaska is also shown ~~in 2019~~. ~~ADF&G~~Alaska Department of Fish and Game Management Districts 6, 7, and 8 are indicated by gray shading and cross-hatching. The two sub-areas comprising District 8 are differentiated because the N-SEAK Inland Waters stock occurs in sub-area 8A and the S-SEAK Inland Waters stock occurs in sub-area 8B (Zerbini et al. 2022).

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). ~~The estimate of abundance computed in 2019 is not statistically different from the estimate computed for Southeast Alaska inland waters in 2010-2012.~~

Current estimates of ~~T~~trend~~s~~ in abundance are not available for any of the Southeast Alaska harbor porpoise stocks.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate (R_{MAX}) is not available for any of the Southeast Alaska stocks 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 th~~is~~e three Southeast Alaska stocks of harbor porpoise is 0.5, the default value for cetacean stocks with unknown population status (NMFS 2016). ~~Using the N_{MIN} of 1,057 (based on the 2019 abundance estimate for harbor porpoise in the inland waters of Southeast Alaska), PBR is 11 harbor porpoise (1,057 × 0.02 × 0.5) for this area.~~

Northern and Southern Southeast Alaska Inland Waters Stocks

PBRs for the N-SEAK and the S-SEAK Inland Waters stocks are 13 (1,250 x 0.02 x 0.5) and 6.1 (610 x 0.02 x 0.5) porpoise, respectively.

Yakutat/Southeast Alaska Offshore Waters Stock

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 as they may no longer meet the requirement that they provide reasonable assurance that the stock size is presently greater than or equal to that estimate. Therefore, the PBR for this stock is considered undetermined.

~~Computing a PBR for harbor porpoise in the area where a portion of the Southeast Alaska salmon drift gillnet fishery was monitored in 2012 and 2013 may provide a frame of reference for the observed mortality and serious injury of harbor porpoise in that area. Based on the 2019 abundance estimate and corresponding N_{MIN}, PBR for the area overlapping ADF&G Districts 6, 7, and 8 is 2.2 harbor porpoise (224 × 0.02 × 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 ~~2015~~2016 and ~~2019~~2020 is listed, by marine mammal stock, in Freed et al. (~~2021~~2022); 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 ~~2015~~2016 and ~~2019~~2020, by stock, is: ~~34~~1) N-SEAK Inland Waters stock = 5.6 porpoise in U.S. commercial fisheries (estimated from observer data collected in 2012-2013); 2) S-SEAK Inland Waters stock = 7.4 porpoise in U.S. commercial fisheries (estimated from observer data collected in 2012-2013); and 3) Y-SEAK Offshore Waters stock = 22.2 porpoise in U.S. commercial fisheries (22 estimated from observer data collected ~~in Yakutat~~ in 2007-2008~~; 12 estimated from observer data collected in ADF&G Districts 6, 7, and 8 in the inland waters of Southeast Alaska in 2012-2013;~~ and 0.2 estimated from a Marine Mammal Authorization Program (MMAP) fisherman self-report in the coastal waters of Southeast Alaska in 2019).

~~; however, this~~The estimates of mortality and serious injury provided above are ~~is~~ considered ~~a~~ minimums because the majority of the salmon and herring fisheries (salmon and herring gillnet and purse seine and salmon hook and line) operating within the range of th~~is~~ese stocks are not observed. The potential threat most likely to result in direct human-caused mortality or serious injury of th~~is~~ese stocks is entanglement in fishing gear. There are no other known causes of human-caused mortality and serious injury for th~~is~~ese stocks.

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 ~~December 2021~~January 2022).

~~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 2015 and 2019.~~

~~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 a total of 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 this fishery.~~

Northern and Southern Southeast Alaska Inland Waters Stocks

No mortality or serious injury of harbor porpoise from the N-SEAK or S-SEAK Inland Waters stocks was observed incidental to federally-managed U.S. commercial fisheries in Alaska between 2016 and 2020. In 2012 and 2013, the Alaska Marine Mammal Observer Program (AMMOP) placed observers on independent vessels in the state-managed Southeast Alaska salmon drift gillnet fishery in Alaska Department of Fish and Game (ADF&G) Management Districts 6, 7, and 8 to assess mortality and serious injury of marine mammals (Manly 2015). Specifically, the program observed sub-areas 6A, 6B, 7A, 8A, and 8B within Districts 6, 7, and 8; sub-areas are referenced herein only if relevant to identifying specific harbor porpoise interactions or assigning interactions to a stock. 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. No mortality or serious injury of harbor porpoise was observed in 2012. However, in 2013, four harbor porpoise were observed entangled and released: two were determined to be seriously injured and two were determined not to be 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).

A previous estimate of harbor porpoise mortality and serious injury from these observed interactions was 23 harbor porpoise for 2012-2013 (an average of 12 individuals per year) (Manly 2015). That estimate is revised here because of an error in the assignment of injury severity for two of the bycaught individuals. Upon review of the data, it was determined that one of the two porpoise that were caught in sub-area 8A and reported to have serious injuries (Manly 2015) should have been classified as having a non-serious injury (Helker et al. 2015), and the porpoise caught in sub-area 6A and classified as having a non-serious injury (Manly 2015) was in fact seriously injured (Helker et al. 2015). These corrections required a review of the estimated bycatch in these sub-areas. Following the same methods used by Manly (2015), mortality and serious injury in sub-areas 6A and 8A were estimated, respectively, as 14.8 (CV = 1.0) and 11.2 (CV = 0.7) porpoise. Total mortality and serious injury estimated for in the observed sub-areas of Districts 6, 7, and 8 was estimated at 26 porpoise (CV = 0.5) for 2012-2013, which results in a mean annual mortality and serious injury rate of 13 porpoise.

Total annual mortality and serious injury was then divided between the inland waters stocks based on the locations of the observed mortalities and serious injuries. As shown in Figure 2, sub-area 8A occurs within the range of the N-SEAK Inland Waters stock, thus the estimated mortality and serious injury in sub-area 8A was assigned to the N-SEAK Inland Waters stocks; similarly, sub-areas 6A, 6B, 7A, and 8B overlap with the range of the S-SEAK Inland Waters stock and thus the estimated mortality and serious injury in sub-area 6A was assigned to the N-SEAK Inland Waters stock. Based on the revised estimates, the mean annual mortality and serious injury rate for the N-SEAK and S-SEAK Inland Waters stocks is estimated to be 5.6 and 7.4 porpoise, respectively (Table 1). Since these three districts represent only a portion of the overall fishing effort in this fishery, It is important to note that theseis isare a minimum estimates of mortality and serious injury for these stocks in the Southeast Alaska salmon drift gillnet fishery because they only apply to the sub-areas in which the fishery was observed (ADF&G sub-areas 6A, 6B, 7A, 8A and 8B), not to other districts where the salmon driftnet fishery is known to operate (e.g., Lynn Canal, Taku/Snettisham, and Tree Point) but was not observed. In addition, there are no estimates of mortality and serious injuries for fisheries other than the salmon drift gillnet fishery.

Yakutat/Southeast Alaska Offshore Waters Stock

No mortality or serious injury of harbor porpoise from any of the Southeast Alaska stocks was observed incidental to federally-managed U.S. commercial fisheries in Alaska between 2016 and 2020. In 2007 and 2008, the 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 a total of 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 for this stock in this fishery.

Mortality of one harbor porpoise in the Y-SEAK Offshore Waters stock due to entanglement in a commercial Southeast Alaska salmon cost recovery drift gillnet was reported in an MMPA fisherman self-report in 2019 (Table 2; Freed et al. 2022), resultings in a minimum mean annual mortality and serious injury rate of 0.2 harbor porpoise for this stock in this fishery between 2016 and 2020. 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 or are self-reported nor are all stranded animals found, reported, or have the cause of death determined.

Table 1. Summary of ~~observed~~ incidental mortality and serious injury of Southeast Alaska harbor porpoise due to U.S. commercial fisheries, by stock, between ~~2015~~2016 and ~~2019~~2020 (estimated from data collected in 2007-2008 and 2012-2013) and ~~calculation of~~ the mean annual mortality and serious injury rate (Manly 2009, 2015; see text for information on re-analysis of estimates from Manly 2015). ~~Methods for calculating percent observer coverage are described in Appendix 3 of the Alaska Stock Assessment Reports.~~Observer coverage levels shown for the Southeast Alaska salmon drift gillnet fishery are specific to individual observed ADF&G sub-areas and do not represent the level of coverage of the entire Southeast Alaska salmon drift gillnet fishery.

Fishery name	Years	Data type	Percent observer coverage	Observed mortality	Estimated mortality	Mean estimated annual mortality
Northern Southeast Alaska Inland Waters stock						
Southeast Alaska salmon drift gillnet (ADF&G sub-area 8A)	2012 2013	obs data	6.9 8.9	0 1	0 11.2	5.6 (CV = 0.7)
Southern Southeast Alaska Inland Waters stock						
Southeast Alaska salmon drift gillnet (ADF&G sub-area 6A)	2012 2013	obs data	7.3 6.7	0 1	0 14.8	7.4 (CV = 1.0)
Yakutat/Southeast Alaska Offshore Waters stock						
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 N-SEAK Inland Waters stock S-SEAK Inland Waters stock Y-SEAK Offshore Waters stock						~~34~~ ~~(CV = 0.77)~~ 5.6 (CV = 0.7) 7.4 (CV = 1.0) 22 (CV = 0.54)

Table 2. Summary of Southeast Alaska harbor porpoise mortality and serious injury, by year and type, reported to the NMFS Alaska Region marine mammal stranding network and in MMAP fisherman self-reports between ~~2015~~ 2016 and ~~2019~~2020 (Freed et al. ~~2021~~2022). Only cases of serious injury were recorded in this table; animals with non-serious injuries have been excluded.

Cause of injury	~~2015~~	2016	2017	2018	2019	2020	Mean annual mortality
Yakutat/Southeast Alaska Offshore Waters stock							
Entangled in commercial Southeast Alaska salmon cost recovery drift gillnet	~~0~~	0	0	0	1*	0	0.2
Total in commercial fisheries Y-SEAK Offshore Waters stock							0.2

*MMAP fisherman self-report.

Based on observed mortality and serious injury in two commercial fisheries in 2007-2008 and 2012-2013 (Table 1) and an MMAP fisherman self-report in 2019 (Table 2), the minimum estimated mean annual mortality and serious injury rate incidental to U.S. commercial fisheries between ~~2015~~ 2016 and ~~2019~~ 2020, by stock, is: 1) N-SEAK Inland Waters stock = 5.6 harbor porpoise from observed fisheries, 2) S-SEAK Inland Waters stock = 7.4 harbor porpoise from observed fisheries; and 3) Y-SEAK Offshore Waters stock = 22 ~~34~~ harbor porpoise from observed fisheries ~~(22 in Yakutat and 12 in the inland waters of Southeast Alaska)~~ and 0.2 from an MMAP fisherman self-report ~~in the coastal waters of Southeast Alaska~~. Thes~~is~~e ~~is~~are likely ~~an~~ underestimates because the majority of the salmon and herring fisheries (salmon and herring gillnet and purse seine and salmon hook and line) operating within the range of these~~is~~ stocks are not observed and not all entangled animals strand or are self-reported nor are all stranded animals found, reported, or have the cause of death determined. Thus, given the known occurrence of fisheries-caused mortality and serious injury of harbor porpoise in gillnet fisheries in Alaska and the lack of thorough and/or recent observation, the total fisheries-caused mortality and serious injury of theseis stocks is likely greater than is reported here.

Alaska Native Subsistence/Harvest Information

Subsistence hunters in Alaska have not been reported to take from theseis stocks of harbor porpoise.

STATUS OF STOCK

None of the stocks of 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.

Northern and Southern Southeast Alaska Inland Waters Stocks

The minimum mean annual level of human-caused mortality and serious injury estimated for the N-SEAK Inland Waters stock (5.6 porpoise, based on data collected from an observer program in ADF&G sub-area 8A) does not exceed the calculated PBR (13); therefore, the stock is not strategic. However, because only a portion of the Southeast Alaska salmon drift gillnet fishery was monitored by AMMOP, it is possible that the actual level of human-caused mortality and serious injury is underestimated, and NMFS is evaluating the feasibility of observing the fishery throughout the stock's range. The minimum estimated mean annual U.S. commercial fishery-related mortality and serious injury rate (5.6 porpoise) is more than 10% of the calculated PBR (10% of PBR = 1.3 porpoise), so it is not 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 currently unknown.

The minimum mean annual level of human-caused mortality and serious injury estimated for the S-SEAK Inland Waters stock (7.4 porpoise, based on data collected from an observer program in ADF&G sub-areas 6A, 6B, 7A, and 8B) exceeds the calculated PBR (6.1); therefore, the stock is strategic. The minimum estimated mean annual U.S. commercial fishery-related mortality and serious injury rate (7.4 porpoise) is more than 10% of the calculated PBR (10% of PBR = 0.6 porpoise), so it is not 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 currently unknown.

The minimum mean annual level of human-caused mortality and serious injury estimated for the entire range of Southeast Alaska harbor porpoise (34 porpoise, based on data collected from observer programs in Yakutat (22 porpoise) and ADF&G Districts 6, 7, and 8 in the inland waters of Southeast Alaska (12 porpoise) and from an MMAP fisherman self-report in the coastal waters of Southeast Alaska (0.2 porpoise)) exceeds the calculated PBR (11 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 = 1.1 porpoise), so it is not considered insignificant and approaching a zero mortality and serious injury rate. However, the calculated PBR is biased low for the entire stock because it is based on an estimate from the 2019 survey of only a portion (the inland waters of Southeast Alaska) of the range of this stock as currently designated, whereas the estimate of mortality and serious injury is for the stock's entire range, although the majority of the salmon and herring fisheries operating within the range of this stock are not observed. For comparison, the mean annual estimate of mortality and serious injury for ADF&G Districts 6, 7, and 8 is 12 harbor porpoise compared to the PBR of 2.2 harbor porpoise calculated for this area from the 2019 abundance estimate. Population trends and status of this stock relative to its Optimum Sustainable Population are currently unknow

Yakutat/Southeast Alaska Offshore Waters Stock

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, it is unknown if the minimum estimate of the mean annual mortality and serious injury rate (22.2 porpoise) in U.S. commercial fisheries can be considered insignificant and approaching a zero mortality and serious injury rate. NMFS considers this stock not strategic at this time because the PBR level is undetermined and a comparison between the level of mortality and serious injury and a PBR level is thus not possible. However, based on information about the range of harbor porpoise stocks in other areas, the Y-SEAK Offshore stock is likely to comprise multiple stocks, and if this is the case, a mortality and serious injury level of 22.2 harbor porpoise from a portion of the total area of this stock is likely to be of concern. Population trends and status of this stock relative to its Optimum Sustainable Population are unknown.

Uncertainties

There are key uncertainties in the assessment of the Southeast Alaska stocks 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. Preliminary results based on eDNA analysis show genetic differentiation

~~between harbor porpoise in the northern and southern regions of the inland waters of Southeast Alaska; however, the geographic delineation between these regions is not known and separate subpopulations or stocks are currently not recognized (but see NOTE above).~~ It is unclear whether there is connectivity between the N-SEAK and S-SEAK Inland Waters stocks and the Y-SEAK Offshore Waters stock. ~~The t~~Trends in abundance of harbor porpoise in these regions ~~is~~are unclear; an early decline in inland waters appears to have reversed in recent years. Several commercial fisheries overlap with the range of th~~is~~ese stocks and ~~are not observed or~~ have not been observed since at least 2013 ~~in a long time~~; thus, the estimates of commercial fishery mortality and serious injury ~~is~~are expected to be ~~a~~ minimum estimates. 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 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).

Algal toxins are a growing concern in Alaska marine food webs, in particular the neurotoxins domoic acid and saxitoxin. While saxitoxin was not detected in harbor porpoise samples collected in Alaska, domoic acid was found in 40% (2 of 5) of the samples and, notably, in maternal transfer to a fetus (Lefebvre et al. 2016).

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Humpback Whale (*Megaptera novaeangliae kuzira*) - Western North Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

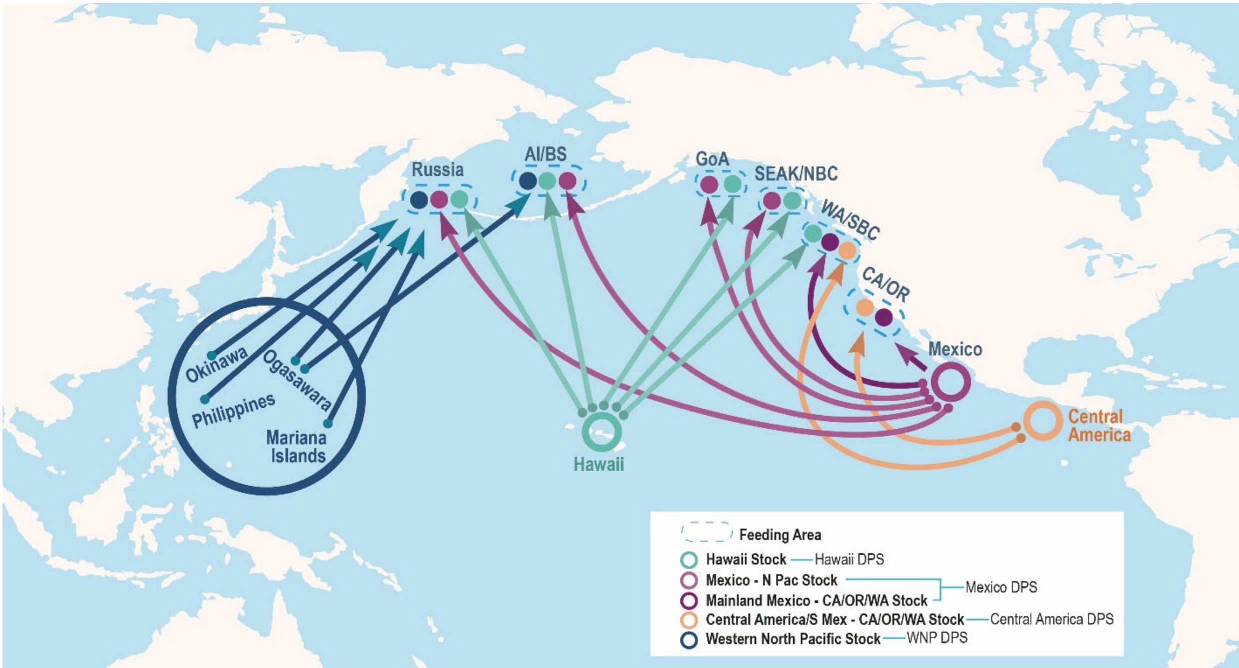

Figure 1. Pacific basin map showing wintering areas of five humpback whale stocks mentioned in this report. Also shown are summering feeding areas mentioned in the text. High-latitude summer feeding areas include Russia, Aleutian Islands / Bering Sea (AI/BS), Gulf of Alaska (GoA), Southeast Alaska / Northern British Columbia (SEAK/NBC), Washington / Southern British Columbia (WA/SBC), and California / Oregon (CA/OR).

Humpback whales occur worldwide and migrate seasonally from high latitude subarctic and temperate summering areas to low latitude subtropical and tropical wintering areas. Three subspecies are recognized globally (North Pacific, Atlantic, and Southern Hemisphere), based on restricted gene flow between ocean basins (Jackson et al. 2014). The North Pacific subspecies (*Megaptera novaeangliae kuzira*) occurs basin-wide, with summering areas in waters of the Russian Far East, Beaufort Sea, Bering Sea, Chukchi Sea, Gulf of Alaska, Western Canada, and the U.S. West Coast. Known wintering areas include waters of Okinawa and Ogasawara in Japan, Philippines, Mariana Archipelago, Hawaiian Islands, Revillagigedos Archipelago, Mainland Mexico, and Central America (Baker et al. 2013, Barlow et al. 2011, Calambokidis et al. 2008, Clarke et al. 2013, Fleming and Jackson 2011, Hashagen et al. 2009). In describing humpback whale population structure in the Pacific, Martien et al. (2020) note that “migratory whale herds”, defined as groups of animals that share the same summering and wintering area, are likely to be demographically independent due to their strong, maternally-inherited fidelity to migratory destinations. Despite whales from multiple wintering areas sharing some summer feeding areas, Baker et al. (2013) reported significant genetic differences between North Pacific summering and wintering areas, driven by strong maternal site fidelity to feeding areas and natal philopatry to wintering areas. This differentiation is supported by photo ID studies showing little interchange of whales between summering areas (Calambokidis et al. 2001).

NMFS has identified 14 distinct population segments (DPSs) of humpback whales worldwide under the Endangered Species Act (ESA) (81 FR 62259, September 8, 2016), based on genetics and movement data (Baker et al. 2013, Calambokidis et al. 2008, Bettridge et al. 2015). In the North Pacific, 4 DPSs are recognized (with ESA listing status), based on their respective low latitude wintering areas: “Western North Pacific” (endangered), “Hawai‘i” (not listed), “Mexico” (threatened), and “Central America” (endangered). The listing status of each DPS was determined following an evaluation of the ESA section 4(a)(1) listing factors as well as an evaluation of demographic risk factors. The evaluation is summarized in the final rule revising the ESA listing status of humpback whales (81 FR 62259, September 8, 2016).

In prior stock assessments, NMFS designated three stocks of humpback whales in the North Pacific: the California/Oregon/Washington (CA/OR/WA) stock, consisting of winter 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; 2) the Central North Pacific stock, consisting of winter populations in the Hawaiian Islands which migrate primarily to northern British Columbia/Southeast Alaska, the Gulf of Alaska, and the Bering Sea/Aleutian Islands; and 3) the Western North Pacific stock, consisting of winter populations off Asia which migrate primarily to Russia and the Bering Sea/Aleutian Islands. These stocks, to varying extents, were not aligned with the more recently identified ESA DPSs (e.g., some stocks were composed of whales from more than one DPS), which led NMFS to reevaluate stock structure under the Marine Mammal Protection Act (MMPA).

NMFS evaluated whether these North Pacific DPSs contain one or more demographically independent populations (DIPs), where demographic independence is defined as "*…the population dynamics of the affected group is more a consequence of births and deaths within the group (internal dynamics) rather than immigration or emigration (external dynamics)*" (NMFS 2016). Evaluation of the four DPSs in the North Pacific by NMFS resulted in the delineation of three DIPs, as well as four "units" that may contain one or more DIPs (Martien et al. 2021, Taylor et al. 2021, Wade et al. 2021, Oleson et al. 2022, Table 1). Delineation of DIPs is based on evaluation of "strong lines of evidence" such as genetics, movement data, and morphology (Martien et al. 2019). From these DIPs and units, NMFS designated five stocks. North Pacific DIPs / units / stocks are described below, along with the lines of evidence used for each. In some cases, multiple units may be combined into a single stock due to lack of sufficient data and/or analytical tools necessary for effective management or for pragmatic reasons (NMFS 2019).

Table 1. DPS of origin for North Pacific humpback whale DIPs, units, and stocks. Names are based on their general winter and summering area linkages. The stock included in *this* report is shown in bold font. All others appear in separate reports.

DPS	ESA Status	DIPs / units	Stocks
Central America	Endangered	Central America - CA-OR-WA DIP	Central America / Southern Mexico - CA-OR-WA stock
Mexico	Threatened	Mainland Mexico - CA-OR-WA DIP	Mainland Mexico – CA-OR-WA stock
		Mexico - North Pacific unit	Mexico - North Pacific stock
Hawaiʻi	Not Listed	Hawaiʻi - North Pacific unit	Hawaiʻi stock
		Hawaiʻi - Southeast Alaska / Northern British Columbia DIP	
Western North Pacific	Endangered	Philippines / Okinawa - North Pacific unit	**Western North Pacific stock**
		Marianas / Ogasawara - North Pacific unit	

Delineation of the **Central America/Southern Mexico – California/Oregon/Washington DIP** is based on two strong lines of evidence indicating demographic independence: genetics and movement data (Taylor et al. 2021). The DIP was designated as a stock because available data make it feasible to manage as a stock and because there are conservation and management benefits to doing so (NMFS 2016, NMFS 2019, NMFS 2022a). Whales in this stock winter off the Pacific coast of Nicaragua, Honduras, El Salvador, Guatemala, Panama, Costa Rica and likely southern coastal Mexico (Taylor et al. 2021). Summer destinations for whales in this DIP include the U.S. West Coast waters of California, Oregon, and Washington (including the Salish Sea, Calambokidis et al. 2017).

Delineation of the **Mainland Mexico – California/Oregon/Washington DIP** is based on two strong lines of evidence indicating demographic independence: genetics and movement data (Martien et al. 2021). The DIP was designated as a stock because available data make it feasible to manage as a stock and because there are conservation and management benefits to doing so (NMFS 2016, NMFS 2019, NMFS 2022b). Whales in this stock winter off the mainland Mexico states of Nayarit and Jalisco, with some animals seen as far south as Colima and Michoacán. Summer destinations for whales in the Mainland Mexico DPS include U.S. West Coast waters of California, Oregon, Washington (including the Salish Sea, Martien et al. 2021), Southern British Columbia, Alaska, and the Bering Sea.

The **Mexico – North Pacific unit** is likely composed of multiple DIPs, based on movement data (Martien et al. 2021, Wade 2021, Wade et al. 2021). However, because currently available data and analyses are not sufficient to delineate or assess DIPs within the unit, it was designated as a single stock (NMFS 2016, NMFS 2019, NMFS 2022b). Whales in this stock winter off Mexico and the Revillagigedo Archipelago and summer primarily in Alaska waters (Martien et al. 2021).

The **Hawaiʻi stock** consists of one DIP - **Hawaiʻi - Southeast Alaska / Northern British Columbia DIP** and one unit - **Hawaiʻi - North Pacific unit,** which may or may not be composed of multiple DIPs (Wade et al. 2021). The DIP and unit are managed as a single stock at this time, due to the lack of data available to separately assess them and lack of compelling conservation benefit to managing them separately (NMFS 2016, NMFS 2019, NMFS 2022c). The DIP is delineated based on two strong lines of evidence: genetics and movement data (Wade et al. 2021). Whales in the Hawaiʻi - Southeast Alaska/Northern British Columbia DIP winter off Hawaiʻi and largely summer in Southeast Alaska and Northern British Columbia, including a small number of whales summering in Southern British Columbia and Washington state waters (Wade et al. 2021). The group of whales that migrate from Russia, western Alaska (Bering Sea and Aleutian Islands), and central Alaska (Gulf of Alaska excluding Southeast Alaska) to Hawaiʻi have been delineated as the **Hawaiʻi-North Pacific unit** (Wade et al. 2021).

The **Western North Pacific (WNP) stock** consists of two units- the **Philippines / Okinawa - North Pacific unit** and the **Marianas / Ogasawara - North Pacific unit**. The units are managed as a single stock at this time, due to a lack of data available to separately assess them (NMFS 2016, NMFS 2019, NMFS 2022d). Recognition of these units is based on movements and genetic data (Oleson et al. 2022). Whales in the Philippines/Okinawa - North Pacific unit winter near the Philippines and in the Ryukyu Archipelago and migrate to summer feeding areas primarily off the Russian mainland (Oleson et al. 2022). Whales that winter off the Mariana Archipelago, Ogasawara, and other areas not yet identified and then migrate to summer feeding areas off the Commander Islands, and to the Bering Sea and Aleutian Islands comprise the Marianas/Ogasawara - North Pacific unit.

This stock assessment report includes information on the **Western North Pacific stock**. The stock definition is largely similar to previous marine mammal stock assessments, with two primary changes. The WNP stock is fully aligned with the WNP DPS and the stock range includes humpback whales in the Mariana Archipelago, as they are now known to be part of this DPS based on both photographic identification matches and genetics (Hill et al. 2020a).

POPULATION SIZE

Between 2004 and 2006, a basin-wide study took place on nearly all North Pacific summer and winter areas (Calambokidis et al. 2008, Barlow et al. 2011, Baker et al. 2013, Wade 2021). The study, known as SPLASH (Structure, Population Levels, And Status of Humpbacks), produced substantial photographic and genetic data which form the basis for the only partial range-wide estimates of population size for WNP humpback whales. SPLASH sampling in Asia was limited to the wintering areas in Okinawa and Ogasawara in Japan, and to the Babuyan Islands in the Philippines. Summer surveys in Russia also identified whales from the Kamchatka Peninsula, the Commander Islands, and Gulf of Anadyr, and from U.S. waters across the Aleutians and Bering Sea. A total of 566 unique individuals were seen in the Okinawa, Ogasawara, and Philippines wintering areas during the three winter field seasons of the SPLASH, and a preliminary mark-recapture abundance estimate of ~1,000 was estimated from the SPLASH data for the "Asia" study area using a multi-strata Hilborn model (Calambokidis et al. 2008). A recent comprehensive reanalysis of the SPLASH data using a multi-strata analysis (Wade et al. 2016, Wade 2021) resulted in an estimate for "Asia" of 1,084 (CV = 0.088) for 2004-2006. SPLASH did not include sampling in the Mariana Archipelago, such that this estimate is likely an underestimate of total population size. However, together with the movement probabilities published in Wade (2021), the portion of the stock that uses summering areas in U.S. waters was estimated by multiplying the probability of movement between each feeding area and the Asian wintering area, and then those abundances were added together. This resulted in an estimate of 127 (CV= 0.741) migrating to summering areas in U.S. waters.

Hill et al. (2020b) derived preliminary annual mark-recapture abundance estimates for their study region near Saipan in the Mariana Archipelago. Using an open population mark-recapture model (the POPAN generalization of the Jolly-Seber model), Hill et al. (2020b) estimated yearly abundances that ranged from 34 (CV = 0.56) whales in 2019 to 126 (CV = 0.35) whales in 2017, with an average of 61 (CV = 0.21) whales across all years. The sampling periods in each year were short relative to the length of the winter breeding season; therefore, the annual abundances potentially underestimate the numbers of whales associated with the study area throughout each winter.

Minimum Population Estimate

The minimum population estimate for this stock is the lower 20th percentile of the Asia wintering area estimate of 1,084 (CV = 0.088) derived from Wade's (2021) multi-strata analysis, which is 1,007 whales, or 75 whales in the U.S. portion of the summer feeding area. The U.S. summer feeding area estimate is not prorated further based on time in U.S. waters given the similarity of this estimate and the preliminary mark-recapture estimates provided for the Mariana Archipelago wintering area. In other words, the U.S summer feeding area estimate is serving as a minimum population estimate for whales in U.S. waters year-round. NMFS' Guidelines for Assessing Marine Mammal Stocks suggest that the N_{MIN} estimate of the stock should be considered unknown if the estimates are more than eight years old, unless there is compelling evidence a stock has not declined since the last estimate (NMFS 2106). While the SPLASH data are more than 15 years old, more recent surveys in portions of the stock's range suggest this is a conservative estimate of total population size given it does not include whales from the Mariana Archipelago, which was not surveyed during SPLASH, nor account for recent increases in the number of whales observed in Russian summer feeding areas (Titova et al. 2018, 2019). The population was also assumed to have increased between 1991-1993 and 2004-2006 (Calambokidis et al. 2008). Additionally, there is no evidence that the apparent declines in humpback whale abundance and calf production following the 2014-2016 marine heatwave in the Gulf of Alaska (Arimitsu et al. 2021, Neilson and Gabriele 2019) affected this stock. For these reasons, the Wade (2021) derived estimate can still be considered a valid minimum population estimate (NMFS 2016).

Current Population Trend

The SPLASH abundance estimate for "Asia" represents a 6.7% annual rate of increase over an abundance estimate from 1991-1993 (Calambokidis et al. 2008), though the 1991-1993 estimate represented only animals photo-identified in Ogasawara and Okinawa, whereas the SPLASH estimate also included effort from the Philippines. Since SPLASH, expanded survey efforts in Russia have yielded a much higher number of whales using some regions, including a sharp increase in the number of whales identified in the Commander Islands, from 17 during SPLASH to 545 in 2010 (Titova et al. 2018). This increase is too great to reflect population growth alone, and may suggest redistribution of whales from other regions, potentially including some not surveyed during SPLASH. The annual rate of increase for the WNP stock is unknown; while it was previously assumed to be increasing, assessments using more recent datasets will be required to assess the current trend.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

There are several studies that have attempted to estimate the annual rate of increase for humpback whale populations in the North Pacific, though most are limited by sampling within a specific study region. Mobley et al. (2001) estimated a trend of 7% per year for 1993-2000 using data from aerial surveys within the main Hawaiian Islands. Mizroch et al. (2004) estimated survival rates for North Pacific humpback whales using mark-recapture methods, and a Pradel model fit to data from Hawaiʻi for 1980-1996, resulting 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 of 6.6% from 1987 to 2003 (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. In contrast, Zerbini et al. (2010) used life history data from humpback whale populations globally to produce plausible rates of population growth and determined two ranges, 7.3% (95% CI: 3.5-10.5%) and 8.6% (95% CI: 5.0-11.4%), depending on how juvenile survival was computed. Although there are no current estimates of growth rate for the WNP stock, it is reasonable to assume a growth rate of at least 6.7% (Calambokidis et al. 2008) derived from SPLASH and earlier abundance estimates.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (1,007) for the Asia wintering area, times one half the estimated population growth rate for this stock of humpback whales (½ of 6.7%), times a recovery factor of 0.1 (for an endangered stock with Nmin < 1,500; Taylor et al. 2003), resulting in a PBR of 3.4. The PBR for the whales that use U.S. waters (minimum population size of 75) is 0.2.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Information for each human-caused mortality, serious injury, and non-serious injury reported for NMFS-managed marine mammals in Alaska between 2016 and 2020 is listed, by marine mammal stock, in Freed et al. (2022); 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 prorated values used for large whale reports with incomplete information, is reported in Freed et al. (2022).

Human-caused mortality and serious injury of humpback whales observed in Alaska includes whales from three stocks: the Mexico-North Pacific stock, the Hawaiʻi stock, and the WNP stock. Human-caused mortality and serious injury data are also available for some other regions of the WNP stock's range, but the data are incomplete and cannot be considered to be a range-wide estimate. To assess human-caused mortality and serious injury of the endangered WNP stock in areas where multiple stocks overlap, mortality and serious injury is prorated using the upper 95th confidence limits of the summering to wintering area movement probabilities reported by Wade (2021). These values are 0.048 (CV = 0.466) for mortality and serious injuries in the Aleutian Islands/Bering Sea and 0.011 (CV = 0.771) for mortality and serious injuries in the Gulf of Alaska.

The minimum estimated mean annual level of human-caused mortality and serious injury for the WNP stock of humpback whales between 2016 and 2020 is 4.46 whales: 0.029 in U.S. commercial fisheries, 4.4 in non-U.S. commercial fisheries, 0.002 in subsistence fisheries, 0.004 in unknown (commercial, recreational, or subsistence) fisheries, 0.012 in marine debris, and 0.011 due to other causes (vessel strikes and intentional unauthorized take) (see text and tables below). However, this estimate is considered a minimum because observers have not been assigned to several fisheries that are known to interact with this stock and, due to limited data, total mortality and serious injury outside of U.S. waters is uncertain. Potential threats most likely to result in direct human-caused mortality or serious injury of this stock include vessel strikes and entanglement in fishing gear and marine debris.

Fisheries Information

U.S. Commercial Fisheries

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 January 2022).

Two humpback whale deaths were observed in the Bering Sea/Aleutian Islands pollock trawl fishery between 2016 and 2020, resulting in a minimum estimated mean annual mortality and serious injury rate of 0.4 humpback whales, of which 0.019 (CV = 0.49) was prorated to the WNP stock (Table 2; Breiwick 2013; MML, unpubl. data).

Table 2. Summary of incidental mortality and serious injury of humpback whales within the range of the Western North Pacific stock due to observed U.S. commercial fisheries between 2016 and 2020. The mean annual mortality estimate is prorated to the WNP stock by multiplying by the area-specific movement probabilities discussed above. Methods for calculating percent observer coverage for Alaska fisheries 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 - overall (CV)	Mean estimated annual mortality of WNP stock (CV)
Bering Sea/Aleutian Islands							
Bering Sea/Aleutian Is. pollock trawl	2016 2017 2018 2019 2020	obs data	99 99 99 98 91	0 0 1 0 1	0 0 1.0 (0.11) 0 1.1 (0.23)	0.4 (0.13)	0.019 (0.49)

Mortality and serious injury in U.S. commercial fisheries within the range of the WNP stock reported to the NMFS Alaska Region marine mammal stranding network and through Marine Mammal Authorization Program (MMAP) fisherman self-reports, for fisheries in which observer data are not available, resulted in a minimum mean annual mortality and serious injury rate of 0.35 humpback whales between 2016 and 2020 (Table 3; Freed et al. 2022). 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 or are self-reported nor are all stranded animals found, reported, or have the cause of death determined.

In summary, the minimum estimate of the mean annual mortality and serious injury rate incidental to U.S. commercial fisheries for the WNP stock between 2016 and 2020 is 0.029 humpback whales, based on observer data from Alaska (Table 2: 0.019) and reports (in which the commercial fishery is confirmed) to the NMFS Alaska Region stranding network (Table 3: 0.010).

Table 3. Summary of mortality and serious injury of humpback whales within the range of the Western North Pacific stock, 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 2016 and 2020 (Freed et al. 2022). 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 Freed et al. (2022). Total mean annual mortality estimates are prorated to the WNP stock by multiplying by the area-specific movement probabilities discussed above.

Cause of injury	2016	2017	2018	2019	2020	Mean annual mortality - total	Mean estimated annual mortality of WNP stock
Bering Sea/Aleutian Islands							
Entangled in Bering Sea/Aleutian Is. commercial Pacific cod pot gear	0	1	0	0	0.75†	0.35	0.01
Entangled in marine debris	1	0	0	0	0	0.2	0.01
Intentional unauthorized take	1	0	0	0	0	0.2	0.01
Gulf of Alaska							
Entangled in subsistence crab pot gear	0	0	0	0.75	0	0.15	0.00
Entangled in shrimp pot gear*	0	0	0	0.75	0	0.15	0.00
Entangled in unidentified fishing gear*	0	0	1	0	0	0.2	0.00
Entangled in marine debris	1	0	0	0	0	0.2	0.00
Vessel strike by AK/WA/OR/CA commercial passenger fishing vessel	0	0.52	0	0	0	0.1	0.00
Vessel strike by recreational vessel	0.2	0	0	0	0	0.04	0.00
TOTALS							
Total in commercial fisheries						0.35	0.01
Total in subsistence fisheries						0.15	0.00
*Total in unknown (commercial, recreational, or subsistence) fisheries						0.35	0.00
Total in marine debris						0.40	0.01
Total due to other causes (intentional unauthorized take, vessel strike)						0.34	0.01

†Stock identification known to be Mexico–North Pacific stock based on known wintering and summering areas.
*Unknown if fishery is commercial, recreational, or subsistence.

Other Fisheries

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 within the range of the WNP stock included: one entanglement in subsistence crab pot gear (with a serious injury prorated at 0.75), resulting in a minimum mean annual mortality and serious injury rate of 0.15 humpback whales, of which 0.002 were prorated to the WNP stock; and two entanglements (one of which was a serious injury prorated at 0.75) in unknown (commercial, recreational, or subsistence) fishing gear, resulting in a minimum mean annual mortality and serious injury rate of 0.35 humpback whales, of which 0.004 were prorated to the WNP stock (Table 3; Freed et al. 2022).

Member nations to the International Whaling Commission (IWC) report fisheries bycatch annually. Such reports are available for Japan and Korea for 2016 to 2020; these data were summarized from the IWC's database of annual progress reports by member nations (https://portal.iwc.int/progressreportspublic, accessed February 2022). China and Russia do not report bycatch to IWC. Japan reported 20 humpback whales died as bycatch in stationary uncovered pound nets from 2016 to 2020. Korea reported two humpback whales killed, one in pot gear and the other in a gillnet. The average mortality rate of humpback whales reported as bycatch in Japanese and Korean fisheries is 4.4 whales per year for 2016 to 2020 (Table 4). All of these are attributed to the WNP stock.

Table 4. Summary of fisheries bycatch reported to the International Whaling Commission by Japan and Korea for 2016 to 2020. Although gear type is reported when known, attribution of bycatch to commercial, recreational, or subsistence fisheries is unknown.

Year	Japan	Gear Type	Korea	Gear Type	Total
2016	11	Stationary uncovered pound net	0		11
2017	3		0		3
2018	3		0		3
2019	3		1	Pot	4
2020	0		1	Gillnet	1
Average 2016-2020					4.4

Fisheries Summary

The minimum estimate of the mean annual mortality and serious injury rate due to interactions with all fisheries between 2016 and 2020 is 4.44 WNP humpback whales (0.029 in U.S. commercial fisheries + 0.002 in subsistence fisheries + 0.004 in unknown fisheries + 4.4 in non-U.S. unknown fisheries). These estimates of mortality and serious injury levels should be considered minimums. Observers have not been assigned to several U.S. fisheries that are known to interact with this stock, and bycatch in foreign fisheries is often unreported or data are not available, making the estimated mortality and serious injury rate an underestimate of actual mortality and serious injury.

Alaska Native Subsistence/Harvest Information

Subsistence hunters in Alaska are not authorized to take humpback whales from this stock, and no takes were reported between 2016 and 2020. 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 2016 and 2020 (0.01 attributed to the WNP stock) (Table 3).

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 January 2022). 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). Humpback whale strandings along the coast of Japan were also higher in 2016 (11) and 2017 (17) than in the recent past (https://portal.iwc.int/progressreportspublic/report, accessed February 2022).

Entanglements in marine debris reported to the NMFS Alaska Region marine mammal stranding network resulted in minimum mean annual mortality and serious injury rates of 0.4 humpback whales within the WNP stock range between 2016 and 2020 (0.012 attributed to the WNP stock, Table 3; Freed et al. 2022). Vessel strikes and other interactions with vessels unrelated to fisheries also occur with humpback whales (Table 3). The minimum mean annual mortality and serious injury rate due to vessel strikes within the range of the WNP stock in Alaska (Table 3) between 2016 and 2020 is 0.14 humpback whales (0.001 attributed to the WNP stock). Most vessel strikes of humpback whales are reported from Southeast Alaska, outside of the range of the WNP stock; however, there are also reports from the south-central, Kodiak Island, and Prince William Sound areas of Alaska (Freed et al. 2022). Vessel collision is also a potential threat to humpback whales in other parts of the WNP stock range. Humpback whales occur off the west side of Saipan where the only harbors on the island are located and vessel traffic is heavy. In 2014, a vessel transporting crew to a Navy ship anchored near the reef was reported to have struck a large whale (Hill et al. 2020c, Pacific Islands Regional Office, unpublished data). No photos were taken of the whale and it was recorded in the report as a possible humpback or sperm whale, but given the shallow-water location it was likely a humpback whale. Personnel from the CNMI Department of Fish and Wildlife responded to the report and found a group of four humpback whales within the immediate area, however none showed signs of recent vessel strike.

Historical Whaling

Whaling for humpback whales in the North Pacific occurred for centuries, with known hunting areas including Japan, Russia, Alaska, and the west coast of North America (Reeves and Smith 2006). The great majority of catches were made by modern whaling (after 1900), with most catches of humpback whales occurring during two periods, first from 1906 to 1928, and then during the post-World War II years from 1948 to 1966 (Ivashchenko and Clapham 2016). 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).

Until recently, the North Pacific-wide catch record was incomplete because of extensive illegal takes by the USSR (Ivashchenko et al. 2013), but recent work has provided what is thought to be a nearly complete catch record. Approximately 37,000-41,000 humpback whales in total were taken from the North Pacific during whaling from 1656 until 1972, with about 31,000 of those taken during the 20th century (1900-1972) (Ivashchenko and Clapham 2021). Catches of North Pacific humpbacks were prohibited beginning in the 1966 season, but catches were already very low by that time, and it was assumed that North Pacific populations had been greatly over-exploited at that point. Illegal takes of humpbacks in the North Pacific by the USSR continued until 1972 (Ivashchenko and Clapham 2016). Preliminary analyses as part of a Comprehensive Assessment of North Pacific humpback whales by the Scientific Committee of the International Whaling Commission suggest that most breeding populations in the North Pacific were depleted at that time (Ivashchenko et al. 2016), but definitive conclusions cannot be reached until that Comprehensive Assessment is completed.

STATUS OF STOCK

The WNP stock of humpback whales is equivalent to the “WNP DPS” of humpback whales listed as endangered under the ESA (Bettridge et al. 2015, Oleson et al. 2022); thus, it is considered a strategic and depleted stock under the MMPA. Total annual human-caused serious injury and mortality of humpback whales is the sum of bycatch reported by foreign nations (4.4/yr) and all takes attributed to this stock in U.S. waters (commercial, subsistence, and unknown fisheries, marine debris, and other causes including vessel strikes; 0.06/yr) for a total of 4.46 WNP humpback whales annually. The stock-wide PBR (3.4) is exceeded. Total U.S. commercial fishery mortality and serious injury (0.03/yr) is less than the PBR (0.2) for the portion of the stock occurring in U.S. waters. There is no estimate of the undocumented fraction of anthropogenic injuries and deaths to humpback whales on the

U.S. summer or winter feeding areas. The Comprehensive Assessment of North Pacific humpback whales by the Scientific Committee of the IWC, when completed, may provide information on whether breeding populations in the North Pacific are currently estimated to be depleted.

HABITAT CONCERNS

This stock is the focus of a moderate whale-watching industry in the Okinawa and Ogasawara wintering areas. In land-based studies in both Hawaiʻi and Southeast Alaska, the presence of vessels was shown to induce energetically demanding avoidance behaviors in humpback whales. These include changes such as increases in swim speed and changes in swimming direction as well as several other changes in respiration metrics such as decreases in dive times, increased respiration rate, and decreased inter-breath intervals (Schuler et al. 2019, Currie et al. 2021).

Increasing levels of anthropogenic sound in the world's oceans (Andrew et al. 2002), such as those produced by shipping traffic, or LFA (Low Frequency Active) sonar, is a habitat concern for whales, as it can reduce acoustic space used for communication (masking) (Clark et al. 2009, NOAA 2016). This can be particularly problematic for baleen whales that may communicate using low-frequency sound (Erbe 2016). Based on vocalizations (Richardson et al. 1995; Au et al. 2006), reactions to sound sources (Lien et al. 1990, 1992; Maybaum 1993), and anatomical studies (Hauser et al. 2001), humpback whales also appear to be sensitive to mid-frequency sounds, including those used in active sonar military exercises (U.S. Navy 2007).

Other potential concerns for this stock include harmful algal blooms (Geraci et al. 1989), possible changes in prey distribution with climate change, vessel strikes due to increased vessel traffic (e.g., from increased shipping in higher latitudes), oil and gas activities, an overlap between humpback whales and high concentrations of marine debris, and exposure to blast fishing in the Philippines (Acebes et al. 2008). In a study that quantified the amount and type of marine debris accumulation in Hawaiʻi coastal waters from 2013 to 2016, the degree of overlap between marine debris and cetacean distribution was greatest for humpback whales (Currie et al. 2017).

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HUMPBACK WHALE (*Megaptera novaeangliae kuzira*) - Hawai'i Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

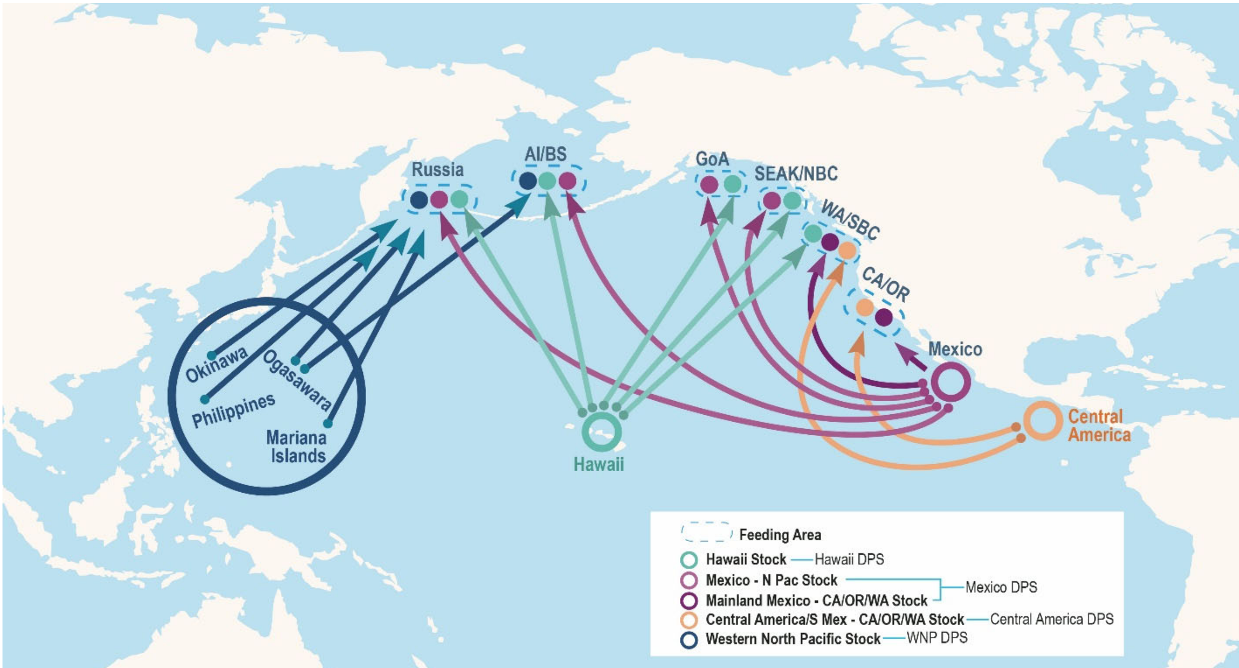

Figure 1. Pacific basin map showing wintering areas of five humpback whale stocks mentioned in this report. Also shown are summering feeding areas mentioned in the text. High-latitude summer feeding areas include Russia, Aleutian Islands / Bering Sea (AI/BS), Gulf of Alaska (GoA), Southeast Alaska / Northern British Columbia (SEAK/NBC), Washington / Southern British Columbia (WA/SBC), and California / Oregon (CA/OR).

Humpback whales occur worldwide and migrate seasonally from high latitude subarctic and temperate summering areas to low latitude subtropical and tropical wintering areas. Three subspecies are recognized globally (North Pacific, Atlantic, and Southern Hemisphere), based on restricted gene flow between ocean basins (Jackson et al. 2014). The North Pacific subspecies (*Megaptera novaeangliae kuzira*) occurs basin-wide, with summering areas in waters of the Russian Far East, Beaufort Sea, Bering Sea, Chukchi Sea, Gulf of Alaska, Western Canada, and the U.S. West Coast. Known wintering areas include waters of Okinawa and Ogasawara in Japan, Philippines, Mariana Archipelago, Hawaiian Islands, Revillagigedos Archipelago, Mainland Mexico, and Central America (Baker et al. 2013, Barlow et al. 2011, Calambokidis et al. 2008, Clarke et al. 2013, Fleming and Jackson 2011, Hashagen et al. 2009). In describing humpback whale population structure in the Pacific, Martien *et al.* (2020) note that "migratory whale herds", defined as groups of animals that share the same summering and wintering area, are likely to be demographically independent due to their strong, maternally-inherited fidelity to migratory destinations. Despite whales from multiple wintering areas sharing some summer feeding areas, Baker et al. (2013) reported significant genetic differences between North Pacific summering and wintering areas, driven by strong maternal site fidelity to feeding areas and natal philopatry to wintering areas. This differentiation is supported by photo ID studies showing little interchange of whales between summering areas (Calambokidis et al. 2001).

NMFS has identified 14 distinct population segments (DPSs) of humpback whales worldwide under the Endangered Species Act (ESA) (81 FR 62259, September 8, 2016), based on genetics and movement data (Baker et al. 2013, Calambokidis et al. 2008, Bettridge et al. 2015). In the North Pacific, 4 DPSs are recognized (with ESA listing status), based on their respective low latitude wintering areas: "Western North Pacific" (endangered), "Hawai'i" (not listed), "Mexico" (threatened), and "Central America" (endangered). The listing status of each DPS was determined following an evaluation of the ESA section 4(a)(1) listing factors as well as an evaluation of demographic risk factors. The evaluation is summarized in the final rule revising the ESA listing status of humpback whales (81 FR 62259, September 8, 2016).

In prior stock assessments, NMFS designated three stocks of humpback whales in the North Pacific: the California/Oregon/Washington (CA/OR/WA) stock, consisting of winter 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; 2) the Central North Pacific stock, consisting of winter populations in the Hawaiian Islands which migrate primarily to northern British Columbia/Southeast Alaska, the Gulf of Alaska, and the Bering Sea/Aleutian Islands; and 3) the Western North Pacific stock, consisting of winter populations off Asia which migrate primarily to Russia and the Bering Sea/Aleutian Islands. These stocks, to varying extents, were not aligned with the more recently identified ESA DPSs (e.g., some stocks were composed of whales from more than one DPS), which led NMFS to reevaluate stock structure under the Marine Mammal Protection Act (MMPA).

NMFS evaluated whether these North Pacific DPSs contain one or more demographically independent populations (DIPs), where demographic independence is defined as "*...the population dynamics of the affected group is more a consequence of births and deaths within the group (internal dynamics) rather than immigration or emigration (external dynamics)*" (NMFS 2016). Evaluation of the four DPSs in the North Pacific by NMFS resulted in the delineation of three DIPs, as well as four "units" that may contain one or more DIPs (Martien et al. 2021, Taylor et al. 2021, Wade et al. 2021, Oleson et al. 2022, Table 1). Delineation of DIPs is based on evaluation of "strong lines of evidence" such as genetics, movement data, and morphology (Martien et al. 2019). From these DIPs and units, NMFS designated five stocks. North Pacific DIPs / units / stocks are described below, along with the lines of evidence used for each. In some cases, multiple units may be combined into a single stock due to lack of sufficient data and/or analytical tools necessary for effective management or for pragmatic reasons (NMFS 2019).

Table 1. DPS of origin for North Pacific humpback whale DIPs, units, and stocks. Names are based on their general winter and summering area linkages. The stock included in *this* report is shown in bold font. All others appear in separate reports.

DPS	ESA Status	DIPs / units	Stocks
Central America	Endangered	Central America - CA-OR-WA DIP	Central America / Southern Mexico - CA-OR-WA stock
Mexico	Threatened	Mainland Mexico - CA-OR-WA DIP	Mainland Mexico – CA-OR-WA stock
		Mexico - North Pacific unit	Mexico - North Pacific stock
Hawai‘i	Not Listed	Hawai‘i - North Pacific unit	**Hawai‘i stock**
		Hawai‘i - Southeast Alaska / Northern British Columbia DIP	
Western North Pacific	Endangered	Philippines / Okinawa - North Pacific unit	Western North Pacific stock
		Marianas / Ogasawara - North Pacific unit	

Delineation of the **Central America/Southern Mexico – California/Oregon/Washington DIP** is based on two strong lines of evidence indicating demographic independence: genetics and movement data (Taylor et al. 2021). The DIP was designated as a stock because available data make it feasible to manage as a stock and because there are conservation and management benefits to doing so (NMFS 2016, NMFS 2019, NMFS 2022a). Whales in this stock winter off the Pacific coast of Nicaragua, Honduras, El Salvador, Guatemala, Panama, Costa Rica and likely southern coastal Mexico (Taylor et al. 2021). Summer destinations for whales in this DIP include the U.S. West Coast waters of California, Oregon, and Washington (including the Salish Sea, Calambokidis et al. 2017).

Delineation of the **Mainland Mexico – California/Oregon/Washington DIP** is based on two strong lines of evidence indicating demographic independence: genetics and movement data (Martien et al. 2021). The DIP was designated as a stock because available data make it feasible to manage as a stock and because there are conservation and management benefits to doing so (NMFS 2016, NMFS 2019, NMFS 2022b). Whales in this stock winter off the mainland Mexico states of Nayarit and Jalisco, with some animals seen as far south as Colima and Michoacán. Summer destinations for whales in the Mainland Mexico DPS include U.S. West Coast waters of California, Oregon, Washington (including the Salish Sea, Martien et al. 2021), Southern British Columbia, Alaska, and the Bering Sea.

The **Mexico – North Pacific unit** is likely composed of multiple DIPs, based on movement data (Martien et al. 2021, Wade 2021, Wade et al. 2021). However, because currently available data and analyses are not sufficient to delineate or assess DIPs within the unit, it was designated as a single stock (NMFS 2016, NMFS 2019, NMFS 2022b). Whales in this stock winter off Mexico and the Revillagigedo Archipelago and summer primarily in Alaska waters (Martien et al. 2021).

The **Hawai'i stock** consists of one DIP - **Hawai'i - Southeast Alaska / Northern British Columbia DIP** and one unit - **Hawai'i - North Pacific unit,** which may or may not be composed of multiple DIPs (Wade et al. 2021). The DIP and unit are managed as a single stock at this time, due to the lack of data available to separately assess them and lack of compelling conservation benefit to managing them separately (NMFS 2016, NMFS 2019, NMFS 2022c). The DIP is delineated based on two strong lines of evidence: genetics and movement data (Wade et al. 2021). Whales in the Hawai'i - Southeast Alaska/Northern British Columbia DIP winter off Hawai'i and largely summer in Southeast Alaska and Northern British Columbia, including a small number of whales summering in Southern British Columbia and Washington state waters (Wade et al. 2021). The group of whales that migrate from Russia, western Alaska (Bering Sea and Aleutian Islands), and central Alaska (Gulf of Alaska excluding Southeast Alaska) to Hawai'i have been delineated as the **Hawai'i-North Pacific unit** (Wade et al. 2021).

The **Western North Pacific stock** consists of two units- the **Philippines / Okinawa - North Pacific unit** and the **Marianas / Ogasawara - North Pacific unit**. The units are managed as a single stock at this time, due to a lack of data available to separately assess them (NMFS 2016, NMFS 2019, NMFS 2022d). Recognition of these units is based on movements and genetic data (Oleson et al. 2022). Whales in the Philippines /Okinawa - North Pacific unit winter near the Philippines and Ryukyu Archipelago and migrate to summer feeding areas primarily off the Russian mainland (Oleson et al. 2022). Whales that winter off the Mariana Archipelago, Ogasawara, and other areas not yet identified and then migrate to summer feeding areas off the Commander Islands, and to the Bering Sea and Aleutian Islands comprise the Marianas / Ogasawara - North Pacific unit.

This stock assessment report includes information on the Hawai'i stock. In previous marine mammal stock assessments, humpback whales that used the Hawai'i wintering area were considered to be the "Central North Pacific" stock, but that stock also included all whales in Alaska, which included multiple DPSs (i.e., whales from the Western North Pacific and Mexico DPSs, as well as Hawai'i), so the Hawai'i stock is not equivalent to the previous Central North Pacific stock for that reason. Whales in Alaska from the Western North Pacific and Mexico DPSs are now included in other stock assessment reports. Also, whales from the Hawai'i DPS previously included in the "California-Oregon-Washington" stock (i.e., whales that feed off Washington) are now included in the Hawai'i stock.

Population Size

Population Size in Hawai'i

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). A total of 2,367 unique individuals were seen in the Hawaiian wintering areas during the three winter field seasons of the SPLASH, and a preliminary mark-recapture abundance estimate of ~10,000 was estimated from the SPLASH data for Hawai'i study using a multi-strata Hilborn model (Calambokidis et al. 2008). Wade et al. (2016) and Wade (2021) finalized the multi-strata analysis, including providing a CV and confidence limits, resulting in an estimate for Hawai'i of 11,540 (CV = 0.042) for 2004-2006.

Data from multiple line-transect surveys since 2002 have been used to develop and update species distribution models (SDMs) for cetaceans within the U.S. Exclusive Economic Zone (EEZ) around the Hawaiian Islands (Becker et al. 2012, 2021; Forney et al. 2015), but these surveys were primarily in summer and fall. Until recently, systematic ship survey data in the winter months were limited to a single focused survey of the Main Hawaiian Islands (MHI) from 6–24 February 2009 (PIFSC 2009), and a few ship transits in proximity to the MHI. To better understand the abundance and distribution of cetaceans in the winter months, a winter survey (Winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey, or WHICEAS) was conducted within offshore waters around the MHI from 18 January to 12 March 2020 (Yano et al. 2020). Becker et al. (2022) used the 2002-2020 survey data, along with environmental variables, to build an SDM to estimate the density and abundance of humpback whales in the Hawaiian Islands EEZ for recent years (2017-2020). Since a significant seasonal difference in abundance was evident for humpback whales, the final SDM was used to derive spatially-explicit monthly density estimates based on the average of weekly predictions spanning 2017–2020. Peak numbers of humpback whales are expected to occur within the Hawaiian Islands EEZ from approximately mid-February to mid-March (Au et al. 2000). The functional plot for Julian date in the SDM was consistent with these findings, with peak numbers of humpback whales expected to occur within the Hawaiian Islands EEZ from approximately February 19 through March 22 (Becker et al. 2022). Therefore, to obtain a single abundance estimate, weekly predictions for this time period were averaged to estimate the density and number of whales within the study area during 2020, the most recent year in the time series and the year of the WHICEAS survey effort. This estimate represents the peak abundance of humpback whales in the Hawaiian Islands EEZ during 2020, but may under-represent the full abundance of whales that overwinter in the region because individual whales may not have a very long residence time in Hawai'i; Craig et al. (2001) found that for the majority of whales (66%), two weeks or less elapsed between their first and last identification within the same field season. Therefore, some individual whales might only be found in Hawai‘i outside of the peak period. The resulting estimate of abundance was 11,278 (CV = 0.56, 95% CI 4,049-31,412) (Becker et al. 2022), which is considered the best current estimate of abundance for Hawai‘i and for the stock as a whole.

Population Size in Summer Areas

Although the population size and estimate of minimum abundance for the stock are based on the abundance in Hawai‘i**,** abundance information from the summer feeding areas is also summarized here. The only comprehensive survey throughout most of the summer range was the SPLASH survey in 2004-2006. Resulting abundance estimates from a multi-strata mark-recapture analysis resulted in abundance estimates of 1,340 (CV = 0.30) for Russia, 7,758 for the Bering Sea and Aleutian Islands (CV = 0.20), 2,129 for the Gulf of Alaska (including the Shumagin Islands, CV = 0.081), 5,890 (CV = 0.08) for Southeast Alaska and northern British Columbia, and 347 (CV = 0.26) for southern British Columbia (CV = 0.26) (Wade et al. 2016, Wade 2021). However, in all of those areas those abundance estimates represent a mixture of whales from up to three winter areas, the western North Pacific (Asia), Hawai‘i, and Mexico, and so cannot represent the abundance of just the Hawai‘i stock in its summer areas. The one near exception is Southeast Alaska and northern British Columbia, where >90% of the whales were estimated to be from Hawai‘i at the time of the SPLASH surveys (Wade 2021, Lizewski et al 2021). Therefore, that abundance estimate (5,890) could serve as an estimate of the number of whales in the Hawai‘i - Southeast Alaska / Northern British Columbia DIP, though that estimate is now more than fifteen years old.

Relatively few estimates of abundance have been made for humpback whales in the summer areas of the Hawai‘i stock in the last decade, with most that are available being for relatively small portions of the range (e.g., Teerlink et al. 2015, Rone et al. 2017, Gabriele et al. 2017). One exception was a line-transect survey throughout nearly all humpback whale habitat in British Columbia, with estimates of 4,935 (CV = 0.13) for the offshore area, 1,816 (CV = 0.13) for the North Coast area, and 279 (CV = 0.40) for the Salish Sea area (inland waters of the Strait of Georgia and Strait of Juan de Fuca) (Wright et al. 2021). The first two of those areas correspond to the northern British Columbia stratum during the SPLASH project, while the third area corresponds to the southern British Columbia stratum. Therefore, the summed estimate of 6,751 would represent the abundance of the northern British Columbia portion of the Hawai‘i - Southeast Alaska / Northern British Columbia DIP. A more recent estimate of abundance for Southeast Alaska, if it becomes available, could be added to this to represent the abundance of the total DIP.

There are no recent abundance estimates for the summer range of the Hawai‘i - North Pacific unit.

Minimum Population Estimate

The minimum population estimate for this stock is the lower 20th percentile of the 2020 estimate from Hawai‘i of 11,278 (CV = 0.56; Becker et al. 2022), which is 7,265.

Current Population Trend

Until recently, most evidence indicated the number of humpback whales in Hawai‘i and Alaska have been increasing for decades. For example, a 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 Hawai‘i 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 within the main Hawaiian Islands. Mizroch et al. (2004) estimated a rate of increase of 10% per year (95% CI: 3-16%) for humpbacks in Hawai‘i from a Pradel mark-recapture model fit to data from Hawai‘i for 1980 to 1996. For shelf waters of the northern Gulf of Alaska, Zerbini et al. (2006) estimated an annual rate of increase for humpback whales of 6.6% (95% CI: 5.2-8.6%) from 1987 to 2003. Comparisons of SPLASH abundance estimates for Hawai‘i 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. Teerlink et al. (2015) estimated an average annual rate of increase of 4.53% (95 % CI 3.28–5.79 %) for 1978-2009 for humpback whales in Prince William Sound, Alaska. Gabriele et al. (2017) estimated an annual rate of increase of 5.1% (95% CI -1.3-11.9%) from 1985-2013 for Glacier Bay and Icy Strait in Southeast Alaska.

Recently, however, the encounter rate of humpback whales and the number of calves declined in Prince William Sound after the marine heatwave in the Gulf of Alaska in 2014-2016, presumably due to disruption of lower trophic level prey (Arimitus et al. 2021). A large whale Unusual Mortality Event in the western Gulf of Alaska in 2015-2016 (Savage 2017) suggested this was, at least partially, a true decline rather than just a shift in distribution. A similar decline in abundance and calf production rates of humpback whales in Glacier Bay and Icy Strait in Southeast

Alaska (Neilson and Gabriele 2019) indicates this decline may have occurred widely throughout the Gulf of Alaska. Therefore, it is unknown if this population is currently increasing.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

There are several studies that have attempted to estimate the annual rate of increase for humpback whale populations in the North Pacific, though most are limited by sampling within a specific study region. Zerbini et al. (2010) analyzed life history rates to estimate that rates of increase for humpback whales can theoretically be as high as 12%, and observed rates of increase approximately that high have been observed in several Southern Hemisphere populations. Estimated rates of increase for the Hawai'i stock include values for Hawai'i of 7.0% from aerial surveys (Mobely et al. 2001), 5.5-6.0% from mark-recapture abundance estimates (Calambokidis et al. 2008), 10% (95% CI: 3-16%) from a model fit to mark-recapture data (Mizroch et al. 2004), and a value for the northern Gulf of Alaska of 6.6% (95% CI: 5.2-8.6%) from ship surveys (Zerbini et al. 2006). Although there is no estimate of the maximum net productivity rate (R_{MAX}) for the stock, it is reasonable to assume that R_{MAX} for this stock would be at least 7%. Until additional data become available for the Hawai'i humpback whale stock, 7% will be used as R_{MAX} for this stock.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (7,265) times one half the estimated population growth rate for this stock of humpback whales (½ of 0.07) times a recovery factor of 0.5 (for a stock of unknown status relative to OSP), resulting in a PBR of 127.

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 2016 and 2020 is listed, by marine mammal stock, in Freed et al. (2022); 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 Freed et al. (2022).

Human-caused mortality and serious injury of humpback whales observed in Alaska includes whales from three stocks: the Mexico-North Pacific stock, the Hawai'i stock, and the Western North Pacific stock. Human-caused mortality and serious injury of the Hawai'i stock also occurs in British Columbia, Washington, and Hawai'i. Mortality and serious injury data are not currently available for British Columbia, although some information is available on humpback whales in Hawai'i carrying British Columbia fishing gear. Mortality and serious injury of humpback whales in Washington is currently prorated only between the Central America / Southern Mexico – CA-OR-WA stock and the Mainland Mexico – CA-OR-WA stock and is reported in those stock assessment reports.

To assess human-caused mortality and serious injury of the Hawai'i stock in areas where multiple stocks overlap, mortality and serious injury is prorated using point estimates of the summering to wintering area movement probabilities reported by Wade (2021) (Table 2).

Table 2. Movement probabilities from Wade (2021) used for prorating human-caused mortality and serious injury to the Hawai'i - Southeast Alaska / Northern British Columbia DIP and the Hawai'i - North Pacific unit, which together comprise the Hawai'i stock.

DIP/Unit	Location of Mortality or Serious Injury			
	Aleutian Islands/Bering Sea	Gulf of Alaska	Southeast Alaska	Hawai'i
Hawai'i - Southeast Alaska / Northern British Columbia DIP	-	-	0.976 (CV = 0.006)	0.798 (CV = 0.043)
Hawai'i - North Pacific unit	0.91 (CV = 0.28)	0.89 (CV = 0.022)	-	0.202 (CV = 0.170)

The minimum estimated mean annual level of human-caused mortality and serious injury for the Hawai'i stock of humpback whales between 2016 and 2020 is 19.62 whales: 7.65 in U.S. commercial fisheries, 0.2 in Canadian commercial fisheries, 0.29 in recreational fisheries, 0.28 in subsistence fisheries, 4.6 in unknown (commercial, recreational, or subsistence) fisheries, 1.1 in marine debris, and 5.5 due to other causes (vessel strikes and entanglement in an Alaska Department of Fish and Game (ADF&G) salmon net pen and in mooring gear). This estimate is considered a minimum because observers have not 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. Potential threats most likely to result in direct human-caused mortality or serious injury of this stock include vessel strikes and entanglement in fishing gear and marine debris.

Fisheries Information

U.S. Commercial Fisheries

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 January 2022).

Two humpback whale mortalities were observed in the Bering Sea/Aleutian Islands pollock trawl fishery between 2016 and 2020, resulting in a minimum estimated mean annual mortality and serious injury rate of 0.4 humpback whales, of which 0.36 were prorated to the Hawaiʻi stock (Table 3; Breiwick 2013; MML, unpubl. data). No humpback whales were seriously injured or killed in the Hawaiʻi longline fisheries between 2016 and 2020, although one unidentified cetacean described as a probable humpback whale was non-seriously injured in the Hawaiʻi deep-set longline fishery in 2019 (Bradford 2018a, 2018b, 2020, 2021; 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 humpback whales in 2012 and 2013, of which 5.4 were prorated to the Hawaiʻi stock (Table 3). Because these three districts represent only a portion of the overall fishing effort in this fishery, this is considered to be a minimum estimate of mortality and serious injury for the fishery.

Mortality and serious injury in U.S. commercial fisheries within the range of the Hawaiʻi stock reported to the NMFS Alaska Region and Pacific Islands Region marine mammal stranding networks and through Marine Mammal Authorization Program (MMAP) fisherman self-reports, for fisheries in which observer data are not available, resulted in a minimum mean annual mortality and serious injury rate of 1.90 humpback whales in Alaska between 2016 and 2020, of which 1.69 were prorated to the Hawaiʻi stock (Table 4; Freed et al. 2022), and 0.2 humpback whales in Hawaiʻi, all of which were attributed to the Hawaiʻi stock (Table 5; Bradford and Lyman 2018, 2019, 2020; NMFS-PIFSC unpubl. data). These 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 summary, the minimum estimate of the mean annual mortality and serious injury rate incidental to U.S. commercial fisheries for the Hawaiʻi stock between 2016 and 2020 is 7.65 humpback whales, based on observer data from Alaska (Table 3: 5.76) and reports (in which the commercial fishery is confirmed) to the NMFS Alaska Region stranding network (Table 4: 1.69) and to the NMFS Pacific Islands Region stranding network (Table 5: 0.2).

Other Fisheries

Reports to the NMFS Alaska Region and NMFS Pacific Islands Region marine mammal stranding networks of swimming, floating, or beachcast humpback whales entangled in fishing gear or with injuries caused by interactions with gear within the range of the Hawaiʻi stock between 2016 and 2020 include: two entanglements (each with a serious injury prorated at 0.75) in recreational pot fisheries gear, resulting in a minimum mean annual mortality and serious injury rate of 0.3 whales, of which 0.29 were prorated to the Hawaiʻi stock (Table 4; Freed et al. 2022); entanglements in subsistence crab pot gear and in unidentified subsistence gillnet (each with a serious injury prorated at 0.75), resulting in a minimum mean annual mortality and serious injury rate of 0.3 humpback whales, of which 0.28 were prorated to the Hawaiʻi stock (Table 4; Freed et al. 2022); and entanglements in unknown (commercial, recreational, or subsistence) fishing gear, resulting in a minimum mean annual mortality and serious injury rate of 4.65 humpback whales (0.9 in Alaska; Table 4; Freed et al. 2022; and 3.8 in Hawaiʻi; Table 5; Bradford and Lyman 2018, 2019, 2020; NMFS-PIFSC unpubl. data), of which 4.6 were prorated to the Hawaiʻi stock. There was also a report of a whale seen in Hawaiʻi carrying commercial pot gear from British Columbia, resulting in a minimum mean annual mortality and serious injury rate of 0.2 (Table 5; Bradford and Lyman 2018, 2019, 2020; NMFS-PIFSC unpubl. data), all attributed to the Hawai‘i stock.

Fisheries Summary

The minimum mean annual mortality and serious injury rate due to interactions with all fisheries between 2016 and 2020 is 13.02 Hawai‘i humpback whales (7.65 in commercial fisheries + 0.29 in recreational fisheries + 0.28 in subsistence fisheries + 4.6 in unknown fisheries + 0.2 in Canadian commercial fisheries). These estimates should be considered minimums. Observers have not 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.

Table 3. Summary of incidental mortality and serious injury of humpback whales due to observed U.S. commercial fisheries between 2016 and 2020 (or the most recent data available) and the mean annual mortality and serious injury rate (Breiwick 2013; Manly 2015; MML, unpubl. data). Mean annual mortality estimates are prorated to the Hawai‘i - Southeast Alaska / Northern British Columbia (HI-SEAK/NBC) DIP and the Hawai‘i - North Pacific (HI-NPac) unit, which together comprise the Hawai‘i stock, by multiplying by the area-specific movement probabilities in Table 2. Methods for calculating percent observer coverage for Alaska fisheries 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 - overall (CV)**	**Mean estimated annual mortality – by DIP/unit**	
							DIP/unit	**Estimate (CV)**
Bering Sea/Aleutian Islands								
Bering Sea/Aleutian Is. pollock trawl	2016 2017 2018 2019 2020	obs data	99 99 99 98 91	0 0 1 0 1	0 0 1.0 (0.11) 0 1.1 (0.23)	0.4 (0.13)	HI-NPac	0.36 (0.13)
Southeast Alaska								
Southeast Alaska salmon drift gillnet (Districts 6, 7, 8)	2012 2013	obs data	6.4 6.6	0 1	0 11	5.5 (1.0)	HI-SEAK/NBC	5.4 (1.0)
Minimum total estimated annual mortality						5.9 (0.93)	HI-SEAK/NBC	5.4 (1.0)
							HI-NPac	0.36 (0.13)

Table 4. Summary of mortality and serious injury of 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 2016 and 2020 (Freed et al. 2022). 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 Freed et al. (2022). Total mean annual mortality estimates are prorated to the Hawaiʻi - Southeast Alaska / Northern British Columbia (HI-SEAK/NBC) DIP and the Hawaiʻi - North Pacific (HI-NPac) unit, which together comprise the Hawaiʻi stock, by multiplying by the area-specific movement probabilities in Table 2.

Cause of injury	2016	2017	2018	2019	2020	Mean annual mortality - total	Mean estimated annual mortality – by DIP/unit	
Bering Sea/Aleutian Islands								
Entangled in Bering Sea/Aleutian Is. commercial Pacific cod pot gear	0	1	0	0	0.75[a]	0.35	HI-NPac	0.18
Entangled in marine debris	1	0	0	0	0	0.2	HI-NPac	0.18
Gulf of Alaska								
Entangled in subsistence crab pot gear	0	0	0	0.75	0	0.15	HI-NPac	0.13
Entangled in shrimp pot gear*	0	0	0	0.75	0	0.15	HI-NPac	0.13
Entangled in unidentified fishing gear*	0	0	1	0	0	0.2	HI-NPac	0.18
Entangled in marine debris	1	0	0	0	0	0.2	HI-NPac	0.18
Vessel strike by AK/WA/OR/CA commercial passenger fishing vessel	0	0.52	0	0	0	0.1	HI-Npac	0.09
Vessel strike by recreational vessel	0.2	0	0	0	0	0.04	HI-Npac	0.04
Southeast Alaska								
Entangled in Southeast Alaska commercial salmon drift gillnet (in ADF&G Districts that were not observed in 2012 and 2013)	2.25	0	1.5	0	1.75 + 0.75[b]	1.25	HI-SEAK/NBC	1.22
Entangled in Southeast Alaska commercial pot gear	0	0	0	0	0.75	0.15	HI-SEAK/NBC	0.15
Entangled in unidentified commercial longline gear	0	0	0	0	0.75	0.15	HI-SEAK/NBC	0.15
Entangled in Southeast Alaska recreational shrimp pot gear	0	0	0.75	0	0	0.15	HI-SEAK/NBC	0.15
Entangled in unidentified recreational pot gear	0	0	0	0.75	0	0.15	HI-SEAK/NBC	0.15

Cause of injury	2016	2017	2018	2019	2020	Mean annual mortality - total	Mean estimated annual mortality – by DIP/unit	
Entangled in unidentified subsistence gillnet	0.75	0	0	0	0	0.15	HI-SEAK/NBC	0.15
Entangled in shrimp pot gear*	0	0	0	0.75	0	0.15	HI-SEAK/NBC	0.15
Entangled in unidentified fishing gear*	0	1	0	0.75	0	0.35	HI-SEAK/NBC	0.34
Entangled in marine debris	2.25	0.75	0	0.75	0	0.75	HI-SEAK/NBC	0.73
Entangled in ADF&G salmon net pen	0.75	0	0	0	0	0.15	HI-SEAK/NBC	0.15
Entangled in mooring gear	0.75	0	0	0	0	0.15	HI-SEAK/NBC	0.15
Vessel strike	1	1.34	3	3	0.4	1.75	HI-SEAK/NBC	1.71
Vessel strike by AK/WA/OR/CA commercial passenger fishing vessel	0	0.2	0	0	0	0. 04	HI-SEAK/NBC	0.04
TOTALS								
Total in commercial fisheries						1.90	HI-SEAK/NBC	1.51
							HI-NPac	0.18
Total in recreational fisheries						0.30	HI-SEAK/NBC	0.29
							HI-NPac	0.00
Total in subsistence fisheries						0.30	HI-SEAK/NBC	0.15
							HI-NPac	0.13
*Total in unknown (commercial, recreational, or subsistence) fisheries						0.85	HI-SEAK/NBC	0.49
							HI-NPac	0.31
Total in marine debris						1.15	HI-SEAK/NBC	0.73
							HI-NPac	0.36
Total due to other causes (entangled in salmon net pen, entangled in mooring gear, vessel strike)						2.23	HI-SEAK/NBC	2.04
							HI-NPac	0.13

[a]Animal known to be from the Mexico – North Pacific stock based on known wintering and summering areas.
[b]Animal was entangled in both AK SEAK salmon drift gillnet gear and AK salmon troll gear.
* Unknown if fishery is commercial, recreational, or subsistence.

Table 5. Summary of mortality and serious injury of humpback whales reported to the NMFS Pacific Islands Region stranding network between 2016 and 2020 (Bradford and Lyman 2018, 2019, 2020; NMFS-PIFSC, unpubl. data). Total mean annual mortality estimates are prorated to the Hawai‘i - Southeast Alaska / Northern British Columbia (HI-SEAK/NBC) DIP and the Hawai‘i - North Pacific (HI-NPac) unit, which together comprise the Hawai‘i stock, by multiplying by the area-specific movement probabilities in Table 2.

Cause of injury	2016	2017	2018	2019	2020	Mean annual mortality - overall	Mean estimated annual mortality - by DIP/unit	
Hawai‘i								
Entangled in commercial Alaska king crab or cod pot gear	0	0	0	1	0	0.2	HI-SEAK/NBC	0.2
							HI-NPac	0.0
Entangled in British Columbia commercial pot gear	0	0	0	1	0	0.2	HI-SEAK/NBC	0.2
							HI-NPac	0.0
Entangled in unidentified British Columbia pot gear*	0	0	2	0	0	0.4	HI-SEAK/NBC	0.3
							HI-NPac	0.1
Entangled in unidentified gillnet*	0	0	1	0	0	0.2	HI-SEAK/NBC	0.2
							HI-NPac	0 0
Entangled in unidentified fishing gear*	2.5	5.25	4	4	0	3. 2	HI-SEAK/NBC	2.5
							HI-NPac	0.6
Vessel strike	0.2	1.2	4	2.2	9	3.3	HI-SEAK/NBC	2.6
							HI-NPac	0.7
Total in U.S commercial fisheries						0.2	HI-SEAK/NBC	0.2
							HI-NPac	0.0
Total in Canadian commercial fisheries						0.2	HI-SEAK/NBC	0.2
							HI-NPac	0.0
*Total in unknown (commercial, recreational, or subsistence) fisheries						3.8	HI-SEAK/NBC	3.0
							HI-NPac	0.8
Total due to other causes (vessel strike)						3.3	HI-SEAK/NBC	2.6
							HI-NPac	0.7

* Unknown if fishery is commercial, recreational, or subsistence.

Alaska Native Subsistence/Harvest Information

Subsistence hunters in Alaska are not authorized to take humpback whales from this stock, and no takes were reported between 2016 and 2020.

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 January 2022). 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 1.15, 0.15, and 0.15 humpback whales (prorated as 1.1, 0.15, and 0.15 Hawaiʻi stock humpback whales), respectively, between 2016 and 2020 (Table 4; Freed et al. 2022). Vessel strikes and other interactions with vessels unrelated to fisheries occur frequently with humpback whales (Tables 4 and 5). The minimum mean annual mortality and serious injury rate due to vessel strikes in Alaska (Table 4: 1.9, prorated as 1.9 Hawaiʻi stock humpback whales) and vessel strikes reported in Hawaiʻi (Table 5: 3.3, all Hawaiʻi stock humpback whales) between 2016 and 2020 is 5.2 humpback whales. Neilson et al. (2012) summarized 108 large whale vessel-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 vessel strikes of humpback whales are reported from Southeast Alaska; however, there are also reports from the south-central, Kodiak Island, and Prince William Sound areas of Alaska (Freed et al. 2022). Many of the vessel strikes occurring off Hawaiʻi are reported from waters near Maui (Bradford and Lyman 2018, 2019). It is not known whether the difference in vessel-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.

Historic whaling

Whaling for humpback whales in the North Pacific occurred for centuries, with known hunting areas including Japan, Russia, Alaska, and the west coast of North America (Reeves and Smith 2006). The great majority of catches were made by modern whaling (after 1900), with most catches of humpback whales occurring during two periods, first from 1906 to 1928, and then during the post-World War II years from 1948 to 1966 (Ivashchenko and Clapham 2016). Until recently, the catch record was incomplete because of extensive illegal takes by the USSR (Ivashchenko et al. 2013), but recent work has allowed for what is thought to be a nearly complete catch record. Approximately 37,000-41,000 humpback whales in total were taken from the North Pacific during whaling from 1656 until 1972, with about 31,000 of those taken during the 20th century (1900-1972) (Ivashchenko and Clapham 2021). Catches of North Pacific humpbacks were prohibited beginning in the 1966 season, but catches were already very low by that time, and it was assumed that North Pacific populations had been greatly over-exploited at that point. Illegal takes of humpbacks in the North Pacific by the USSR continued until 1972 (Ivashchenko and Clapham 2016). Preliminary analyses as part of a Comprehensive Assessment of North Pacific humpback whales by the Scientific Committee of the International Whaling Commission suggest that most breeding populations in the North Pacific were depleted at that time (Ivashchenko et al. 2016), but definitive conclusions cannot be reached until that Comprehensive Assessment is completed.

STATUS OF STOCK

Total annual human-caused serious injury and mortality of the Hawaiʻi stock of humpback whales is the sum of U.S. commercial fisheries (7.65/year), Canadian commercial fisheries (0.2/year), recreational fisheries (0.29/year), subsistence fisheries (0.28/year), unknown (commercial, recreational, or subsistence) fisheries (4.6/year), marine debris (1.1/year), and other causes (vessel strikes and entanglement in an Alaska Department of Fish and Game (ADF&G) salmon net pen and in mooring gear) (5.5/year), or 19.62 humpback whales annually. The minimum estimate of the mean annual U.S. commercial fishery-related mortality and serious injury rate for this stock (7.65 whales) is less than 10% of the calculated PBR for the entire stock (10% of PBR = 12.7) and, therefore, can be considered insignificant and approaching a zero mortality and serious injury rate. There is no estimate of the undocumented fraction of anthropogenic injuries and deaths to humpback whales in Alaska or Hawaiʻi. On the U.S. West Coast, a comparison of observed vs. estimated annual vessel strikes suggests that approximately 10% of vessel strikes are documented.

The Hawaiʻi stock of humpback whales is equivalent to the Hawaiʻi DPS of humpback whales, which is not listed under the ESA (Bettridge et al. 2015, Wade et al. 2021). Humpback whales were previously considered to be depleted species-wide under the MMPA solely on the basis of the species' ESA listing. After the evaluation of the listing status of DPSs of humpback whales, humpback whale DPSs that are not listed as threatened or endangered were not considered to have depleted status under the MMPA (81 FR 62259, September 8, 2016). However, because the Central North Pacific stock included some whales from the ESA-listed Mexico and Western North Pacific DPSs, the stock was considered to be endangered and depleted, and as a result, was classified as a strategic stock. The newly defined Hawaiʻi stock of humpback whales does not include whales from any listed DPSs and, therefore, is not currently considered depleted under the MMPA, and is also not a strategic stock due to its ESA status. It is also not strategic because total annual human-caused mortality and serious injury (19.5) does not exceed the stock's PBR (127).

As discussed above, it is widely believed that most breeding populations of humpback whales in the North Pacific were over-exploited by whaling and depleted as of ~1966. However, as also discussed above, it is thought that at least some populations in the North Pacific, including humpback whales in Hawaiʻi and Alaska, have experienced substantial population growth from when monitoring began (~1980) until recently. The Comprehensive Assessment of North Pacific humpback whales by the Scientific Committee of the International Whaling Commission, when completed, may provide information on whether breeding populations in the North Pacific are currently estimated to be depleted.

One key uncertainty in the assessment of the Hawaiʻi stock of humpback whales is that 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 (Hawaiʻi) 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 Hawaiʻi and Alaska waters in an attempt to minimize the effect of whale watching. In land-based studies in both Hawaiʻi and Southeast Alaska, the presence of vessels was shown to induce energetically demanding avoidance behaviors in humpback whales. These include changes such as increases in swim speed and changes in swimming direction as well as several other changes in respiration metrics such as decreases in dive times, increased respiration rate, and decreased inter-breath intervals (Schuler et al. 2019, Currie et al. 2021). Additional concerns have been raised in Hawaiʻi 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). Similarly, in Hawaiʻi, NMFS first issued regulations in 1987 that made it unlawful to operate an aircraft within 1,000 feet, approach by any means within 100 yards, cause a vessel or other object to approach within a 100 yards, or disrupt the normal behavior or prior activity of a humpback whale by any other act or omission (52 FR 44912, 23 November 1987). 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 February 2022). The growth of the whale-watching industry is an ongoing concern as preferred habitats may be abandoned if disturbance levels are too high.

Increasing levels of anthropogenic sound in the world's oceans (Andrew et al. 2002), such as those produced by shipping traffic, or Low Frequency Active sonar, is a habitat concern for whales, as it can reduce acoustic space used for communication (masking) (Clark et al. 2009, NOAA 2016). This can be particularly problematic for baleen whales that may communicate using low-frequency sound (Erbe 2016). Based on vocalizations (Richardson et al. 1995, Au et al. 2006), reactions to sound sources (Lien et al. 1990, 1992; Maybaum 1993), and anatomical studies (Hauser et al. 2001), humpback whales also appear to be sensitive to mid-frequency sounds, including those used in active sonar military exercises (U.S. Navy 2007).

Other potential concerns for this stock include harmful algal blooms (Geraci et al. 1989), possible changes in prey distribution with climate change, vessel strikes due to increased vessel traffic (e.g., from increased shipping in higher latitudes), oil and gas activities, and an overlap between humpback whales and high concentrations of marine debris. In a study that quantified the amount and type of marine debris accumulation in Hawaiʻi coastal waters from 2013 to 2016, the degree of overlap between marine debris and cetacean distribution was greatest for humpback whales (Currie et al. 2017).

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HUMPBACK WHALE (*Megaptera novaeangliae kuzira*): Mexico-North Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

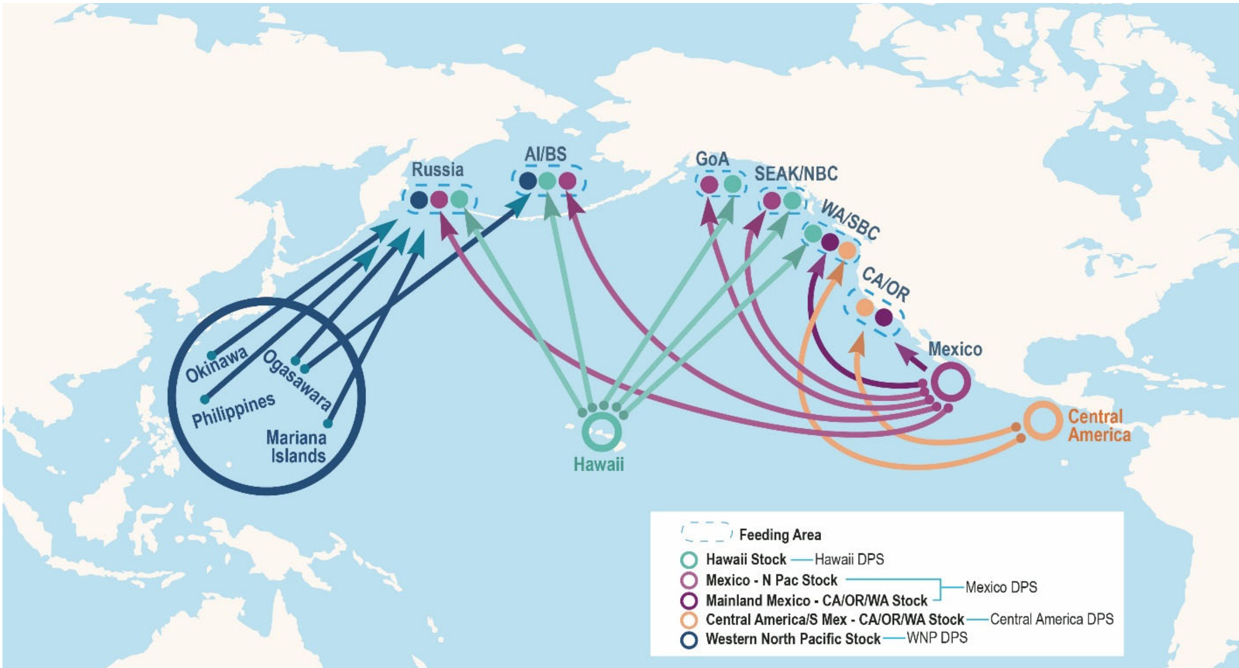

Figure 1. Pacific basin map showing wintering areas of five humpback whale stocks mentioned in this report. Also shown are summering feeding areas mentioned in the text. High-latitude summer feeding areas include Russia, Aleutian Islands / Bering Sea (AI/BS), Gulf of Alaska (GoA), Southeast Alaska / Northern British Columbia (SEAK/NBC), Washington / Southern British Columbia (WA/SBC), and California / Oregon (CA/OR).

Humpback whales occur worldwide and migrate seasonally from high latitude subarctic and temperate summering areas to low latitude subtropical and tropical wintering areas. Three subspecies are recognized globally (North Pacific, Atlantic, and Southern Hemisphere), based on restricted gene flow between ocean basins (Jackson et al. 2014). The North Pacific subspecies (*Megaptera novaeangliae kuzira*) occurs basin-wide, with summering areas in waters of the Russian Far East, Beaufort Sea, Bering Sea, Chukchi Sea, Gulf of Alaska, Western Canada, and the U.S. West Coast. Known wintering areas include waters of Okinawa and Ogasawara in Japan, Philippines, Mariana Archipelago, Hawaiian Islands, Revillagigedos Archipelago, Mainland Mexico, and Central America (Baker et al. 2013, Barlow et al. 2011, Calambokidis et al. 2008, Clarke et al. 2013, Fleming and Jackson 2011, Hashagen et al. 2009). In describing humpback whale population structure in the Pacific, Martien et al. (2020) note that "migratory whale herds", defined as groups of animals that share the same summering and wintering area, are likely to be demographically independent due to their strong, maternally-inherited fidelity to migratory destinations. Despite whales from multiple wintering areas sharing some summer feeding areas, Baker et al. (2013) reported significant genetic differences between North Pacific summering and wintering areas, driven by strong maternal site fidelity to feeding areas and natal philopatry to wintering areas. This differentiation is supported by photo ID studies showing little interchange of whales between summering areas (Calambokidis et al. 2001).

NMFS has identified 14 distinct population segments (DPSs) of humpback whales worldwide under the Endangered Species Act (ESA) (81 FR 62259, September 8, 2016), based on genetics and movement data (Baker et al. 2013, Calambokidis et al. 2008, Bettridge et al. 2015). In the North Pacific, 4 DPSs are recognized (with ESA listing status), based on their respective low latitude wintering areas: "Western North Pacific" (endangered), "Hawai'i" (not listed), "Mexico" (threatened), and "Central America" (endangered). The listing status of each DPS was determined following an evaluation of the ESA section 4(a)(1) listing factors as well as an evaluation of demographic risk factors. The evaluation is summarized in the final rule revising the ESA listing status of humpback whales (81 FR 62259, September 8, 2016).

In prior stock assessments, NMFS designated three stocks of humpback whales in the North Pacific: the California/Oregon/Washington (CA/OR/WA) stock, consisting of winter 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; 2) the Central North Pacific stock, consisting of winter populations in the Hawaiian Islands which migrate primarily to northern British Columbia/Southeast Alaska, the Gulf of Alaska, and the Bering Sea/Aleutian Islands; and 3) the Western North Pacific stock, consisting of winter populations off Asia which migrate primarily to Russia and the Bering Sea/Aleutian Islands. These stocks, to varying extents, were not aligned with the more recently identified ESA DPSs (e.g., some stocks were composed of whales from more than one DPS), which led NMFS to reevaluate stock structure under the Marine Mammal Protection Act (MMPA).

NMFS evaluated whether these North Pacific DPSs contain one or more demographically independent populations (DIPs), where demographic independence is defined as "*…the population dynamics of the affected group is more a consequence of births and deaths within the group (internal dynamics) rather than immigration or emigration (external dynamics)*" (NMFS 2016). Evaluation of the four DPSs in the North Pacific by NMFS resulted in the delineation of three DIPs, as well as four "units" that may contain one or more DIPs (Martien et al. 2021, Taylor et al. 2021, Wade et al. 2021, Oleson et al. 2022, Table 1). Delineation of DIPs is based on evaluation of "strong lines of evidence" such as genetics, movement data, and morphology (Martien et al. 2019). From these DIPs and units, NMFS designated five stocks. North Pacific DIPs / units / stocks are described below, along with the lines of evidence used for each. In some cases, multiple units may be combined into a single stock due to lack of sufficient data and/or analytical tools necessary for effective management or for pragmatic reasons (NMFS 2019).

Table 1. DPS of origin for North Pacific humpback whale DIPs, units, and stocks. Names are based on their general winter and summering area linkages. The stock included in *this* report is shown in bold font. All others appear in separate reports.

<table>
<tr><th>DPS</th><th>ESA Status</th><th>DIPs / units</th><th>Stocks</th></tr>
<tr><td>Central America</td><td>Endangered</td><td>Central America - CA-OR-WA DIP</td><td>Central America / Southern Mexico - CA-OR-WA stock</td></tr>
<tr><td rowspan="2">Mexico</td><td rowspan="2">Threatened</td><td>Mainland Mexico - CA-OR-WA DIP</td><td>Mainland Mexico – CA-OR-WA stock</td></tr>
<tr><td>Mexico - North Pacific unit</td><td>Mexico - North Pacific stock</td></tr>
<tr><td rowspan="2">Hawaiʻi</td><td rowspan="2">Not Listed</td><td>Hawaiʻi - North Pacific unit</td><td rowspan="2">Hawaiʻi stock</td></tr>
<tr><td>Hawaiʻi - Southeast Alaska / Northern British Columbia DIP</td></tr>
<tr><td rowspan="2">Western North Pacific</td><td rowspan="2">Endangered</td><td>Philippines / Okinawa - North Pacific unit</td><td rowspan="2">Western North Pacific stock</td></tr>
<tr><td>Marianas / Ogasawara - North Pacific unit</td></tr>
</table>

Delineation of the **Central America/Southern Mexico – California/Oregon/Washington DIP** is based on two strong lines of evidence indicating demographic independence: genetics and movement data (Taylor et al. 2021). The DIP was designated as a stock because available data make it feasible to manage as a stock and because there are conservation and management benefits to doing so (NMFS 2016, NMFS 2019, NMFS 2022a). Whales in this stock winter off the Pacific coast of Nicaragua, Honduras, El Salvador, Guatemala, Panama, Costa Rica and likely southern coastal Mexico (Taylor et al. 2021). Summer destinations for whales in this DIP include the U.S. West Coast waters of California, Oregon, and Washington (including the Salish Sea, Calambokidis et al. 2017).

Delineation of the **Mainland Mexico – California/Oregon/Washington DIP** is based on two strong lines of evidence indicating demographic independence: genetics and movement data (Martien et al. 2021). The DIP was designated as a stock because available data make it feasible to manage as a stock and because there are conservation and management benefits to doing so (NMFS 2016, NMFS 2019, NMFS 2022b). Whales in this stock winter off the mainland Mexico states of Nayarit and Jalisco, with some animals seen as far south as Colima and Michoacán. Summer destinations for whales in the Mainland Mexico DPS include U.S. West Coast waters of California, Oregon, Washington (including the Salish Sea, Martien et al. 2021), Southern British Columbia, Alaska, and the Bering Sea.

The **Mexico – North Pacific unit** is likely composed of multiple DIPs, based on movement data (Martien et al. 2021, Wade 2021, Wade et al. 2021). However, because currently available data and analyses are not sufficient to delineate or assess DIPs within the unit, it was designated as a single stock (NMFS 2016, NMFS 2019, NMFS 2022b).

Whales in this stock winter off Mexico and the Revillagigedo Archipelago and summer primarily in Alaska waters (Martien et al. 2021).

The **Hawai'i stock** consists of one DIP - **Hawai'i - Southeast Alaska / Northern British Columbia DIP** and one unit - **Hawai'i - North Pacific unit,** which may or may not be composed of multiple DIPs (Wade et al. 2021). The DIP and unit are managed as a single stock at this time, due to the lack of data available to separately assess them and lack of compelling conservation benefit to managing them separately (NMFS 2016, NMFS 2019, NMFS 2022c). The DIP is delineated based on two strong lines of evidence: genetics and movement data (Wade et al. 2021). Whales in the Hawai'i - Southeast Alaska/Northern British Columbia DIP winter off Hawai'i and largely summer in Southeast Alaska and Northern British Columbia, including a small number of whales summering in Southern British Columbia and Washington state waters (Wade et al. 2021). The group of whales that migrate from Russia, western Alaska (Bering Sea and Aleutian Islands), and central Alaska (Gulf of Alaska excluding Southeast Alaska) to Hawai'i have been delineated as the **Hawai'i-North Pacific unit** (Wade et al. 2021).

The **Western North Pacific stock** consists of two units- the **Philippines / Okinawa - North Pacific unit** and the **Marianas / Ogasawara - North Pacific unit**. The units are managed as a single stock at this time, due to a lack of data available to separately assess them (NMFS 2016, NMFS 2019, NMFS 2022d). Recognition of these units is based on movements and genetic data (Oleson et al. 2022). Whales in the Philippines /Okinawa - North Pacific unit winter near the Philippines and Ryukyu Archipelago and migrate to summer feeding areas primarily off the Russian mainland (Oleson et al. 2022). Whales that winter off the Mariana Archipelago, Ogasawara, and other areas not yet identified and then migrate to summer feeding areas off the Commander Islands, and to the Bering Sea and Aleutian Islands comprise the Marianas / Ogasawara - North Pacific unit.

In previous marine mammal stock assessments, most humpback whales that summer and feed in Alaska waters were treated as one stock (the "Central North Pacific stock"), with only whales that winter in Asia (a relatively small proportion of the whales in the Bering Sea, Aleutian Islands, and Gulf of Alaska) identified as belonging to a separate stock (the "Western North Pacific stock"). However, this meant that the Central North Pacific stock contained whales from both the Hawai'i and Mexico DPSs, making that previous stock incompatible with the ESA DPSs. Therefore, humpback whales that summer in Alaska have now been placed in one of three separate stocks defined by their winter area, which are consistent with their ESA DPSs. Regarding the whales that summer in Alaska and winter in Mexico, as noted above, two stocks have been designated within the Mexico DPS. Humpback whales that winter along the Mexico Mainland coast and feed in summer along the west coast of the United States are part of the Mainland Mexico – California/Oregon/Washington stock.

This stock assessment report includes information on humpback whales that winter in Mexico and summer primarily in Alaska. This includes some of the humpback whales that winter along the mainland coast of Mexico that migrate to Alaska in summer. Additionally, none of the whales in the offshore Revillagigedo Archipelago in Mexico migrate to the west coast of the U.S.; they primarily migrate to Alaska in summer (with a small number migrating to Russia or to southern British Columbia/Washington). Therefore, this stock, the Mexico – North Pacific stock, includes humpback whales that winter off mainland Mexico and the Revillagigedo Archipelago and summer primarily in Alaska waters (Martien et al. 2021). This stock specifically excludes any whales that migrate from Mexico to California or Oregon.

POPULATION SIZE

<u>Winter Areas</u>

All of the humpback whales in the Revillagigedo Archipelago are part of this stock. Therefore, an estimate of abundance for the Revillagigedo Archipelago can serve as a partial estimate for the stock. Such estimates will be negatively biased to an unknown degree, as they will not include an estimate of the number of whales in this stock found along the mainland coast of Mexico. There is currently no method that would allow partitioning the abundance of humpback whales along the mainland Mexico coast to the two Mexican stocks.

Using a modified model of the Jolly-Seber population model, Urbán et al. (1999) estimated that in 1991 there were 1,813 (95% CI: 918-2505) whales in the coastal stock and 914 (95% CI: 590-1193) whales in the Revillagigedo Archipelago stock. During the SPLASH project in 2004-2006, a total of 562 unique individuals were identified in the Revillagigedo Archipelago (Table 6 in Calambokidis et al. 2008). Abundance estimates were also calculated from those same data using a Hilborn mark-recapture model. From what they identified as the best-fitting model (the non-Markov p(n) model), the estimate of abundance for the Revillagigedo Archipelago was 681 (no CV was estimated) (Calambokidis et al. 2008). Martinez-Aguilar (2011) conducted mark-recapture abundance estimates from photo-identification data from 3 regions in the Mexican Pacific, including the Revillagigedo Archipelago. A number of closed population models were fit to the data, with the best model being a Chao m(th) model specifying time-varying and individual heterogeneity in capture probability. That model resulted in an estimate for the years 1987-1990 of

571 (95% CI 465-729) for the Revillagigedo Archipelago. Martinez-Aguilar (2011) also analyzed data from the 2004-2006 SPLASH years from Mexico, and added an additional year of data (2003) from outside the SPLASH years. For that time period, the Chao m(th) model resulted in an estimate of 2,352 (95% CI 2,030-2,762, with CV~0.075) for the Revillagigedo Archipelago.

Summer Areas

Abundance estimates from a multi-strata mark-recapture analysis from the SPLASH data resulted in abundance estimates of 7,758 for the Bering Sea and Aleutian Islands (CV=0.20), 2,129 for the Gulf of Alaska (including the Shumagin Islands, CV=0.081), and 5,890 (CV=0.075) for Southeast Alaska and northern British Columbia (Wade 2021). In all of those areas those abundance estimates represent a mixture of whales from up to three winter areas, the western North Pacific (Asia), Hawaiʻi, and Mexico, and so cannot represent the abundance of just the Mexico-North Pacific stock in its summer areas. To determine the number of animals in these feeding areas belonging to the Mexico-North Pacific stock, the abundance estimate for each feeding area was multiplied by the probability of movement between that feeding area and the Mexican wintering area, as estimated by Wade (2021), and then added together. This resulted in an estimate of 918 animals (CV=0.217).

Minimum Population Estimate

Using the Chao m(th) model abundance estimate for 2003-2006 reported by Martinez-Aguilar (2011), which is 2,352 with ~CV=0.075, N_{MIN} for this population would be 2,241. Using the estimate of 918 animals (CV=0.217) derived from Wade's (2021) multi-strata analysis of 2004-2006 SPLASH data, the N_{MIN} for this population would be 766. Both of these estimates of abundance are based on data collected more than eight years ago. NMFS' Guidelines for Assessing Marine Mammal Stocks suggest that the N_{MIN} estimate of the stock should be considered unknown if the estimates are more than eight years old, unless there is compelling evidence a stock has not declined since the last estimate (NMFS 2106). Although there was evidence that the population in the Revillagigedo Archipelago was increasing between 1987-1990 and 2003-2006, there are no estimates of the population trend for that area since 2003-2006. Additionally, as discussed below in the Current Population Trend section, it is no longer clear that the trend of the population is increasing. Therefore, the minimum population estimate for this stock is considered unknown.

Current Population Trend

Calambokidis et al. (2008) noted that the abundance estimate for all areas in Mexico estimated from the SPLASH data suggested an increase relative to previous estimates. Specifically, they noted that "an increase from about 2,500 whales in the early 1990s to the SPLASH estimate of 5,928 would be consistent with a 6.9% rate of annual increase, but should be interpreted cautiously given the variability in the earlier estimates" (Calambokidis et al. 2008). A comparison of two mark-recapture estimates for the Revillagigedo Archipelago for 1987-1990 and 2003-2006 resulted in an estimate of an annual rate of increase of 8.8% (Table 9 in Martinez-Aguilar 2011). Estimates of annual rates of increase from the same years of data for other parts of Mexico were 10.5% for the Baja Peninsula, 8.7% for the mainland Mexico coast, and 8.9% for all areas in Mexico combined. This suggests that the portion of this stock along the mainland coast was also increasing over this time period.

Whales in this stock migrate to areas of Alaska, particularly the Aleutian Islands, Bering Sea, and Gulf of Alaska. There are no trend data for humpback whales in the Aleutian Islands and Bering Sea. For shelf waters of the northern Gulf of Alaska, Zerbini et al. (2006) estimated an annual rate of increase for humpback whales of 6.6% (95% CI: 5.2-8.6%) from 1987 to 2003. Teerlink et al. (2015) estimated an average annual rate of increase of 4.53% (95 % CI 3.28–5.79%) for 1978-2009 for humpback whales in Prince William Sound, Alaska. Although these areas are a mixture of whales from Hawaii, Mexico, and Asia, and so do not reflect the trend of a single stock, the data are still consistent with the evidence above suggesting humpback whales in Mexico were increasing.

Recently, however, the encounter rate of humpback whales and the number of calves declined in Prince William Sound after the marine heatwave in the Gulf of Alaska in 2014-2016, presumably due to disruption of lower trophic level prey (Arimitsu et al. 2021). A large whale Unusual Mortality Event in the western Gulf of Alaska in 2015-2016 (Savage 2017) suggested this was, at least partially, a true decline rather than just a shift in distribution. A similar decline in abundance and calf production rates of humpback whales in Glacier Bay and Icy Strait in Southeast Alaska (Neilson and Gabriele 2019) indicates this decline may have occurred widely throughout the Gulf of Alaska. Therefore, it is unknown if this population is currently increasing.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Zerbini et al. (2010) analyzed observed life history rates to estimate that rates of increase for humpback whales can theoretically be as high as 12%, and rates of increase approximately that high have been observed in several Southern Hemisphere populations. As mentioned above, Martinez-Aguilar (2011) estimated an annual increase of 8.8% (no CV or CI reported) for the Revillagigedo Archipelago over a 16-year period (1987-1990 to 2003-2006), based on point estimates of 571 and 2,352, respectively. Taking the upper confidence limit for the first time period (729) and the lower confidence limit of the second time period (2030) represents an annual rate of increase of at least 6.6%.

An estimated rate of increase for humpback whales in the northern Gulf of Alaska of 6.6% (95% CI: 5.2-8.6%) was estimated from ship survey data (Zerbini et al. 2006); although this represents a mixture of several stocks (including the Mexico—North Pacific stock), this value is consistent with the increase reported for the Revillagigedo Archipelago, and is a feeding area used by this stock.

There is no estimate of the maximum net productivity rate (R_{MAX}) for the entire stock (i.e., including both the Revillagigedo Archipelago and the whales along the mainland Mexico coast that migrate to Alaska). However, Martinez-Aguilar (2011) reports an annual rate of increase of 8.7% for coastal areas of Mexico. Therefore, it is reasonable to assume that R_{MAX} for this stock would be at least 6.6%. Until additional data become available for the Hawaiʻi humpback whale stock, 6.6% will be used as R_{MAX} for this stock.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock would be calculated as the minimum population size times one half the estimated population growth rate for this stock of humpback whales (½ of 6.6%) times a recovery factor of 0.5, the default value for a stock part of a DPS listed as Threatened (NMFS 2016). Due to a lack of quantitative data, it is assumed that this stock spends approximately half its time outside the U.S. Exclusive Economic Zone (EEZ), the PBR in U.S. waters would be ½ of the calculated value. However, because N_{MIN} is considered unknown, PBR is undetermined.

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 2016 and 2020 is listed, by marine mammal stock, in Freed et al. (2022); 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 Freed et al. (2022).

Human-caused mortality and serious injury of humpback whales observed in Alaska includes whales from three stocks: the Mexico-North Pacific stock, the Hawaiʻi stock, and the Western North Pacific stock. Human-caused mortality and serious injury of the Mexico-North Pacific stock also occurs in Mexico, but those data are not currently available. To assess human-caused mortality and serious injury of the Hawaiʻi stock in areas where multiple stocks overlap, mortality and serious injury is prorated using point estimates of the summering to wintering area movement probabilities reported by Wade (2021) (Table 2).

Table 2. Movement probabilities from Wade (2021) used for prorating human-caused mortality and serious injury to the Mexico-North Pacific stock.

Stock or DIP/Unit	Aleutian Islands/Bering Sea	Gulf of Alaska	Southeast Alaska
Mexico-North Pacific	0.071 (CV = 0.28)	0.106 (CV = 0.177)	0.024 (CV = 0.260)

The minimum estimated mean annual level of human-caused mortality and serious injury for the Mexico-North Pacific stock of humpback whales between 2016 and 2020 in U.S. waters is 0.56 whales: 0.36 in U.S. commercial fisheries, 0.01 in recreational fisheries, 0.02 in subsistence fisheries, 0.05 in unknown (commercial, recreational, or subsistence) fisheries, 0.05 in marine debris, and 0.07 due to other causes (vessel strikes and entanglement in an Alaska Department of Fish and Game (ADF&G) salmon net pen and in mooring gear) (see text and tables below). This estimate is considered a minimum because observers have not been assigned to several fisheries that are known to interact with this stock. Potential threats most likely to result in direct human-caused mortality or serious injury of this stock include vessel strikes and entanglement in fishing gear and marine debris.

Fisheries Information

U.S. Commercial Fisheries

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 January 2022).

Two humpback whale mortalities were observed in the Bering Sea/Aleutian Islands pollock trawl fishery between 2016 and 2020, resulting in a minimum estimated mean annual mortality and serious injury rate of 0.4 humpback whales, of which 0.03 were prorated to the Mexico-North Pacific stock (Table 3; Breiwick 2013; MML, 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 humpback whales in 2012 and 2013, of which 0.13 were prorated to the Mexico-North Pacific stock (Table 3). Because these three districts represent only a portion of the overall fishing effort in this fishery, this is considered to be a minimum estimate of mortality and serious injury for the fishery.

Table 3. Summary of incidental mortality and serious injury of humpback whales due to observed U.S. commercial fisheries between 2016 and 2020 (or the most recent data available) and the mean annual mortality and serious injury rate for Alaska fisheries (Breiwick 2013; Manly 2015; MML, unpubl. data). Mean annual mortality estimates are prorated to the Mexico-North Pacific stock by multiplying by the area-specific movement probabilities in Table 2. Methods for calculating percent observer coverage for Alaska fisheries are described in Appendix 3 of the Alaska Stock Assessment Reports.

<table>
<tr><th>Fishery name</th><th>Years</th><th>Data type</th><th>Percent observer coverage</th><th>Observed mortality</th><th>Estimated mortality (CV)</th><th>Mean estimated annual mortality - overall (CV)</th><th>Mean estimated annual mortality of Mexico-North Pacific stock (CV)</th></tr>
<tr><td colspan="8">Bering Sea/Aleutian Islands</td></tr>
<tr><td rowspan="5">Bering Sea/Aleutian Is. pollock trawl</td><td>2016</td><td rowspan="5">obs data</td><td>99</td><td>0</td><td>0</td><td rowspan="5">0.4 (0.13)</td><td rowspan="5">0.03 (0.31)</td></tr>
<tr><td>2017</td><td>99</td><td>0</td><td>0</td></tr>
<tr><td>2018</td><td>99</td><td>1</td><td>1.0 (0.11)</td></tr>
<tr><td>2019</td><td>98</td><td>0</td><td>0</td></tr>
<tr><td>2020</td><td>91</td><td>1</td><td>1.1 (0.23)</td></tr>
<tr><td colspan="8">Southeast Alaska</td></tr>
<tr><td rowspan="2">Southeast Alaska salmon drift gillnet (Districts 6, 7, 8)</td><td>2012</td><td rowspan="2">obs data</td><td>6.4</td><td>0</td><td>0</td><td rowspan="2">5.5 (1.0)</td><td rowspan="2">0.13 (1.1)</td></tr>
<tr><td>2013</td><td>6.6</td><td>1</td><td>11</td></tr>
<tr><td colspan="6">Minimum total estimated annual mortality</td><td>5.9 (0.93)</td><td>0.16 (0.88)</td></tr>
</table>

Mortality and serious injury in U.S. commercial fisheries within the range of the Mexico-North Pacific stock reported to the NMFS Alaska Region marine mammal stranding network and through Marine Mammal Authorization Program (MMAP) fisherman self-reports, for fisheries in which observer data are not available, resulted in a minimum mean annual mortality and serious injury rate of 1.9 humpback whales between 2016 and 2020 (Table 4; Freed et al. 2022), of which 0.2 were prorated to the Mexico-North Pacific stock. 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 summary, the minimum estimate of the mean annual mortality and serious injury rate incidental to U.S. commercial fisheries for the Mexico-North Pacific stock between 2016 and 2020 (or the most recent data available) is 0.36 humpback whales, based on observer data from Alaska (Table 3: 0.16) and reports (in which the commercial fishery is confirmed) to the NMFS Alaska Region stranding network (Table 4: 0.2).

Other Fisheries

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 within the range of the Mexico-North Pacific stock between 2016 and 2020 included: two (each with a serious injury prorated as 0.75) entanglements in recreational pot fisheries gear, resulting in a minimum mean annual mortality and serious injury rate of 0.3 humpback whales, of which 0.01 were prorated to the Mexico-North Pacific stock; entanglements in subsistence crab pot gear and in unidentified subsistence gillnet (each with a serious injury prorated as 0.75), resulting in a minimum mean annual mortality and serious injury rate of 0.3 humpback whales, of which 0.02 were prorated to the Mexico-North Pacific stock; entanglements in unknown (commercial, recreational, or subsistence) fishing gear, resulting in a minimum mean annual mortality and serious injury rate of 0.85 humpback whales, of which 0.05 were prorated to the Mexico-North Pacific stock (Table 4; Freed et al. 2022).

Fisheries Summary

The minimum estimate of the mean annual mortality and serious injury rate due to interactions with all fisheries between 2016 and 2020 is 0.44 Mexico-North Pacific humpback whales (0.36 in commercial fisheries + 0.01 in recreational fisheries + 0.02 in subsistence fisheries + 0.05 in unknown fisheries). These estimates of mortality and serious injury levels should be considered minimums. Observers have not 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.

Alaska Native Subsistence/Harvest Information

Subsistence hunters in Alaska are not authorized to take humpback whales from this stock, and no takes were reported between 2016 and 2020.

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 January 2022). 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 1.15, 0.15, and 0.15 humpback whales (prorated as 0.05, 0.00, and 0.00 Mexico-North Pacific stock humpback whales), respectively, between 2016 and 2020 (Table 4; Freed et al. 2022). The mean minimum annual morality and serious injury due to vessel strikes and other interactions with vessels unrelated to fisheries between 2016 and 2020 is 1.9 humpback whales (prorated as 0.05 Mexico-North Pacific stock humpback whales; Table 4). Neilson et al. (2012) summarized 108 large whale vessel-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 vessel strikes of humpback whales are reported from Southeast Alaska; however, there are also reports from the south-central, Kodiak Island, and Prince William Sound areas of Alaska (Freed et al. 2022). It is not known whether the difference in vessel-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.

Table 4. Summary of mortality and serious injury of humpback whales within the range of the Mexico-North Pacific stock, 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 2016 and 2020 (Freed et al. 2022). 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 Freed et al. (2022). Total mean annual mortality estimates are prorated to the Mexico-North Pacific stock by multiplying by the area-specific movement probabilities from Table 2.

Cause of injury	2016	2017	2018	2019	2020	Mean annual mortality - total	Mean estimated annual mortality of Mexico-North Pacific stock
Bering Sea/Aleutian Islands							
Entangled in Bering Sea/Aleutian Is. commercial Pacific cod pot gear	0	1	0	0	0.75[a]	0.35	0.16
Entangled in marine debris	1	0	0	0	0	0.2	0.01
Gulf of Alaska							
Entangled in subsistence crab pot gear	0	0	0	0.75	0	0.15	0.02
Entangled in shrimp pot gear*	0	0	0	0.75	0	0.15	0.02
Entangled in unidentified fishing gear*	0	0	1	0	0	0.2	0.02
Entangled in marine debris	1	0	0	0	0	0.2	0.02
Vessel strike by AK/WA/OR/CA commercial passenger fishing vessel	0	0.52	0	0	0	0.1	0.01
Vessel strike by recreational vessel	0.2	0	0	0	0	0.04	<0.00
Southeast Alaska							
Entangled in Southeast Alaska commercial salmon drift gillnet (in ADF&G Districts that were not observed in 2012 and 2013)	2.25	0	1.5	0	1.75 + 0.75[b]	1.25	0.03
Entangled in Southeast Alaska commercial pot gear	0	0	0	0	0.75	0.15	0.00
Entangled in unidentified commercial longline gear	0	0	0	0	0.75	0.15	0.00
Entangled in Southeast Alaska recreational shrimp pot gear	0	0	0.75	0	0	0.15	0.00
Entangled in unidentified recreational pot gear	0	0	0	0.75	0	0.15	0.00
Entangled in unidentified subsistence gillnet	0.75	0	0	0	0	0.15	0.00
Entangled in shrimp pot gear*	0	0	0	0.75	0	0.15	0.00
Entangled in unidentified fishing gear*	0	1	0	0.75	0	0.35	0.01
Entangled in marine debris	2.25	0.75	0	0.75	0	0.75	0.02
Entangled in ADF&G salmon net pen	0.75	0	0	0	0	0.15	0.00
Entangled in mooring gear	0.75	0	0	0	0	0.15	0.00
Vessel strike	1	1.34	3	3	0.4	1.75	0.04

Cause of injury	2016	2017	2018	2019	2020	Mean annual mortality - total	Mean estimated annual mortality of Mexico-North Pacific stock
Vessel strike by AK/WA/OR/CA commercial passenger fishing vessel	0	0.2	0	0	0	0.04	0.00
TOTALS							
Total in commercial fisheries						1.90	0.20
Total in recreational fisheries						0.30	0.01
Total in subsistence fisheries						0.30	0.02
*Total in unknown (commercial, recreational, or subsistence) fisheries						0.85	0.05
Total in marine debris						1.15	0.05
Total due to other causes (entangled in salmon net pen, entangled in mooring gear, vessel strike)						2.23	0.07

[a] Known to be Mexico-North Pacific stock based on known wintering and summering areas.
[b] Animal was entangled in both AK SEAK salmon drift gillnet gear and AK salmon troll gear.
* Unknown if fishery is commercial, recreational, or subsistence.

Historic whaling

Whaling for humpback whales in the North Pacific occurred for centuries, with known hunting areas including Japan, Russia, Alaska, and the west coast of North America (Reeves and Smith 2006). The great majority of catches were made by modern whaling (after 1900), with most catches of humpback whales occurring during two periods, first from 1906 to 1928, and then during the post-World War II years from 1948 to 1966 (Ivashchenko and Clapham 2016). Until recently, the catch record was incomplete because of extensive illegal takes by the USSR (Ivashchenko et al. 2013), but recent work has allowed for the completion of a nearly complete catch record. Approximately 37,000-41,000 humpback whales in total were taken from the North Pacific during whaling from 1656 until 1972, with about 31,000 of those taken during the 20th century (1900-1972) (Ivashchenko and Clapham 2021). Mexico was the only breeding ground which had relatively high catches and was also connected to feeding areas with high catches, making it likely that the breeding populations in Mexico were over-exploited. A total of at least 1,264 whales were caught in the Revillagigedo Archipelago, with all known takes occurring between 1859-1868 and between 1914-1935 (Ivashchenko and Clapham 2021).

Catches of North Pacific humpbacks were prohibited beginning in the 1966 season, but catches were already very low by that time, and it was assumed that all or most North Pacific populations had been greatly over-exploited at that point. Illegal takes of humpbacks in the North Pacific by the USSR continued until 1972 (Ivashchenko and Clapham 2016). Preliminary modeling analyses as part of a Comprehensive Assessment of North Pacific humpback whales by the Scientific Committee of the International Whaling Commission suggest that most breeding populations in the North Pacific were depleted as of 1972 (Ivashchenko et al. 2016), but definitive conclusions cannot be reached until that Comprehensive Assessment is completed.

STATUS OF STOCK

The Mexico-North Pacific stock of humpback whales is one of two stocks that make up the "Mexico DPS" of humpback whales, which are listed as threatened under the ESA (Bettridge et al. 2015, Martien et al. 2021), and is therefore considered "depleted" and "strategic" under the MMPA. Total annual human-caused serious injury and mortality of Mexico-North Pacific humpback whales is the sum of U.S. commercial fisheries (0.36/year), recreational fisheries (0.01/year), subsistence fisheries (0.02/year), unknown (commercial, recreational, or subsistence) fisheries (0.05/year), marine debris (0.05/year), and other causes (vessel strikes and entanglement in an Alaska Department of Fish and Game (ADF&G) salmon net pen and in mooring gear) (0.07/year), or 0.56 humpback whales annually. PBR is unknown, so it cannot be determined if total commercial fishery mortality and serious injury (0.36/yr) is less than PBR or less than 10% of PBR for this stock. There is no estimate of the undocumented fraction of anthropogenic injuries and deaths to humpback whales in Alaska or in Mexico; on the U.S. West Coast, a comparison of observed vs. estimated annual vessel strikes suggests that approximately 10% of vessel strikes are documented, so reports of such vessel strikes may also be underreported for this stock. The abundance of humpback whales in the Revillagigedo Archipelago, which represents a substantial portion of this stock, was estimated to have increased at an annual rate of 8.8% between 1987-1990 and 2003-2006 (Table 9 in Martinez-Aguilar 2011); no more recent trend data are available for that area. Habitat concerns include sensitivity to anthropogenic sound sources.

There are key uncertainties in the assessment of the Mexico-North Pacific stock of humpback whales. The stock is likely composed of multiple DIPs, but currently available data and analyses are not sufficient to delineate or assess DIPs within the stock. There is no current estimate of abundance or trend for this stock and PBR is undetermined. The 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

Increasing levels of anthropogenic sound in the world's oceans (Andrew et al. 2002), such as those produced by shipping traffic, or Low Frequency Active sonar, is a habitat concern for whales, as it can reduce acoustic space used for communication (masking) (Clark et al. 2009, NOAA 2016). This can be particularly problematic for baleen whales that may communicate using low-frequency sound (Erbe 2016). Based on vocalizations (Richardson et al. 1995; Au et al. 2006), reactions to sound sources (Lien et al. 1990, 1992; Maybaum 1993), and anatomical studies (Hauser et al. 2001), humpback whales also appear to be sensitive to mid-frequency sounds, including those used in active sonar military exercises (U.S. Navy 2007).

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BOWHEAD WHALE (*Balaena mysticetus*): Western Arctic Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

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 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, Vacquié-Garcia et al. 2017). 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 Seas 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).

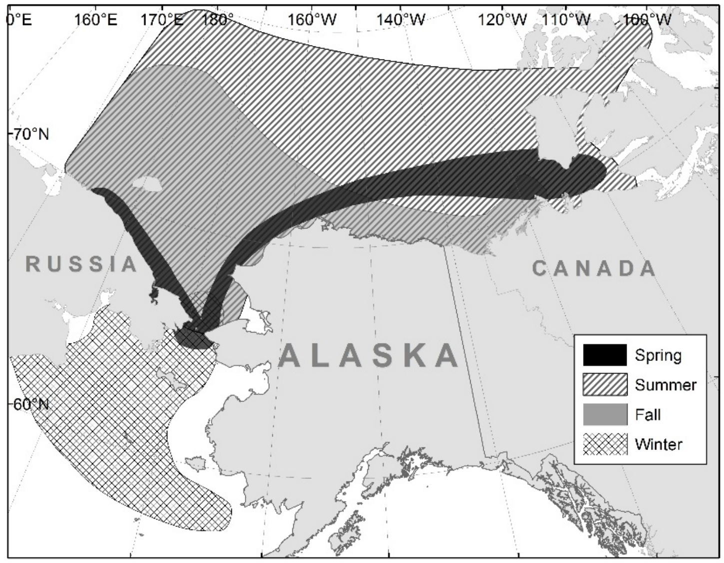

Figure 1. Annual range of the Western Arctic stock of bowhead whales by season from satellite tracking data, 2006-2017 (map based on Quakenbush et al. (2018): Fig. 2).

The majority of the Western Arctic stock migrates annually from wintering areas in the northern Bering and southern Chukchi 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 (May through September). During late summer and autumn (September through December), this stock migrates back to the Chukchi Sea and then to the Bering Sea (Fig. 1) to overwinter (Braham et al. 1980; Moore and Reeves 1993; Quakenbush et al. 2010~~a~~, 2018; Citta et al. 2015). During winter and spring, bowhead whales are closely associated with sea ice (Moore and Reeves 1993, Quakenbush et al. 2010~~a~~, 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, a large proportion of the population is in the relatively ice-free waters of Amundsen Gulf in the eastern Beaufort Sea (Citta et al. 2015), an area ~~often exposed to~~where industrial activity related to petroleum exploration often occurs (e.g., Richardson et al. 1987, Davies 1997). ~~However, s~~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, bowhead whales generally inhabit shelf waters across the Beaufort Sea (Citta et al. 2015). The autumn migration across the Chukchi Sea is more dispersed (Clarke et al. 2016); here, bowhead whales generally prefer cold, saline waters that are mostly of Bering Sea origin (Citta et al. 2018). During winter in the Bering Sea, bowhead whales often use areas covered by nearly 100% sea ice, 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 Beaufort Sea; the central and western Beaufort Sea; the Chukchi shelf break, especially Herald Valley and the Central Channel; and the coast of Chukotka between Wrangel Island and 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, 2018; Clarke et al. 2017; Harwood et al. 2017; Olnes et al. 2020). 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 ascend 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). 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 feed in shelf waters of the Bering Sea, from Bering Strait south through Anadyr Strait, and near the seafloor in the Gulf of Anadyr (Citta et al. 2012, 2015). Of four bowhead whales harvested in November (two in 2012) and December (two in 2010) 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) identified nine important areas for bowhead whales in the U.S. Arctic based on aerial survey data and satellite telemetry. Four are reproductive areas where the majority of bowhead whales identified as calves were observed each season. Three are feeding areas 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, Olnes et al. 2020).

This stock assessment report assesses the abundance and Alaska Native subsistence harvest of Western Arctic bowhead whales throughout the stock's entire geographic range. Human-caused mortality and serious injury, other than Alaska Native subsistence harvest, is estimated for the portion of the range within U.S. waters (i.e., the U.S. Exclusive Economic Zone) because relevant data are generally not available for the broader range of the stock. However, some pot gear entanglements and rope scars first detected in U.S. waters may have been caused by Russian pot fisheries (Citta et al. 2014).

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~~ updated at least 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). 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 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. More recent satellite tagging data also indicate that only a small proportion (~4%) of the population migrates to Chukotka (Quakenbush and Citta 2019).

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. Historical estimates are from Woodby and Botkin (1993); 1978-2001 estimates are from George et al. (2004) and Zeh and Punt (2005). 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 (2005).~~ The ~~2011~~2019 estimate is reported in Givens et al. (~~2016~~2021a, 2021b).

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)
		2019	14,025 (0.228)

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 the 2011 ice-based estimate had a lower coefficient of variation (CV), the IWC Scientific Committee considered this estimate the most appropriate for management and use in the SLA (IWC 2018).~~ This estimate is more than 8 years old and is outdated for use in stock assessments; however, because this population is increasing, this is still considered a valid minimum population estimate (NMFS 2016).~~

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)

In 2019, a spring ice-based visual survey and a summer aerial line-transect survey were conducted to provide independent estimates of abundance. For the 2019 ice-based survey, Givens et al. (2021a) produced an initial estimate of abundance of 12,505 whales (CV = 0.228) but acknowledged that the estimate was likely biased low due to numerous factors, including closed leads that inhibited survey effort early in the migration; unprecedented wide leads later in the migration that resulted in an unusual migration route that was sometimes too distant from observers to detect whales; an unusually short observation platform compared to previous surveys; and hunters' heavy use of powered skiffs near the observation platform, which likely disturbed the whales during the survey. Givens et al. (2021b) developed a correction factor to account for the disturbance to the migration from powered skiffs, resulting in the best estimate of abundance from the 2019 ice-based survey of 14,025 whales (CV = 0.228). The 2019 abundance estimate from the aerial line-transect surveys is presently in review.

Minimum Population Estimate

The minimum population estimate (N_{MIN}) for 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~~2019 population estimate (N) from the ice-based survey of ~~16,820~~14,025 and its associated CV(N) of ~~0.052~~0.228 (Table 1), N_{MIN} for this stock of bowhead whales is ~~16,100~~11,603 whales.~~ 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, this is still considered a valid minimum population estimate.~~

Current Population Trend

Based on concurrent passive acoustic and ice-based visual surveys, Givens et al. (2016) 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). Although the ice-based abundance estimate from 2019 (Givens et al. 2021a, 2021b) is lower than that from 2011, Givens et al. (2021a) do not interpret this to be a true decline in population abundance due to the abnormal ice conditions and migration route that were not accounted for in the abundance estimate and likely resulted in an underestimate of abundance. 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.

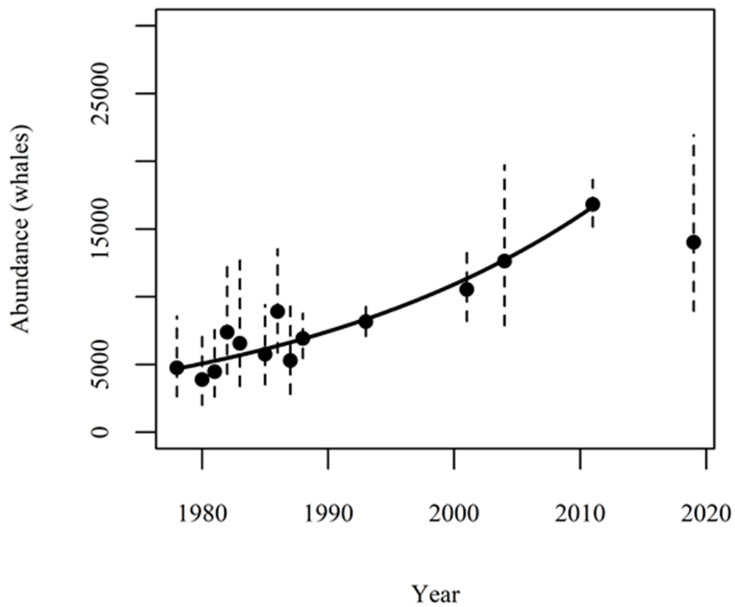

Figure ~~3~~2. Estimated ~~A~~abundance ~~estimates (points with confidence interval lines)~~ and trend of ~~(black line with confidence range) for the~~ Western Arctic ~~stock of~~ bowhead whales, 1978-2011 (Givens et al. 201~~3~~6), as computed from ice-based counts and acoustic data collected during bowhead whale spring migrations past Point Barrow, Alaska. The 2019 ice-based abundance estimate and confidence interval (Givens et al. 2021a, 2021b) are also shown; however, the trend line has not been extended because a formal analysis has not been conducted to determine whether the population is likely to have continued to increase exponentially.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

The presumed current estimate for the rate of increase for the Western Arctic stock of bowhead whales (3.7%: 95% CI = 2.9-4.6%: Givens et al. 2016) 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); therefore, this stock may not be growing at its maximum rate. Thus, 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 not known to be ~~increasing~~decreasing (Givens et al. 2021a, 2021b) in the presence of a known take (NMFS 2016). Thus, PBR is ~~161~~116 whales (~~16,100~~11,603 × 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, because it is managed under the Whaling Convention Act, an international treaty. In 2018, the IWC revised the bowhead whale subsistence quota (IWC 2018 Schedule amendment). Under the revisions, the total block quota for 2019 to 2025 is 392 landed whales (an average of 56/year), with no more than 67 strikes per year, 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 (i.e., no more than 33 strikes) is added to the strike quota for any one year (IWC 2018 Schedule amendment, section 13(b)1). Hence, 67 strikes are allocated annually, with the possibility of adding 33 strikes if they are available from the prior three quota blocks. A bilateral agreement 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 bilateral arrangement, the Chukotka Natives in Russia may use no more than seven strikes and Alaska Natives may use no more than 93 strikes per 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 ~~2015~~2016 and ~~2019~~2020 is listed, by marine mammal stock, in Freed et al. (~~2021~~2022); 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 ~~2015~~2016 and ~~2019~~2020 is ~~52~~56 whales: calculated as the sum of ~~0.2 in U.S. commercial fisheries, 0.6 in unknown (commercial, recreational, or subsistence) fisheries, 50~~54 ~~in~~ subsistence takes by Alaska Natives ~~of Alaska (51~~55; ~~whales~~ (mean actual number of landed whales plus mean annual struck and lost mortality) ~~minus 0.6 whales seriously injured in fisheries interactions prior to harvest), and 0.8~~plus whales landed in subsistence takes by Natives of Russia (0.8; ~~number landed;~~ struck and lost whales not reported). Several bowhead whales harvested by Alaska Natives were found to have been seriously injured by unknown (commercial, recreational, or subsistence) fisheries prior to harvest (mean of 0.6/year; Freed et al. 2022); to avoid double counting, these are not added to the total mortality and serious injury for the stock. 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 vesse;~~ship~~ strikes due to increased vessel traffic (from increased commercial shipping in Bering Strait and the Chukchi and Beaufort seas).

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 ~~December 2021~~January 2022).

Based on historical reports and the stock's geographic range, pot fishery gear is the only documented source of fisheries-caused bowhead whale mortality and serious injury ~~has been from entanglement in pot fishery gear~~. ~~Given the minimal range overlap of bowhead whales and active pot fisheries,~~ T~~t~~he levels of ~~these~~ interactions ~~may be low; however, the levels~~ are unknown, even for observed fisheries. While some finfish pot and crab pot fisheries have onboard observers, the observers are unlikely to observe interactions unless an animal is anchored in gear. In most cases, large whale interactions occur while the pots are left untended to fish or "soak" and the whale swims away with gear attached. Because an observer generally cannot determine if a missing pot was lost due to whale entanglement, mortality and serious injury events are seldom reported in these fisheries. Therefore, the potential for fisheries-caused mortality and serious injury may be greater than is reflected in existing observer data. Additionally, bowhead whales may become entangled in derelict pot gear and such interactions would also not be reflected in observer data. ~~A northward shift of fish stocks and fisheries due to climate change (Morley et al. 2018) will also increase the risk of bowhead whale interactions with fishing gear.~~

There are no observer program records of bowhead whale mortality or serious injury incidental to U.S. commercial fisheries in Alaska; however, there have been reports of bowhead whale mortality and serious injury due to entanglement in fishing gear (Table 3). Because no U.S. commercial fisheries occur in the Beaufort or Chukchi seas, bowhead whale mortality or injury that can be associated with U.S. commercial fisheries is currently attributed to interactions with fisheries in the Bering Sea. 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. George et al. (2017) analyzed scarring data for bowhead whales harvested between 1990 and 2012 to estimate the frequency of line entanglement. Approximately 12.2% of the harvested whales examined for signs of entanglement (59/485) had scar patterns that were identified as definite entanglement injuries (29 whales with possible entanglement scars were excluded). Most of the entanglement scars occurred on the peduncle, and entanglement scars were rare on smaller subadult and juvenile whales (body length <10 m), possibly because young whales are less likely to survive entanglements and have had fewer years during which to acquire entanglement scars (George et al. 2017). The authors suspected the entanglement scars were largely the result of interactions with commercial pot gear (including derelict gear) in the Bering Sea. A review of the photo-identification catalog~~ue~~ from 1985 to 2011 found the probability of scarring due to entanglement was 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).

Between ~~2015~~2016 and ~~2019~~2020, there were ~~four~~three reports of bowhead whale mortality or serious injury caused by interactions with fishing gear (Table 3). ~~In July 2015, a dead adult female bowhead whale drifting near~~

~~Saint Lawrence Island in the Bering Strait was entangled in commercial crab fishing gear (Sheffield and Savoonga Whaling Captains Association 2015, Suydam et al. 2016, Freed et al. 2021), resulting in a mean annual mortality and serious injury rate of 0.2 whales in commercial fisheries between 2015 and 2019 (Table 3).~~ Three of the bowhead whales taken in the Alaska Native subsistence hunt in 2017 were seriously injured prior to harvest due to entanglement in pot gear suspected (but not confirmed) to be from Bering Sea commercial pot fisheries (Rolland et al. 2019, Freed et al. ~~2021~~2022), resulting in a mean annual mortality and serious injury rate of 0.6 bowhead whales in unknown (commercial, recreational, or subsistence) fisheries between ~~2015~~2016 and ~~2019~~2020 (Table 3). ~~Because t~~These three whales are also included in the Alaska Native subsistence harvest for 2017 (Table 4)~~, the mean annual mortality and serious injury rate for these three events (0.6 whales) will be subtracted from the mean annual subsistence harvest for 2015-2019 to prevent double counting~~.

Thus, the minimum estimated ~~average~~mean annual mortality and serious injury rate in ~~U.S. commercial fisheries between 2015 and 2019 is 0.2 bowhead whales and the rate in~~ unknown (commercial, recreational, or subsistence) fisheries between 2016 and 2020 is 0.6 whales (Table 3; Freed et al. ~~2021~~2022), although~~,~~ the actual rates are currently unknown. These mortality and serious injury estimates result from actual counts of verified human-caused deaths and serious injuries and are minimums 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 between ~~2015~~2016 and ~~2019~~2020 (NMFS Alaska Region marine mammal stranding network, ~~Sheffield and Savoonga Whaling Captains Association 2015, Suydam et al. 2016,~~ Rolland et al. 2019, Freed et al. ~~2021~~2022).

Cause of injury	~~2015~~	2016	2017	2018	2019	2020	Mean annual mortality
~~Entangled in commercial Bering Sea/Aleutian Is. crab pot gear~~	~~1~~	~~0~~	~~0~~	~~0~~	~~0~~		~~0.2~~
Entangled in Bering Sea/Aleutian Is. pot gear*	~~0~~	0	3	0	0	0	0.6
~~Total in commercial fisheries~~ *Total in unknown (commercial, recreational, or subsistence) fisheries							~~0.2~~ 0.6

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~~ Alaska Native 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 ~~December 2021~~January 2022).

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~~year (Philo et al. 1993, Suydam et al. 2011). Under this quota, the number of bowhead whales landed by Alaska Natives between 1974 and ~~2019~~2020 ranged from 8 to 55 whales per year (Suydam and George 2012; Suydam et al. 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020; George and Suydam 2014; Scheimreif et al. 2021). 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) (see the Potential Biological Removal section). 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 ~~213~~228 bowhead whales between ~~2015~~2016 and ~~2019~~2020 and ~~42~~49 of the ~~56~~61 whales that were struck and lost were determined to have died or had a poor chance of survival, resulting in a~~n~~ ~~average~~mean annual take (number of whales landed + struck and lost mortality) of ~~51~~55 whales (Table 4); however, because a mean annual 0.6 whales were determined to have been seriously injured in fishery interactions prior to harvest, the total subsistence harvest by Alaska Natives between ~~2015~~2016 and ~~2019~~2020 is ~~50~~54 whales. Unlike the NMFS process for determining serious injuries (described in NMFS 2012), the estimates of struck and lost mortality in the subsistence harvest 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 ~~2019~~2020, ~~30~~54 of ~~36~~69 whales struck were landed, resulting in an efficiency of ~~83~~78% and the mean efficiency for ~~2009~~2010 to ~~2018~~2019 was 77% (~~Suydam et al. 2020~~Scheimreif et al. 2021).

Indigenous Peoples in Canad~~ian~~a and Russia~~n~~ ~~Natives~~ also take whales from this stock. No catches of Western Arctic bowhead whales were reported by Canadian hunters between ~~2015~~2016 and ~~2019~~2020; however, two bowhead whales were landed in Russia in 2016 (Ilyashenko and Zharikov 2017), one in 2017 (Zharikov 2018), none in 2018 (Zharikov et al. 2019), and one in 2019 (Zharikov et al. 2020), resulting in an average annual take of 0.8 (landed) whales by Indigenous Russian~~ Native~~s between 2015 and 2019, which are the most recent data available.

The total ~~average~~mean annual subsistence take ~~from 2015 to 2019~~ is ~~51~~56 bowhead whales: ~~50~~55 whales taken by Alaska Natives between 2016 and 2020 (~~51~~equals the number of landed whales plus the struck and lost mortality (Table 4)~~ minus 0.6 seriously injured in fisheries interactions prior to harvest (Table 3)) and~~plus 0.8 whales landed by Indigenous Russian~~ Native~~s (~~landed;~~ struck and lost whales not reported) between 2015 and 2019.

Table 4. Summary of the Alaska Native subsistence harvest of Western Arctic bowhead whales between ~~2015~~2016 and ~~2019~~2020.

Year	Landed	Struck and lost	Struck and lost mortality[a]	Total (landed + struck and lost mortality)
~~2015[a]~~	~~39~~	~~10~~	~~6~~	~~45~~
2016[b]	47	12	12	59
2017[c]	50	7	5	55
2018[d]	47	21	17	64
2019[e]	30	6	2	32
2020[f]	54	15	13	67
Mean annual number taken (landed + struck and lost mortality)				~~51~~55

[a]~~Suydam et al. (2016)~~Struck and lost mortality includes animals determined to have died or had a poor chance of survival (per the criteria described in Suydam et al. 1995); [b]Suydam et al. (2017); [c]Suydam et al. (2018); [d]Suydam et al. (2019); [e]Suydam et al. (2020); [f]Scheimreif et al. (2021).

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 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 2010 (one carcass), 2012 (two), 2013 (three), 2015 (three), 2016 (four), 2017 (one), 2018 (four), and 2019 (six) (Willoughby et al. 2020a, 2020b).

~~With increasing ship traffic in the Chukchi and Beaufort seas, ship strikes may pose a greater risk to bowhead whales.~~ Currently, vessel~~ship~~-strike injuries on bowhead whales in Alaska 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 vessel~~ship~~ propellers (George et al. 2017), while only seven whales from the photo-identification catalog~~ue~~ from 1985 to 2011 (1% of the sample) had evidence of vessel~~ship~~-inflicted scars (George et al. 2019). One carcass observed in 2019 during the ASAMM surveys had blubber sections with straight wound edges and was likely struck by a vessel (Willoughby et al. 2020b).

HABITAT CONCERNS

Vessel traffic in arctic waters is increasing, largely due to an increase in commercial shipping facilitated by the lack of sea ice (Smith and Stephenson 2013, Reeves et al. 2014, Hauser et al. 2018, CMTS 2019, George et al. 2020). For example, large vessels carrying liquefied natural gas recently transited through Anadyr Strait (west of Saint Lawrence Island) and there are plans for consistent year-round shipping through the Strait (Stolyarov 2021), including the wintering area for western Arctic bowhead whales. The~~is~~ increase in vessel traffic could result in an increased number of vessel collisions with bowhead whales (Huntington et al. 2015, Hauser et al. 2018) and increased acoustic disturbance (Halliday et al. 2021). Oil and gas development in the Beaufort Sea 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 (Blackwell and Thode 2021). 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, including calling rates (~~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~~ reviewed in Blackwell and Thode 2021).

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 (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 (Moore et al. 2019). 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. 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, the Western Arctic stock of bowhead whales commonly feeds in waters ranging from 4° to 6°C near Tuktoyaktuk (Citta et al. 2021a); a bowhead was sighted in the relatively warm waters of the Gulf of Maine during summer 2012, 2014, and 2017 (Accardo et al. 2018); and bowhead whales in the Sea of Okhotsk are found in waters with sea surface temperatures up to 16.5°C (Shpak and Paramonov 2018). Therefore, it is possible that bowhead whales' selection of cooler waters in some regions could be primarily due to prey availability as opposed to thermal stress. Additionally, landed Western Arctic bowhead whales had better body condition during years of light ice cover (George et al. 2006). 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). 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. Ashjian et al. (2021) found that interannual variability in sea ice and winds in the Chukchi Sea affect krill population structure in the bowhead whale feeding hotspot near Point Barrow. ~~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. Stafford et al. (2021) found that bowhead whales delayed their migration out of the Beaufort Sea by 7 days per year from 2008-2018. Insley et al. (2021) used passive acoustic monitoring to document the first known occurrence of bowhead whales overwintering in Amundsen Gulf and the eastern Beaufort Sea. 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. 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. The reduction in sea ice may lead to increased predation of bowhead whales by killer whales. A northward shift of fish stocks and fisheries due to climate change (Morley et al. 2018) will also increase the risk of bowhead whale interactions with fishing gear.

Ocean acidification, driven primarily by the ~~production~~ release of carbon dioxide (CO_2) emissions into the atmosphere, is also a concern due to potential effects on prey. Because their primary prey are small crustaceans (especially calanoid copepods, euphausiids, gammarid and hyperid amphipods, and mysids that have exoskeletons composed of chitin and calcium carbonate), 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.

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~~12) 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 (~~52~~56 whales) is not known to exceed the PBR (~~161~~116)~~ nor~~, the IWC annual maximum strike limit (67 + up to 33 previously unused strikes), nor the IWC block-level landing limit (392 whales, or 56 landings per year). By 2011, ~~T~~the Western Arctic bowhead whale stock ~~has been increasing; the estimate of~~had increased to 16,820 whales; ~~from 2011 is~~this represents between 31% and 168% of the pre-exploitation abundance of 10,000 to 55,000 whales estimated by Brandon and Wade (2004, 2006). The most recent ice-based abundance estimate from 2019 (Givens et al. 2021a, 2021b), is not statistically different from the corresponding estimate for 2011; therefore, the abundance is not believed to have decreased. However, the stock is classified as strategic 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. The current best estimate of abundance ~~estimate~~ is ~~calculated using data from 2011; however, the N_{MIN} is still considered a valid minimum population estimate because the population is increasing (NMFS 2016)~~based on the 2019 ice-based survey, which was negatively affected by disturbance from powered skiffs and anomalies in sea ice conditions that subsequently affected observation effort and the whales' migration route (Givens et al. 2021a). Givens et al. (2021b) derived a correction factor to account for the disturbance from powered skiffs, but the other known sources of negative bias were not accounted for in the best abundance estimate. 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.~~

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Appendix 1. Summary of substantial changes to the text and/or values in the ~~2021~~2022 stock assessments (last revised ~~12/30/2021~~9/1/2022). An 'X' indicates sections where the information presented has been updated since the ~~2020~~2021 stock assessments were released. Stock Assessment Reports for those stocks in boldface were updated in ~~2021~~2022.

Stock	**Stock definition**	**Population size**	**PBR**	**Fishery mortality**	**Subsistence mortality**	**Status**
Steller sea lion (Western U.S.)						
Steller sea lion (Eastern U.S.)						
Northern fur seal (Eastern Pacific)		~~X~~	~~X~~	~~X~~	~~X~~	~~X~~
Harbor seal (Aleutian Islands)						
Harbor seal (Pribilof Islands)						
Harbor seal (Bristol Bay)						
Harbor seal (North Kodiak)						
Harbor seal (South Kodiak)						
Harbor seal (Prince William Sound)						
Harbor seal (Cook Inlet/Shelikof Strait)						
Harbor seal (Glacier Bay/Icy Strait)						
Harbor seal (Lynn Canal/Stephens Passage)						
Harbor seal (Sitka/Chatham Strait)						
Harbor seal (Dixon/Cape Decision)						
Harbor seal (Clarence Strait)						
Spotted seal (Bering)						
Bearded seal (Beringia)						
Ringed seal (Arctic)						
Ribbon seal						
Beluga whale (Beaufort Sea)						
Beluga whale (Eastern Chukchi Sea)						
Beluga whale (Eastern Bering Sea)	**X**	**X**	**X**	**X**	**X**	**X**
Beluga whale (Bristol Bay)						
Beluga whale (Cook Inlet)	~~X~~					~~X~~
Narwhal (Unidentified)						
Killer whale (ENP Alaska Resident)	**X**	**X**	**X**	**X**		**X**
Killer whale (ENP Northern Resident)						
Killer whale (ENP Gulf of Alaska, Aleutian Islands, and Bering Sea Transient)						
Killer whale (AT1 Transient)						
Killer whale (West Coast Transient)						
Pacific white-sided dolphin (North Pacific)						
Harbor porpoise (Northern Southeast Alaska Inland Waters)	**X**	**X**	**X**	**X**	**X**	**X**
Harbor porpoise (Southern Southeast Alaska Inland Waters)	**X**	**X**	**X**	**X**	**X**	**X**
Harbor porpoise (Yakutat/Southeast Alaska Offshore Waters)	**X**	**X**	**X**	**X**	**X**	**X**
Harbor porpoise (Gulf of Alaska)						
Harbor porpoise (Bering Sea)						
Dall's porpoise (Alaska)	~~X~~	~~X~~	~~X~~	~~X~~		~~X~~
Sperm whale (North Pacific)						
Baird's beaked whale (Alaska)						
Cuvier's beaked whale (Alaska)						
Stejneger's beaked whale (Alaska)						
Humpback whale (Western North Pacific)	**X**	**X**	**X**	**X**	**X**	**X**
Humpback whale (~~Central North Pacific~~Hawai'i)	**X**	**X**	**X**	**X**	**X**	**X**

Stock	Stock definition	Population size	PBR	Fishery mortality	Subsistence mortality	Status
Humpback whale (Mexico-North Pacific)	**X**	**X**	**X**	**X**	**X**	**X**
Fin whale (Northeast Pacific)						
Minke whale (Alaska)						
North Pacific right whale (Eastern North Pacific)						
Bowhead whale (Western Arctic)		**X**	**X**	**X**	**X**	**X**

Appendix 2. Stock summary table (last revised ~~12/30/2021~~9/1/2022). 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.

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	Last survey year(s) for estimating abundance	Comments
Steller sea lion	Western U.S.	N	52,932		52,932	0.12	0.1	318	254	37	209	S	2020	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		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	N~~Y~~	626,618	0.2	530,376	0.086	0.5	11,403	373	3.5	360	S	~~2020~~ 2021	2014-2019	Survey years = Sea Lion Rock - 2014; St. Paul and St. George Is. - 2014, 2016, 2018; Bogoslof Is. - 2015, 2019.
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		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	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	Bering	N	461,625		423,237	0.12	1.0	25,394	5,254	1	5,253	NS	2020	2012-2013	
Bearded seal	Beringia	N				0.12	0.5		6,709	1.8	6,707	S	2020	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	Last survey year(s) for estimating abundance	Comments
Ringed seal	Arctic	N				0.12	0.5		6,459	5	6,454	S	2020	2012-2013	N_{EST}, N_{MIN}, and PBR have been calculated, however, important caveats exist; see SAR text for details.
Ribbon seal		N	184,697		163,086	0.12	1.0	9,785	163	0.9	162	NS	2020	2012-2013	
Beluga whale	Beaufort Sea	N	39,258	0.229	N/A	0.04	1.0	UNDET	104	0	104	NS	2020	1992	
Beluga whale	Eastern Chukchi Sea	N	13,305	0.51	8,875	0.04	1.0	178	56	0	56	NS	2020	2017	
Beluga whale	Eastern Bering Sea	~~N~~Y	~~6,994~~ 12,269	~~0.37~~ 0.118	~~N/A~~ 11,112	~~0.04~~ 0.048	1.0	~~UNDET~~ 267	~~206~~ 226	~~0.2~~ 0	~~206~~ 226	NS	2017	~~2000~~ 2017	
Beluga whale	Bristol Bay	N	2,040	0.26	1,645	0.04	1.0	33	19		19	NS	2020	2016	
Beluga whale	Cook Inlet	~~Y~~N	279	0.061	267	0.04	0.1		0	0	0	S	~~2020~~ 2021	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~~ Y	~~2,347~~ 1,920	N/A	~~2,347~~ 1,920	0.04	0.5	~~24~~ 19	1.3	1.1	0	NS	2016	~~2012~~ 2005-2019	N_{EST} is based on counts of individuals identified from photo-ID catalog~~ue~~s.
Killer whale	Eastern North Pacific Northern Resident (British Columbia)	N	302	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 catalog~~ue~~s.

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	Last survey year(s) for estimating abundance	Comments
Killer whale	Eastern North Pacific Gulf of Alaska, Aleutian Islands, and Bering Sea Transient	N	587	N/A	587	0.04	0.5	5.9	0.8	0.8	0	NS	2020	2012	N_{EST} is based on counts of individuals identified from photo-ID catalog~~ue~~s.
Killer whale	AT1 Transient	N	7	N/A	7	0.04	0.1		0	0	0	S	2020	2019	N_{EST} is based on counts of individuals identified from photo-ID catalog~~ue~~s. PBR has been calculated, however, important caveats exist; see SAR text for details.
Killer whale	West Coast Transient	N	349	N/A	349	0.04	0.5	3.5	0.4	0.2	0	NS	2020	2018	N_{EST} is based on counts of individuals identified from photo-ID catalog~~ue~~s 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~~				~~0.04~~	~~0.5~~	34	—	~~34~~	~~0~~	~~S~~	~~2020~~	~~2019~~	~~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	Last survey year(s) for estimating abundance	Comments
Harbor porpoise	Northern Southeast Alaska Inland Waters	Y	1,619	0.26	1,250	0.04	0.5	13	5.6	5.6	0	NS	2021	2019	New stock split from Southeast Alaska stock.
Harbor porpoise	Southern Southeast Alaska Inland Waters	Y	890	0.37	610	0.04	0.5	6.1	7.4	7.4	0	S	2021	2019	New stock split from Southeast Alaska stock.
Harbor porpoise	Yakutat/Southeast Alaska Offshore Waters	Y	N/A		N/A	0.04	0.5	UNDET	22.2	22.2	0	NS	2021	1997	New stock split from Southeast Alaska stock.
Harbor porpoise	Gulf of Alaska	N	31,046	0.21	N/A	0.04	0.5	UNDET	72	72	0	S	2020	1998	
Harbor porpoise	Bering Sea	N			N/A	0.04	0.5	UNDET	0.4	0	0	S	2020	2008	N_{EST} has been calculated, however, important caveats exist; see SAR text for details.
Dall's porpoise	Alaska	~~Y~~N				0.04	0.5		37	37	0	NS	~~2018~~ 2021	2015	N_{EST}, N_{MIN}, and PBR have been calculated, however, important caveats exist; see SAR text for details.
Sperm whale	North Pacific	N				0.04	0.1		3.5	3.3	0	S	2020	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		

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	Last survey year(s) for estimating abundance	Comments
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~~	~~N~~	~~1,107~~	~~0.300~~	~~865~~	~~0.07~~	~~0.1~~	~~3.0~~	~~2.8~~	~~0.9~~	~~0~~	~~S~~	~~2020~~	~~2004-2006~~	
~~Humpback whale~~	~~Central North Pacific - entire stock~~	~~N~~	~~10,103~~	~~0.300~~	~~7,891~~	~~0.07~~	~~0.3~~	~~83~~	~~26~~	~~9.8~~	~~0~~	~~S~~	~~2020~~	~~2004-2006~~	
Humpback whale	Western North Pacific	Y	1,084	0.088	1,007	0.07	0.1	3.4 (0.2 for U.S. waters)	4.46 (0.06 in U.S. waters)	0.03	0	S	N/A (New SAR in 2022)	2004-2006	New SAR following North Pacific humpback whale stock structure changes
Humpback whale	Hawai'i	Y	11,278	0.56	7,265	0.07	0.5	127	19.6	7.7	0	NS	N/A (New SAR in 2022)	2002-2020	New SAR in 2022 following North Pacific humpback whale stock structure changes
Humpback whale	Mexico-North Pacific	Y			N/A	0.066	0.5	UNDET	0.56	0.36	0	S	N/A (New SAR in 2022)	2003-2006	New SAR following North Pacific humpback whale stock structure changes. N_{EST} has 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	Last survey year(s) for estimating abundance	Comments
Fin whale	Northeast Pacific	N				0.04	0.1		0.6	0	0	S	2020	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		
North Pacific right whale	Eastern North Pacific	N	31	0.226	26	0.04	0.1		0	0	0	S	2020	2008	PBR has been calculated, however, important caveats exist; see SAR text for details.
Bowhead whale	Western Arctic	Y	~~16,820~~ 14,025	~~0.052~~ 0.228	~~16,100~~ 11,603	0.04	0.5	~~161~~ 116	~~52~~ 56	~~0.2~~ 0	~~51~~ 56	S	~~2020~~ 2021	~~2011~~ 2019	

Appendix 3. Percent observer coverage in Alaska commercial fisheries 1990-~~2019~~2020 (last revised ~~12/30/2021~~9/1/2022).

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	2019	2020
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	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	35	39	38
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	28	28	100
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	20	23	9.5
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	94	95	93
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	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	39	28	33	0
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	2.5	~~2.3~~ 2.9	~~1.1~~ 1.3	~~1.7~~ 2	~~1.9~~ 2.2	1.3
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	5	4.4	~~5.6~~ 6.3	0	0.8	6.2
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	18	12	10	~~8.6~~ 8.9	~~11~~ 12	6.1
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	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	7.6	0
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	N/A	N/A
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	16	13
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	11	18
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	23	57
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	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	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	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	67	74

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	2019	2020
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	98	91
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	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	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	56	52
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	52	53
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	3.9	~~2.5~~ 3	~~1.4~~ 1.6	~~2.7~~ 3	2.2	1.4
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	71	53	0	82	73	100
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	23	~~5.6~~ 7.1	7.7	~~8.4~~ 9.4	30
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.	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.	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.	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.	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.	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.	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.	not obs.	not obs.
Southeast Alaska salmon drift gillnet (Districts 6, 7, and 8)[c]	% 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.	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 the total catch that was observed. 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.

[c] Total percent observer coverage levels for the observed areas (Alaska Department of Fish & Game districts 6, 7, and 8) are shown (Manly 2015). Coverage levels varied by sub-district and year. Coverage levels in 2012 and 2013 by sub-district were 7.3% and 6.7% (6A), 5.5% and 6.0% (6B), 6.0% and 7.9% (7A), 6.9% and 8.9% (8A), and 6.3% and 5.7% (8B), respectively.

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