DRAFT U.S. PACIFIC MARINE MAMMAL STOCK ASSESSMENTS: 2022

NOAA Fisheries
Southwest Fisheries Science Center
Pacific Islands Fisheries Science Center
Marine Mammal Laboratory
Northwest Fisheries Science Center

U. S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service

Stock assessment reports and appendices revised in 2022 are highlighted; all others can be found at the NOAA marine mammal stock assessment homepage.

PINNIPEDS

CALIFORNIA SEA LION (*Zalophus californianus californianus*): U.S. Stock x
HARBOR SEAL (*Phoca vitulina richardii*): California Stock x
HARBOR SEAL (*Phoca vitulina richardii*): Oregon & Washington Coast Stock x
HARBOR SEAL (*Phoca vitulina richardii*): Washington Inland Waters Stocks (Hood Canal, Southern Puget Sound, and Northern Washington Inland Waters) x
NORTHERN ELEPHANT SEAL (*Mirounga angustirostris*): California Breeding Stock x
GUADALUPE FUR SEAL (*Arctocephalus townsendi*) x
NORTHERN FUR SEAL (*Callorhinus ursinus*): California Stock x
HAWAIIAN MONK SEAL (*Neomonachus schauinslandi*) 1

CETACEANS - U.S. WEST COAST

HARBOR PORPOISE (*Phocoena phocoena vomerina*): Morro Bay Stock x
HARBOR PORPOISE (*Phocoena phocoena vomerina*): Monterey Bay Stock x
HARBOR PORPOISE (*Phocoena phocoena vomerina*): San Francisco-Russian River Stock x
HARBOR PORPOISE (*Phocoena phocoena vomerina*): Northern California/Southern Oregon Stock x
HARBOR PORPOISE (*Phocoena phocoena vomerina*): Northern Oregon/Washington Coast Stock x
HARBOR PORPOISE (*Phocoena phocoena vomerina*): Washington Inland Waters Stock x
DALL'S PORPOISE (*Phocoenoides dalli dalli*): California/Oregon/Washington Stock x
PACIFIC WHITE-SIDED DOLPHIN (*Lagenorhynchus obliquidens*):
California/Oregon/Washington, Northern and Southern Stocks x
RISSO'S DOLPHIN (*Grampus griseus*): California/Oregon/Washington Stock x
COMMON BOTTLENOSE DOLPHIN (*Tursiops truncatus*): California Coastal Stock x
COMMON BOTTLENOSE DOLPHIN (*Tursiops truncatus*):
California/Oregon/Washington Offshore Stock x
STRIPED DOLPHIN (*Stenella coeruleoalba*): California/Oregon/Washington Stock x
SHORT-BEAKED COMMON DOLPHIN (*Delphinus delphis delphis*): California/Oregon/Washington Stock x
LONG-BEAKED COMMON DOLPHIN (Delphinus capensis capensis): California Stock x
NORTHERN RIGHT-WHALE DOLPHIN (*Lissodelphis borealis*): California/Oregon/Washington x
KILLER WHALE (*Orcinus orca*): Eastern North Pacific Offshore Stock x
KILLER WHALE (*Orcinus orca*): Eastern North Pacific Southern Resident Stock 11
SHORT-FINNED PILOT WHALE (*Globicephala macrorhynchus*): California/Oregon/Washington x
BAIRD'S BEAKED WHALE (*Berardius bairdii*): California/Oregon/Washington Stock x
MESOPLODONT BEAKED WHALES (*Mesoplodon* spp.): California/Oregon/Washington Stocks x
CUVIER'S BEAKED WHALE (*Ziphius cavirostris*): California/Oregon/Washington Stock 19
PYGMY SPERM WHALE (*Kogia breviceps*): California/Oregon/Washington Stock x
DWARF SPERM WHALE (*Kogia sima*): California/Oregon/Washington Stock x
SPERM WHALE (*Physeter macrocephalus*): California/Oregon/Washington Stock x
GRAY WHALE (*Eschrichtius robustus*): Eastern North Pacific Stock and Pacific Coast Feeding Group x
GRAY WHALE (*Eschrichtius robustus*): Western North Pacific Stock x
HUMPBACK WHALE (*Megaptera novaeangliae*): Central America / Southern Mexico - California-Oregon-Washington Stock 25
HUMPBACK WHALE (*Megaptera novaeangliae*): Mainland Mexico - California-Oregon-Washington Stock 38
BLUE WHALE (*Balaenoptera musculus musculus*): Eastern North Pacific Stock x
FIN WHALE (*Balaenoptera physalus physalus*): California/Oregon/Washington Stock x
SEI WHALE (*Balaenoptera borealis borealis*): Eastern North Pacific Stock x
MINKE WHALE (*Balaenoptera acutorostrata scammoni*): California/Oregon/Washington x
BRYDE'S WHALE (*Balaenoptera edeni*): Eastern Tropical Pacific x

CETACEANS – HAWAII & WESTERN PACIFIC

ROUGH-TOOTHED DOLPHIN (*Steno bredanensis*): Hawaii Stock x
ROUGH-TOOTHED DOLPHIN (*Steno bredanensis*): American Samoa Stock x
RISSO'S DOLPHIN (*Grampus griseus*): Hawaii Stock x
COMMON BOTTLENOSE DOLPHIN (*Tursiops truncatus truncatus*): Hawaiian Islands Stock Complex (Kauai / Niihau, Oahu, 4-Island, Hawaii Island, and Hawaii Pelagic Stocks x
PANTROPICAL SPOTTED DOLPHIN (*Stenella attenuata attenuata*): Hawaiian Pelagic, Hawaii Island, Oahu, 4 Islands Stocks x
SPINNER DOLPHIN (*Stenella longirostris longirostris*): Hawaii Pelagic, Hawaii Island, Oahu / 4 Islands, Kauai / Niihau, Kure / Midway, and Pearl and Hermes Reef Stocks x
SPINNER DOLPHIN (*Stenella longirostris longirostris*): American Samoa Stock x
STRIPED DOLPHIN (*Stenella coeruleoalba*): Hawaii Stock.......... x
FRASER'S DOLPHIN (*Lagenodelphis hosei*): Hawaii Stock x
MELON-HEADED WHALE (*Peponocephala electra*): Hawaiian Islands and Kohala Resident Stocks x
PYGMY KILLER WHALE (*Feresa attenuata*): Hawaiian Stock x
FALSE KILLER WHALE (*Pseudorca crassidens*): Hawaiian Islands Stock Complex: Main Hawaiian Islands Insular, Northwestern Hawaiian Islands, and Hawaii Pelagic x
FALSE KILLER WHALE (*Pseudorca crassidens*): Palmyra Atoll Stock x
FALSE KILLER WHALE (*Pseudorca crassidens*): American Samoa Stock x
KILLER WHALE (*Orcinus orca*): Hawaiian Stock x
SHORT-FINNED PILOT WHALE (*Globicephala macrorhynchus*): Hawaii Stock x
BLAINVILLE'S BEAKED WHALE (*Mesoplodon densirostris*): Hawaii Stock x
LONGMAN'S BEAKED WHALE (*Indopacetus pacificus*): Hawaii Stock x
CUVIER'S BEAKED WHALE (*Ziphius cavirostris*): Hawaii Stock x
PYGMY SPERM WHALE (*Kogia breviceps*): Hawaii Stock x
DWARF SPERM WHALE (*Kogia sima*): Hawaii Stock x
SPERM WHALE (*Physeter macrocephalus*): Hawaii Stock x
BLUE WHALE (*Balaenoptera musculus musculus*): Central North Pacific Stock x
FIN WHALE (*Balaenoptera physalus physalus*): Hawaii Stock.......... x
BRYDE'S WHALE (*Balaenoptera edeni*): Hawaii Stock x
SEI WHALE (*Balaenoptera borealis borealis*): Hawaii Stock x
MINKE WHALE (*Balaenoptera acutorostrata scammoni*): Hawaii Stock x
HUMPBACK WHALE (*Megaptera novaeangliae)*: American Samoa Stock x

APPENDICES

APPENDIX 1: Summary of 2022 U.S. Pacific Draft Marine Mammal Stock Assessment Reports 51

PREFACE

Under the 1994 amendments to the Marine Mammal Protection Act (MMPA), the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) are required to publish Stock Assessment Reports for all stocks of marine mammals within U.S. waters, to review new information every year for strategic stocks and every three years for non-strategic stocks, and to update the stock assessment reports when significant new information becomes available.

Pacific region stock assessments include those studied by the Southwest Fisheries Science Center (SWFSC, La Jolla, CA), the Pacific Islands Fisheries Science Center (PIFSC, Honolulu, HI), the Marine Mammal Laboratory (NMML, Seattle, WA), and the Northwest Fisheries Science Center (NWFSC, Seattle, WA). The 2022 Draft Pacific marine mammal stock assessments include revised reports for 5 Pacific marine mammal stocks under NMFS jurisdiction, including 4 "strategic" stocks: Hawaiian monk seal, Southern Resident killer whale, and two new humpback whale stocks that summer in U.S. West Coast waters and winter in Central America and Mexico waters. NMFS revised the stock structure for all North Pacific humpback whale stocks. This resulted in five new humpback whale stocks in the North Pacific, two of which are contained within the Pacific SARs: the "**Central America / Southern Mexico - CA-OR-WA**", and "**Mainland Mexico - CA-OR-WA**" humpback whale stocks. New information on abundance is included in all the revised reports, as well as new information on human-caused sources of mortality and serious injury Information on sea otters, manatees, walrus, and polar bears are published separately by the US Fish and Wildlife Service.

This is a working document and individual stock assessment reports will be updated as new information on marine mammal stocks and fisheries becomes available. Background information and guidelines for preparing stock assessment reports are reviewed in NOAA (2016). The authors solicit any new information or comments which would improve future stock assessment reports. Draft versions of the 2022 stock assessment reports were reviewed by the Pacific Scientific Review Group (PSRG) at the March 2022 meeting. These Stock Assessment Reports summarize information from a wide range of original data sources and an extensive bibliography of published sources are provided in each report. We recommend users of this document refer to and *cite original literature* sources cited within the stock assessment reports rather than citing this report or previous Stock Assessment Reports.

References:

NOAA. 2016. Guidelines for Preparing Stock Assessment Reports Pursuant to the 1994 amendments to the MMPA. https://www.fisheries.noaa.gov/national/marine-mammal-protection/guidelines-assessing-marine-mammal-stocks

Revised ~~8/5/2021~~ 9/13/2022

HAWAIIAN MONK SEAL (*Neomonachus schauinslandi*)

STOCK DEFINITION AND GEOGRAPHIC RANGE

Hawaiian monk seals are distributed throughout the Northwestern Hawaiian Islands (NWHI), with subpopulations at French Frigate Shoals, Laysan Island, Lisianski Island, Pearl and Hermes Reef, Midway Atoll, Kure Atoll, and Necker and Nihoa Islands. They also occur throughout the main Hawaiian Islands (MHI). Genetic variation among monk seals is extremely low and may reflect a long-term history at low population levels and more recent human influences (Kretzmann *et al*. 1997, 2001, Schultz *et al*. 2009). Though monk seal subpopulations often exhibit asynchronous variation in demographic parameters (such as abundance trends and survival rates), they are connected by animal movement throughout the species' range (Johanos *et al*. 2013). Genetic analysis (Schultz *et al*. 2011) indicates the species is a single panmictic population. The Hawaiian monk seal is therefore considered a single stock. Scheel *et al*. (2014) established a new genus, *Neomonachus*, comprising the Caribbean and Hawaiian monk seals, based upon molecular and skull morphology evidence.

POPULATION SIZE

The best estimate of the total population size is ~~1,437~~1,465 ~~(no change from 2020 SAR)~~ (95% confidence interval ~~1,369~~ 1,388 – ~~1,532~~1,688); CV = 0.03), (Table 1, Johanos ~~2021a~~2022a, b, c). In 2016, new approaches were developed to estimate Hawaiian monk seal abundance, both range-wide and at individual subpopulations (Baker *et al.* 2016, Harting *et al.* 2017). In brief, methods for abundance estimation vary by site and year depending on the type and quantity of data available. Total enumeration is the favored method, but requires sufficient field presence to convincingly identify all the seals present, which is typically not achieved at most sites (Baker *et al*. 2006). When total enumeration is not possible, capture-recapture estimates (using Program CAPTURE) are conducted (Baker 2004; Otis *et al*. 1978, Rexstad & Burnham 1991, White *et al*. 1982). When no reliable estimator is obtainable in Program CAPTURE (i.e., the model selection criterion is < 0.75, following Otis *et al*. 1978), total non-pup abundance is estimated using pre-existing information on the relationship between proportion of the population identified and field effort hours expended (referred to as discovery curve analysis). At rarely visited sites (Necker, Nihoa, Niihau and Lehua Islands) where data are insufficient to use any of the above methods, beach counts are corrected for the proportion of seals at sea. In the MHI other than Niihau and Lehua Islands, abundance is estimated as the minimum tally of all individuals identified by an established sighting network during the calendar year. At all sites, pups are tallied. Finally, site-specific abundance estimates and their uncertainty are combined using Monte Carlo methods to obtain a range-wide abundance estimate distribution. All the above methods are described or referenced in Baker *et al*. (2016) and Harting *et al*. (2017). Note that because some of the abundance estimation methods utilize empirical distributions which are updated as new data accrue, previous years' estimates can change slightly when recalculated using these updated distributions.

In ~~2019~~2020, NMFS did not conduct field surveys in the NWHI due to the COVID pandemic. NMFS partners, including the USFWS, the State of Hawaii, the Papahānaumokuākea Marine Debris Project (PMDP), and Friends of Hawaiian Islands Natural Wildlife Refuges, conducted limited monk seal surveys. ~~total~~ The most thorough monitoring in the NWHI in 2020 occurred at Midway and Kure Atolls. Total enumeration was not achieved at these sites, and because the amount and timing of survey effort was not comparable to typical years, standard abundance estimation methods (see above) could not be applied. Consequently, minimum tallies were used to represent Midway and Kure Atoll abundance in 2020. ~~at Lisianski Island and Kure Atoll, and at Midway Atoll, Laysan Island, French Frigate Shoals, and Pearl and Hermes Reef, abundance estimates were obtained using discovery curve analysis (Table 1)~~. A single count was conducted at Nihoa Island in 2020. Counts at Necker and Nihoa Islands are typically conducted from zero to a few times per year. Pups are born over the course of many months and have very different haulout patterns compared to older animals. Therefore, pup production at Necker and Nihoa Islands is estimated as the mean of the total pups observed in the past 5 years, excluding counts occurring early in the pupping season when most have yet to be born. For the purposes of estimating total and minimum range wide abundance in 2020 for this report, 2019 values were used for subpopulations other than Nihoa Island and Kure and Midway Atolls.

In the MHI, NMFS collects information on seal sightings reported throughout the year by a variety of sources, including a volunteer network, the public, and directed NMFS observation effort. A small number of surveys of Ni'ihau and nearby Lehua Islands are conducted through a collaboration between NMFS, Ni'ihau residents and the US Navy. Total MHI monk seal abundance is estimated by adding the number of individually identifiable seals documented during a calendar year on all MHI other than Ni'ihau and Lehua to an estimate for these latter two islands based on counts expanded by a haulout correction factor. A telemetry study (Wilson *et al*., 2017) found that MHI monk seals (N=23) spent a greater proportion of time ashore than Harting *et al*. (2017) estimated for NWHI seals. Therefore, the total non-pup estimate for Ni'ihau and Lehua Islands was the total beach count at those sites (less individual seals already counted at other MHI) divided by the mean proportion of time hauled out in the MHI (Wilson *et al*., 2017). The total pups observed at Ni'ihau and Lehua Islands were added to obtain the total (Table 1). While NMFS surveys in 2020 were very limited, information from partners and the public were typical, such that MHI estimates were obtained.

Table 1. Total and minimum estimated abundance (N_{min}) of Hawaiian monk seals by location ~~in 2019~~. Estimates from 2020 data were available for Kure and Midway Atolls, Nihoa Island, and the MHI. Estimates from 2019 were used for all remaining subpopulations. The estimation method is indicated for each site. Methods used include DC: discovery curve analysis, EN: total enumeration; CR: capture-recapture; CC: counts corrected for the proportion of seals at sea; Min: minimum tally. Median values are presented. Note that the median range-wide abundance is not equal to the total of the individual sites' medians, because the median of sums may differ from the sum of medians for non-symmetrical distributions. N_{min} for individual sites are either the minimum number of individuals identified or the 20th percentile of the abundance distribution (the latter applies to Necker, Nihoa, Ni'ihau/Lehua, and range-wide).

	~~Total~~			~~*Nmin*~~			
~~**Location**~~	~~**Non-pups**~~	~~**Pups**~~	~~**Total**~~	~~**Non-pups**~~	~~**Pups**~~	~~**Total**~~	~~**Method**~~
~~French Frigate Shoals~~	~~188~~	~~35~~	~~223~~	~~186~~	~~35~~	~~221~~	~~DC~~
~~Laysan~~	~~194~~	~~40~~	~~234~~	~~193~~	~~40~~	~~233~~	~~DC~~
~~Lisianski~~	~~139~~	~~19~~	~~158~~	~~139~~	~~19~~	~~158~~	~~EN~~
~~Pearl and Hermes Reef~~	~~120~~	~~21~~	~~141~~	~~120~~	~~21~~	~~141~~	~~DC~~
~~Midway~~	~~70~~	~~10~~	~~80~~	~~70~~	~~10~~	~~80~~	~~DC~~
~~Kure~~	~~81~~	~~13~~	~~94~~	~~81~~	~~13~~	~~94~~	~~EN~~
~~Necker~~	~~62~~	~~8~~	~~70~~	~~52~~	~~8~~	~~60~~	~~CC~~
~~Nihoa~~	~~72~~	~~4~~	~~76~~	~~61~~	~~4~~	~~65~~	~~CC~~
~~MHI (without Ni'ihau/ Lehua)~~	~~161~~	~~25~~	~~186~~	~~161~~	~~25~~	~~186~~	~~Min~~
~~Ni'ihau/Lehua~~	~~138~~	~~23~~	~~161~~	~~115~~	~~23~~	~~138~~	~~CC~~
~~**Range-wide**~~	~~***1239***~~	~~***198***~~	~~***1437***~~	~~***1178***~~	~~***198***~~	~~***1376***~~	

	Total			***Nmin***			
Location	**Non-pups**	**Pups**	**Total**	**Non-pups**	**Pups**	**Total**	**Method**
French Frigate Shoals	188	35	223	186	35	221	DC
Laysan	194	40	234	193	40	233	DC
Lisianski	139	19	158	139	19	158	EN
Pearl and Hermes Reef	120	21	141	120	21	141	DC
Midway	65	12	77	65	12	77	Min
Kure	75	15	90	75	15	90	Min
Necker	62	8	70	53	8	61	CC
Nihoa	82	4	86	69	4	73	CC
MHI (without Ni'ihau/ Lehua)	175	20	195	175	20	195	Min

Ni'ihau/Lehua	161	18	179	136	18	154	CC
Range-wide	***1273***	***192***	***1465***	***1239***	***192***	***1431***	

Minimum Population Estimate

The total numbers of seals identified at the NWHI subpopulations other than Necker and Nihoa, and in the MHI other than Ni'ihau and Lehua, are the best estimates of minimum population size at those sites. Minimum population sizes for Necker, Nihoa, Ni'ihau, and Lehua Islands are estimated as the lower 20th percentiles of the non-pup abundance distributions generated using haulout corrections as described above, plus the pup estimates. The minimum abundance estimates for each site and for all sites combined (~~1,376~~1,431) are presented in Table 1.

Current Population Trend

Range-wide abundance estimates are available from 2013 to 2019, and a value for 2020 was generated using 2020 data where available and 2019 values elsewhere (Table 1, Figure 1). While these estimates remain somewhat negatively-biased for reasons explained in Baker et al. (2016), they provided a much more comprehensive assessment of status and trends than has been previously available. A Monte Carlo approximation of the annual multiplicative rate of realized population growth during 2013-~~2019~~ 2020 was generated by fitting 10,000 log-linear regressions to randomly selected values from each year's abundance distributions. The median rate (and 95% confidence limits) is 1.02 (1.01, 1.03). Thus, the best estimate is that the population grew at an average rate of about 2% per year from 2013 to ~~2019~~2020. ~~Less than 1% of the distribution was below 1, indicating that there is greater than a 99% chance that the monk seal population increased during 2013- 2019.~~ Because there were no new estimates for most of the NWHI subpopulations in 2020, true uncertainty is greater than indicated by the nominal confidence intervals above.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Mean non-pup beach counts are used as a long-term index of abundance for years when data are insufficient to estimate total abundance as described above. Prior to 1999, beach count increases of up to 7% annually were observed at Pearl and Hermes Reef, and this is the highest estimate of the maximum net productivity rate (R_{max}) observed for this species (Johanos ~~2021a~~2022a). Consistent with this value, a life table analysis representing a time when the MHI monk seal population was apparently expanding, yielded an estimated intrinsic population growth rate of 1.07 (Baker *et al*. 2011).

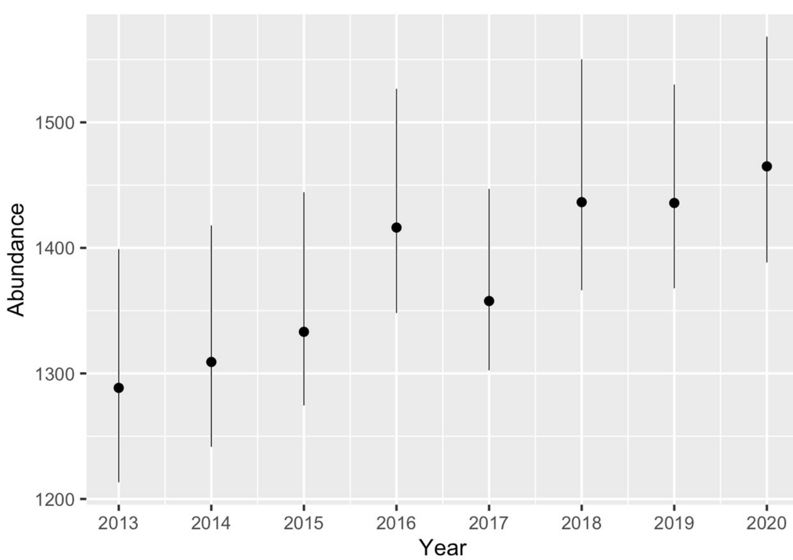

Figure 1. Range-wide abundance of Hawaiian monk seals, 2013-~~2019~~2020. Medians and 95% confidence limits are shown. Estimates prior to ~~2019~~ 2020 are re-estimated based on new data and represent negligible changes compared with values reported in the previous final stock assessments. Note that 2019 estimates were used to represent abundance at most of the NWHI subpopulations where no information was collected in 2020 (Table 1).

POTENTIAL BIOLOGICAL REMOVAL

Using current minimum population size (~~1,376~~1,431), R_{max} (0.07) and a recovery factor (F_r) for ESA endangered stocks (0.1), yields a Potential Biological Removal (PBR) of ~~4.8~~5.0.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Human-related mortality has caused two major declines of the Hawaiian monk seal (Ragen 1999). In the 1800s, this species was decimated by sealers, crews of wrecked vessels, and guano and feather hunters (Dill and Bryan 1912; Wetmore 1925; Bailey 1952; Clapp and Woodward 1972). Following a period of at least partial recovery in the first half of the 20th century (Rice 1960), most subpopulations again declined. This second decline has not been fully explained, but long-term trends at several sites appear to have been driven both by variable oceanic productivity (represented by the Pacific Decadal Oscillation) and by human disturbance (Baker *et al*. 2012, Ragen 1999, Kenyon 1972, Gerrodette and Gilmartin 1990). Currently, human activities in the NWHI are limited and human disturbance is relatively rare, but human-seal interactions, have become an important issue in the MHI. Intentional killing of seals in the MHI is an ongoing and serious concern (Table 2).

Table 2. Intentional and potentially intentional killings of MHI monk seals, and anthropogenic mortalities not associated with fishing gear during ~~2015~~2016-~~2019~~ 2020 (Johanos ~~2021d~~2022d, Mercer ~~2021~~2022). There were no confirmed cases in 2016, ~~nor~~ 2019, nor 2020.

Year	Age/sex	Island	Cause of Death	Comments
~~2015~~	~~Pup male~~	~~Kauai~~	~~Dog attack/bite wounds~~	~~4 other seals injured during this event~~
~~2015~~	~~Juvenile male~~	~~Kauai~~	~~Probable boat strike~~	
~~2015~~	~~Adult male~~	~~Laysan~~	~~Research handling~~	~~Accidental, specific cause undetermined~~
2017	Adult female	Kauai	Trauma	Suspect intentional
2017	Juvenile female	Molokai	Blunt force trauma	Suspect intentional
2018	Juvenile female	Molokai	Blunt force trauma	Intentional

Harting et al. (2021) found that the 46% of carcasses of monk seals which died in the MHI during 2004-2019 were detected. Consequently, the cases in Table 2 must be considered a minimum representation of intentional killings.

Fishery Information

Fishery interactions with monk seals can include direct interaction with gear (hooking or entanglement), seal consumption of discarded or depredated catch, and competition for prey. Entanglement of monk seals in derelict fishing gear, which is believed to originate outside the Hawaiian archipelago, is described in a separate section. Fishery interactions are a serious concern in the MHI, especially involving nearshore fisheries managed by the State of Hawaii (Gobush et al. 2016). There are no fisheries operating in or near the NWHI. In ~~2019~~2020, ~~17~~ 29 seal hookings were documented, one of which resulted in death, another ~~was~~ classified as serious, and ~~16~~ 27 as non-serious injuries. Of the non-serious injuries, ~~five~~ four would have been deemed serious had they not been mitigated (Henderson 2019a, Mercer ~~2021~~2022). ~~The hooks involved included circle, treble and J-hooks of widely varying sizes. Two seals that had been previously scored as having serious injuries from hooking in 2018 have been reclassified as having non-serious injuries upon further review. Also, two mitigated serious injuries reported as fishery interactions in 2018 were reclassified as debris entanglements.~~ Monk seals also interact with nearshore gillnets, and several confirmed deaths have resulted. In ~~2019~~2020, the deaths of two seals were ~~attributed~~deemed most likely due~~-~~ to net drowning based on ~~necropsy and other~~available information. ~~A third seal was suspected of having drowned in a net but the carcass was at sea and could not be recovered.~~ No mortality or injuries have been attributed to the MHI bottomfish handline fishery, and no interactions with longline fisheries have occurred since 1991. Consequently, these fisheries are no long included in ~~(~~Table 3~~)~~. Published studies on monk seal prey selection based upon scat/spew analysis and video from seal-mounted cameras revealed evidence that monk seals fed on families of bottomfish which contain commercial species (many prey items recovered from scats and spews were identified only to the level of family; Goodman-Lowe 1998, Longenecker *et al*. 2006, Parrish *et al*. 2000). Quantitative fatty acid signature analysis (QFASA) results support previous studies illustrating that monk seals consume a wide range of species (Iverson *et al*. 2011). However, deepwater-slope species, including two commercially targeted bottomfishes and other species not caught in the fishery, were estimated to comprise a large portion of the diet for some individuals. Similar species were estimated to be consumed by seals regardless of location, age or gender, but the relative importance of each species varied. Diets differed considerably between individual seals. These results highlight the need to better understand potential ecological interactions with the MHI bottomfish handline fishery.

Table 3. Summary of mortality, serious and non-serious injury of Hawaiian monk seals due to fisheries and calculation of annual mortality rate. n/a indicates that sufficient data are not available~~. Percent observer coverage for the deep and shallow-set components, respectively, of the pelagic longline fishery, are shown.~~ Total non-serious injuries are presented as well as, in parentheses, the number of those injuries that would have been deemed serious had they not been mitigated (e.g., by de-hooking or disentangling). Nearshore fisheries injuries and mortalities include seals entangled/drowned in nearshore gillnets and hooked/entangled in hook-and-line gear, recognizing that it is not possible to determine whether the nets or hook-and-line gear involved were being used for commercial purposes.

Fishery Name	Year	Data Type	% Obs. coverage	Observed/Reported Mortality/Serious Injury	Estimated Mortality/ Serious Injury	Non-serious (Mitigated serious)	Mean Takes (CV)
~~Pelagic Longline~~	~~2015~~ ~~2016~~ ~~2017~~ ~~2018~~ ~~2019~~	~~observer~~ ~~observer~~ ~~observer~~ ~~observer~~ ~~observer~~	~~20.6% & 100%~~ ~~20.1% & 100%~~ ~~20.4% & 100%~~ ~~20.4% & 100%~~ ~~20.5 & 100%~~	~~0~~ ~~0~~ ~~0~~ ~~0~~ ~~0~~	~~0~~ ~~0~~ ~~0~~ ~~0~~ ~~0~~	~~0~~ ~~0~~ ~~0~~ ~~0~~ ~~0~~	~~0 (0)~~
~~MHI Bottomfish~~	~~2015~~ ~~2016~~ ~~2017~~ ~~2018~~ ~~2019~~	~~Incidental observations of seals~~	~~none~~	~~0~~ ~~0~~ ~~0~~ ~~0~~ ~~0~~	~~n/a~~	~~0~~ ~~0~~ ~~0~~ ~~0~~ ~~0~~	~~n/a~~
Nearshore	~~2015~~ 2016 2017 2018 2019 2020	Incidental observations of seals	none	~~3~~ 0 3 0 3 4	n/a	~~8 (2)~~ 11 (6) 19(6) 11(3) 17(5) 29(4)	≥ ~~1.8~~2.0
Mariculture	~~2015~~ 2016 2017 2018 2019 2020	Incidental Observation	none	~~0~~ 0 1 0 0 0	n/a	~~0~~ 0 0 0 0 0	0.2 (2.2)
Minimum total annual takes							≥ 2.2~~2.0~~

Fishery Mortality Rate

Total fishery mortality and serious injury is not considered to be insignificant and approaching a rate of zero. Monk seals are regularly hooked and entangled in the MHI and the resulting deaths have substantially reduced the population growth rate (Harting et al. 2021). Monk seals also die from entanglement in fishing gear and other debris throughout their range (likely originating from various sources outside of Hawaii), and NMFS along with partner agencies is ~~pursuing a program~~actively working to mitigate entanglement (see below).

Entanglement in Marine Debris

Hawaiian monk seals become entangled in fishing and other marine debris at rates higher than reported for other pinnipeds (Henderson 2001). Several hundred cases of debris entanglement have been documented in monk seals (nearly all in the NWHI), including ten documented deaths (Henderson 2001; Henderson 2019b, Mercer ~~2021~~2022). The number of marine debris entanglements documented in the past five years (Table 4) is an underestimate of the total impact of this threat because no people are present to document nor mitigate entanglements at most of the NWHI for the majority of the year. The low number of entanglements documented in 2020 is due to limited or no surveillance conducted at NWHI subpopulations due to the COVID pandemic. ~~Nearly all documented~~

~~cases would have been deemed serious had they not been mitigated by field biologists.~~ The fishing gear fouling the reefs and beaches of the NWHI and entangling monk seals only rarely includes types used in Hawaii fisheries. For example, trawl net and monofilament gillnet accounted for approximately 35% and 34%, respectively, of the debris removed from reefs in the NWHI by weight, and trawl net alone accounted for 88% of the debris by frequency (Donohue *et al*. 2001), despite the fact that trawl fisheries have been prohibited in Hawaii since the 1980s.

Table 4. Summary of documented marine debris entanglements of Hawaiian monk seals during the most recent five years. Total non-serious injuries are presented as well as, in parentheses, the number of those injuries that would have been deemed serious had the seals not been disentangled.

Year	Observed/Reported Mortality/Serious Injury	Non-serious (Mitigated serious)
~~2015~~	~~0~~	~~12(8)~~
2016	0	3(2)
2017	0	11(8)
2018	1	15(6)
2019	0	16(10)
2020	0	5(1)
Minimum total annual takes	≥ 0.2	

The NMFS and partner agencies continue to mitigate impacts of marine debris on monk seals as well as turtles, coral reefs and other wildlife. Marine debris is removed from beaches and seals are disentangled during ~~annual~~ population assessment activities ~~at the main reproductive sites~~in the NWHI. Since 1996, annual debris survey and removal efforts in the NWHI coral reef habitat have been ongoing (Donohue *et al*. 2000, Donohue *et al*. 2001, Dameron *et al*. 2007).

Toxoplasmosis

Land-to-sea transfer of *Toxoplasma gondii,* a protozoal parasite shed in the feces of cats, is of growing concern. Although the parasite can infect many species, felids are the definitive host, meaning it can only reproduce in cats. There are no native felids in Hawaii, but several hundred thousand feral and domestic cats occur throughout the MHI. As such, all monk seal deaths attributable to toxoplasmosis are considered human caused. A case definition for toxoplasmosis and other protozoal-related mortalities was developed and retrospectively applied to 306 cases of monk seal mortality from 1982-2015 (Barbieri et al. 2016). During the past five years (~~2015~~2016-~~2019~~2020) five monk seal deaths (representing a minimum average of one death per year) have been directly attributed to toxoplasmosis (Mercer 2021). ~~All~~ Four of the five deaths involved female seals. The number of deaths from this pathogen are likely underrepresented, given that more seals disappear each year than are found dead and examined (Harting et al. 2021), and the potential for chronic infections remains poorly understood in this species. Furthermore, *T. gondii* can be transmitted vertically from dam to fetus, and failed pregnancies are difficult to detect in wild, free-ranging animals. Unlike threats such as hook ingestion or malnutrition, which can often be mitigated through rehabilitation, options for treating seals with toxoplasmosis are ~~severely restricted~~challenging and have not been successful (n = 2). The accumulating number of monk seal deaths from toxoplasmosis in recent years is a growing concern given the increasing geographic overlap between humans, cats, and Hawaiian monk seals in the MHI.

Other Mortality

Sources of mortality that impede recovery include food limitation (see Habitat Issues), single and multiple-male intra-species aggression (mobbing), shark predation, and disease~~/parasitism~~. Male seal aggression has caused episodes of mortality and injury. Past interventions to remove aggressive males greatly mitigated, but have not eliminated, this source of mortality (Johanos *et al*. 2010). Galapagos shark predation on monk seal pups has been a chronic and significant source of mortality at French Frigate Shoals since the late 1990s, despite mitigation efforts by NMFS (Gobush 2010). Besides toxoplasmosis, infectious disease effects on monk seal demographic trends are low relative to other stressors. However, a disease outbreak ~~introduced from livestock, feral animals, pets or other carrier wildlife~~ could be catastrophic to the immunologically naïve monk seal population. Key disease threats include West Nile virus, morbillivirus and influenza.

Habitat Issues

Poor juvenile survival rates and variability in the relationship between weaning size and survival suggest that prey availability has limited recovery of NWHI monk seals (Baker and Thompson 2007, Baker *et al*. 2007, Baker 2008). Multiple strategies for improving juvenile survival, including translocation and captive care are being implemented (Baker and Littnan 2008, Baker *et al*. 2013, Norris 2013). A testament to the effectiveness of past actions to improve survival, Harting *et al.* (2014) demonstrated that approximately one-third of the monk seal population alive in 2012 was made up of seals that either had been intervened with to mitigate life-threatening situations, or were descendants of such seals. In 2014, NMFS produced a final Programmatic Environmental Impact Statement (PEIS) on current and future anticipated research and enhancement activities and issued a permit covering the activities described in the PEIS preferred alternative. Loss of terrestrial habitat at French Frigate Shoals is a serious threat to the viability of the resident monk seal population (Baker et al. 2020). Prior to 2018, pupping and resting islets had shrunk or virtually disappeared (Antonelis *et al*. 2006). In 2018, the two remaining primary islands where pups were born at French Frigate Shoals (Trig and East Islands) were obliterated due to progressive erosion and hurricane Walaka (in September 2018). Projected increases in global average sea level are expected to further significantly reduce terrestrial habitat for monk seals in the NWHI (Baker *et al*. 2006, Reynolds *et al*. 2012).

The seawall at Tern Island, French Frigate Shoals, continues to degrade and poses an increasing entrapment hazard for monk seals and other fauna. The situation has worsened since 2012, when the USFWS ceased operations on Tern Island, thus leaving the island unmanned for most of the year. Previously, daily surveys were conducted throughout the year to remove entrapped animals. Now this only occurs when NMFS ~~monk seal field~~ staff are on site. Furthermore, sea wall breaches are allowing sections of the island to erode and undermine buildings and other infrastructure. Several large water tanks have collapsed, exposing pipes and wiring that may entangle or entrap seals. In September 2018, hurricane Walaka exacerbated this situation by largely destroying remaining structures and strewing the resulting debris around the island. Strategies to mitigate these threats are currently under consideration. In 2020, the Papahānaumokuākea Marine Debris Project (PMDP), a non-profit organization, conducted an extensive cleanup operation at Tern Island, removing over 80,000 lb of debris and cutting multiple gaps in the seawall to provide escape routes for seals.

Goodman-Lowe (1998) provided information on prey selection using hard parts in scats and spewings. Information on at-sea movement and diving is available for seals at all six main subpopulations in the NWHI using satellite telemetry (Stewart *et al*. 2006). Cahoon (2011) and Cahoon *et al*. (2013) described diet and foraging behavior of MHI monk seals, and found no striking difference in prey selection between the NWHI and MHI.

Monk seal juvenile survival rates are favorable in the MHI (Baker *et al*. 2011). Further, the excellent condition of pups weaned on these islands suggests that there are ample prey resources available, perhaps in part due to fishing pressure that has reduced monk seal competition with large fish predators (sharks and jacks) (Baker and Johanos 2004). Yet, there are many challenges that may limit the potential for growth in this region. The human population in the MHI is approximately 1.4 million compared to fewer than 100 in the NWHI, such that anthropogenic threats in the MHI are considerable. Intentional killing of seals is a very serious concern. Also, the same fishing pressure that may have reduced the monk seal's competitors is a source of injury and mortality. Vessel traffic in the populated islands entails risk of collision with seals and impacts from oil spills. A mortality in 2015 was deemed most likely due to boat strike. Finally, as noted above, toxoplasmosis is now recognized as a serious anthropogenic threat to seals in the MHI.

STATUS OF STOCK

In 1976, the Hawaiian monk seal was designated depleted under the Marine Mammal Protection Act of 1972 and as endangered under the Endangered Species Act of 1973 (NMFS 2007). Therefore, the Hawaiian monk seal is a strategic stock. The species is well below its optimum sustainable population and has not recovered from past declines. Annual human-caused mortality for the most recent 5-year period (2015-2019) was at least 4.0 ~~4.6~~ animals, including fishery-related mortality in nearshore gillnets, hook-and-line gear, and mariculture (≥ ~~2.0~~2.2/yr, Table 3), intentional killings and other human-caused mortalities (≥ ~~1.2~~0.6/yr, Table 2), entanglement in marine debris (≥ 0.2/yr, Table 4), and deaths due to toxoplasmosis (≥ 1.0/yr). Because 4.6 is a minimum rate of annual human-caused mortality, the true value almost certainly exceeds PBR (~~4.8~~5.0).

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Revised ~~3/14/2022~~ 9/12/2022

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

STOCK DEFINITION AND GEOGRAPHIC RANGE

Killer whales occur in all oceans and seas (Leatherwood and Dahlheim 1978). Although they occur in tropical and offshore waters, killer whales prefer the colder waters of both hemispheres, with greatest abundances found within 800 km of major continents (Mitchell 1975, Forney and Wade 2006). Along the west coast of North America, killer whales occur along the entire Alaskan coast (Braham and Dahlheim 1982, Hamilton *et al.* 2009), in British Columbia and Washington inland waterways (Bigg *et al.* 1990), and along the outer coasts of Washington, Oregon and California (Hamilton *et al.* 2009). Seasonal and year-round occurrence is documented for killer whales throughout Alaska (Braham and Dahlheim 1982) and in the intracoastal waterways of British Columbia and Washington, where three ecotypes have been recognized: 'resident', 'transient' and 'offshore' (Bigg *et al.* 1990, Ford *et al.* 1994), 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, Morin *et al.* 2010, Ford *et al.* 2014). Genetic studies of killer whales globally suggest that residents and transient ecotypes warrant subspecies recognition (Morin *et al.* 2010) and each are currently listed as unnamed subspecies of *Orcinus orca* (Committee on Taxonomy 2018).

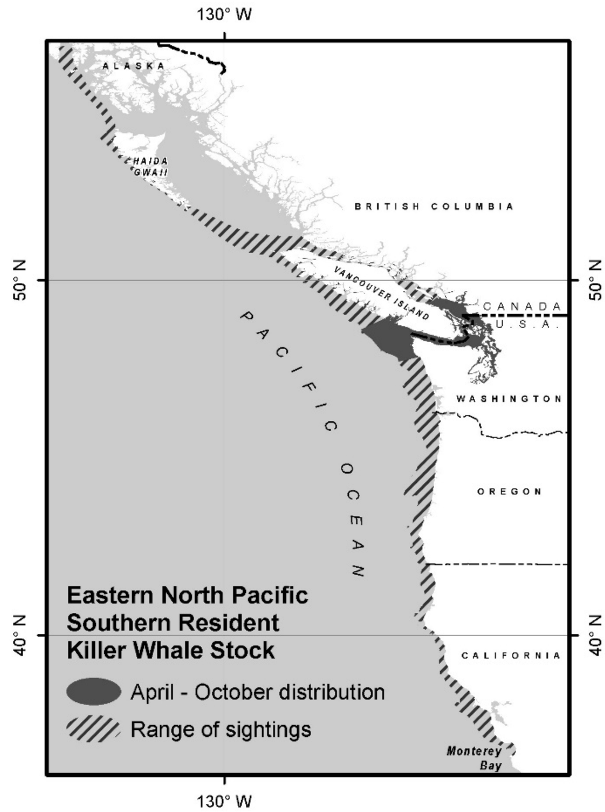

Figure 1. Approximate April - October distribution of the Eastern North Pacific Southern Resident killer whale stock (shaded area) and range of sightings (diagonal lines).

The range of southern resident killer whales is described in the ~~draft~~ biological report for the ~~Proposed~~ Revision of the Critical Habitat Designation for Southern Resident Killer Whales (NMFS 2021a, 2021b): "The three pods of the Southern Resident DPS, identified as J, K, and L pods, reside for part of the year in the inland waterways of Washington State and British Columbia known as the Salish Sea (Strait of Georgia, Strait of Juan de Fuca, and Puget Sound), principally during the late spring, summer, and fall (Ford et al. 2000, Krahn et al. 2002). The whales also ~~visit~~ occur in outer coastal waters, primarily in winter, off Washington and Vancouver Island, especially in the area between Grays Harbor and the Columbia River, and off Westport, WA (Ford et al. 2000, Hanson et al. 2017), but ~~travel~~ have been documented as far south as central California and as far north as the Southeast Alaska. Although less is known about the whales' movements in outer coastal waters, satellite tagging, opportunistic sighting, and acoustic recording data suggest that Southern Residents spend nearly all of their time on the continental shelf, within 34 km (21.1 mi) of shore in water less than 200 m (656.2 ft) deep (Hanson *et al.* 2017)." Details of their winter range from satellite-tagging reveal whales use the entire Salish Sea (northern end of the Strait of Georgia and Puget Sound) in addition to coastal waters from the central west coast of Vancouver Island, British Columbia to Pt. Reyes in northern California. Animals from J pod were documented moving between the northern Strait of Georgia and the western entrance of the Strait of Juan de Fuca, with limited movement into coastal waters. In contrast, K and L pod movements were characterized by a coastal distribution from the western entrance to the Strait of Juan de Fuca to Pt. Reyes California (Hanson *et al.* 2017). Of the three pods comprising this stock, one (J) is commonly sighted in inshore waters in winter, while the other two (K and L) apparently spend more time offshore (Ford *et al.* 2000). Krahn *et al.* (2009) described sample pollutant ratios from K and L pod whales that were consistent with a hypothesis of time spent foraging in California waters, which is consistent with sightings of K and L pods as far south as Monterey Bay. In June 2007, whales from L-pod were sighted off Chatham Strait, Alaska, the farthest north they have ever been documented (J. Ford, pers. comm.). Southern resident killer whale attendance in their core summer habitat in the Salish Sea appears to be declining, with occurrence well-below average since 2017 (Center for Whale Research 2019). Passive autonomous acoustic recorders have provided more information on the seasonal occurrence of these pods along the west coast of the U.S. (Hanson *et al.* 2013). In addition, satellite-linked tags were deployed in winter months on members of J, K, and L pods. Results were consistent with previous data, but provided much greater detail, showing wide-ranging use of inland waters by J Pod whales and extensive movements in U.S. coastal waters by K and L Pods.

Based on data regarding association patterns, acoustics, movements, genetic differences and potential fishery interactions, eight killer whale stocks are recognized within the Pacific U.S. EEZ: 1) the Eastern North Pacific Alaska Resident stock - occurring from Southeast Alaska to the Bering Sea, 2) the Eastern North Pacific Northern Resident stock - occurring from British Columbia through Alaska, 3) the Eastern North Pacific Southern Resident stock - occurring mainly within the inland waters of Washington State and southern British Columbia but extending from central California into southern Southeast Alaska (see Fig. 1), 4) the West Coast Transient stock - occurring from Alaska through California, 5) the Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock - occurring from southeast Alaska to the Bering Sea, 6) the AT1 Stock – found only in Prince William Sound, 7) the Eastern North Pacific Offshore stock - occurring from Southeast Alaska through California, 8) the Hawaiian stock. The Stock Assessment Reports for the Alaska Region contain information concerning the Eastern North Pacific Alaska Resident, Eastern North Pacific Northern Resident and the Gulf of Alaska, Aleutian Islands, and Bering Sea, AT1, and Eastern North Pacific Transient stocks.

POPULATION SIZE

The Eastern North Pacific Southern Resident stock is a trans-boundary stock including killer whales in inland Washington and southern British Columbia waters. In 1993, the three pods comprising this stock totaled 96 killer whales (Ford *et al.* 1994). The population increased to 99 whales in 1995, then declined to 79 whales in 2001, and most recently numbered ~~72~~ 74 whales in ~~2020~~ 2021 (Fig. 2; Ford *et al.* 2000; Center for Whale Research ~~2019~~2021). ~~The 2001-2005 counts included a whale born in 1999 (L-98) that was listed as missing during the annual census in May and June 2001 but was subsequently discovered alone in an inlet off the west coast of Vancouver Island. L-98 remained separate from L pod until 10 March 2006 when he died due to injuries associated with a vessel interaction in Nootka Sound. L-98 has been subtracted from the official 2006 and subsequent population censuses.~~ The most recent census spanning 1 July ~~2019~~ 2020 through 1 July ~~2020~~ 2021 includes three new calves (J57, J58, L125), the death of ~~an adult male~~ a post-reproductive female, but does not include the death of an adult male in late summer of 2021, or two calves born in early 2022. ~~two calves that were born in fall 2020.~~

Minimum Population Estimate

The abundance estimate for this stock of killer whales is a direct count of individually identifiable animals. It is thought that the entire population is censused every year. This estimate therefore serves as both a best estimate of abundance and a minimum estimate of abundance. Thus, the minimum population estimate (N_{min}) for the Eastern North Pacific Southern Resident stock of killer whales is ~~72~~ 74 animals.

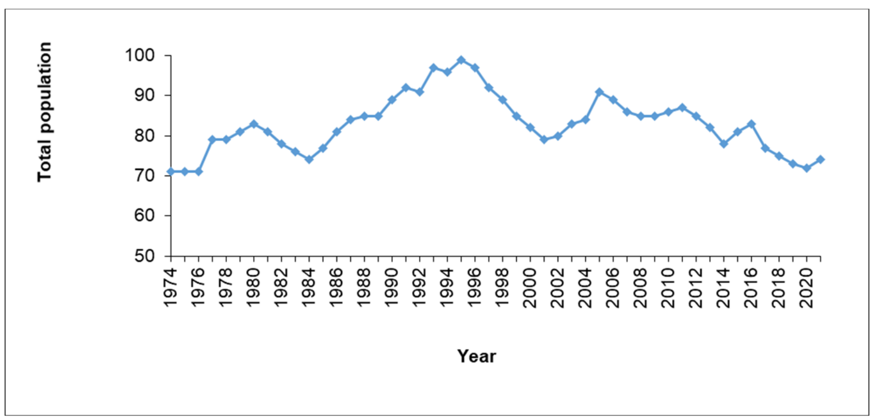

Figure 2. Population of Eastern North Pacific Southern Resident stock of killer whales, 1974-~~2020~~2021. Each year's count includes animals first seen and first missed; a whale is considered first missed the year after it was last seen alive (Ford *et al.* 2000; Center for Whale Research ~~2020~~2021).

Current Population Trend

During the live-capture fishery that existed from 1967 to 1973, it is estimated that 47 killer whales, mostly immature, were taken out of this stock (Ford *et al.* 1994). Since the first complete census of this stock in 1974 when 71 animals were identified, the number of southern resident killer whales has fluctuated. Between 1974 and the mid-1990s, the Southern Resident stock increased approximately 35% (Ford *et al.* 1994), representing a net annual growth rate of 1.8% during those years. Following the peak census count of 99 animals in 1995, the population size has declined approximately 1% annually and currently stands at ~~72~~ 74 animals as of the ~~2020~~ 2021 census (Ford *et al.* 2000; Center for Whale Research ~~2020~~2021).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

A reliable estimate of the maximum net productivity rate is currently unavailable for this stock of killer whales. Matkin *et al.* (2014) estimated a maximum population annual growth rate of 1.035 for southern Alaska resident killer whales. The authors noted that the 3.5% annual rate estimated for southern Alaska residents is higher than previously measured rates for British Columbia northern residents (2.9%, Olesiuk *et al.* 1990) and "probably represents a population at r-max (maximum rate of growth)." In the absence of published estimates of R_{max} for southern resident killer whales, the maximum annual rate of 3.5% found for southern Alaska residents is used for this stock of southern resident killer whales. This reflects more information about the known life history of resident killer whales than the default R_{max} of 4% and results in a more conservative estimate of potential biological removal (PBR).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (~~72~~74) times one-half the maximum net growth rate for *Alaska* resident killer whales (½ of 3.5%) times a recovery factor of 0.1 (for an endangered stock, Wade and Angliss 1997), resulting in a PBR of 0.13 whales per year, or approximately 1 animal every 7 years.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

Salmon drift gillnet fisheries in Washington inland waters were last observed in 1993 and 1994 and no killer whale entanglements were documented, though observer coverage levels were less than 10% (Erstad *et al.* 1996, Pierce *et al.* 1994, Pierce *et al.* 1996, NWIFC 1995). Fishing effort in the inland waters drift gillnet fishery has declined considerably since 1994 because far fewer vessels participate today. Past marine mammal entanglements in this fishery included harbor porpoise, Dall's porpoise, and harbor seals. Coastal marine tribal set gillnets also occur along the outer Washington coast and no killer whale interactions have been reported in this fishery since the inception of the observer program in 1988, though the fishery is not active every year (Gearin *et al.* 1994, Gearin *et al.* 2000, Makah Fisheries Management). No fishery-related mortality from gillnet fisheries in California waters was documented between 2015-~~2019~~ 2020 (Carretta 2021, Carretta *et al.* 2021, Carretta *et al.* 2022).

An additional source of information on killer whale mortality and injury incidental to commercial fishery operations is the self-reported fisheries information required of vessel operators by the MMPA. No self-report records of killer whale mortality have been reported.

Due to a lack of observer programs, there are few data concerning the mortality of marine mammals incidental to Canadian commercial fisheries. Since 1990, there have been no reported fishery-related strandings of killer whales in Canadian waters. However, in 1994 one killer whale was reported to have contacted a salmon gillnet but did not entangle (Guenther *et al.* 1995). In 2014 a northern resident killer whale became entangled in a gillnet, was released from the net, but died the next winter (Fisheries and Oceans Canada 2018). Data regarding the level of killer whale mortality related to commercial fisheries in Canadian waters are not available.

The known total fishery mortality and serious injury for the southern resident stock of killer whales is zero, but undetected mortality and serious injury may occur.

Other Mortality

In 2012, a moderately decomposed juvenile female southern resident killer whale (L-112) was found dead near Long Beach, WA. A full necropsy was performed and the cause of death was determined to be blunt force trauma to the head, however the source of the trauma (vessel strike, intraspecific aggression, or other unknown source) could not be established (NOAA 2014). There was documentation of a whale-boat collision in Haro Strait in 2005 which resulted in a minor injury to a whale. In 2006, whale L98 was killed during a vessel interaction. It is important to note that L98 had become habituated to regularly interacting with vessels during its isolation in Nootka Sound. In spring 2016, a young adult male, L95, was found to have died of a fungal infection related to a satellite tag deployment approximately 5 weeks prior to its death. The expert panel reviewing the stranding noted that "the tag loss, tag petal retention with biofilm formation or direct pathogen implantation, and development of a fungal infection at the tag site contributed to the illness, stranding, and death of this whale." (NMFS 2016). In fall 2016 another young adult male, J34, was found dead in the northern Georgia Strait. The necropsy indicated that "the animal had injuries consistent with blunt trauma to the dorsal side, and a hematoma indicating that it was alive at the time of injury and would have survived the initial trauma for a period of time prior to death" (Fisheries and Oceans Canada 2019). The injuries are consistent with those incurred during a vessel strike. A recent summary of killer whale strandings in the northeastern Pacific Ocean and Hawaii noted the occurrence of human interactions across all age classes (Raverty et al. 2020).

Habitat Issues

A population viability analysis identified several risk factors to this population, including limitation of preferred Chinook salmon prey, anthropogenic noise and disturbance resulting in decreased foraging efficiency, and high levels of contaminants, including PCBs and DDT (Ebre 2002, Clark *et al.* 2009, Krahn *et al.* 2007, 2009, Lacy *et al.* 2017). The summer range of this population, the inland waters of Washington and British Columbia, are home to a large commercial whale watch industry, and high levels of recreational boating and commercial shipping. Potential for acoustic masking effects on the whales' communication and foraging due to vessel traffic remains a concern (Erbe 2002, Clark *et al.* 2009, Lacy *et al.* 2017, Holt *et al.* 2021a, b). In 2011, vessel approach regulations were implemented to restrict vessels from approaching closer than 200m. A genetic study of diet of southern resident killer whales from fecal remains collected during 2006-2011 noted that salmonids accounted for >98.6% of genetic sequences (Ford *et* al. 2016). Of six salmonid species documented, Chinook salmon accounted for 79.5% of the sequences, followed by coho salmon (15%). Chinook salmon dominate the diet in early summer, with coho salmon averaging >40% of the diet in late summer. Sockeye salmon were also found to be occasionally important (>18% in some samples). Non-salmonids were rarely observed. These results are consistent with those obtained from surface prey remains, and confirm the importance of Chinook salmon in this population's diet. These authors also noted the absence of pink salmon in the fecal samples. Prior studies note the prevalence of Chinook salmon in the killer whale diet, despite the relatively low abundance of this species in the region, supporting the thesis that southern resident killer whales are Chinook salmon specialists (Ford and Ellis 2006, Hanson *et al.* 2010). Recent studies of diet in other seasons and regions of their range indicate that although Chinook represent a major component of their diet almost year-round, other species also make potentially important contributions, likely when Chinook are less available (Hanson et al. 2021). There is evidence that reduced abundance of Chinook salmon has negatively affected this population via reduced fecundity (Ayres *et al*. 2012, Ford *et al.* 2009, Ward *et al.* 2009, Wasser *et al.* 2017). Studies on body condition and sizes of southern resident killer whales using aerial photogrammetry (Fearnbach et al. 2011, Fearnbach et al. 2018, Stewart et al. 2021) reflect hypotheses between Chinook salmon abundance and killer whale body condition and overall body size. In some cases (J-Pod), Chinook abundance was found to have the greatest predictive power on southern resident body condition, while this relationship was absent for K-Pod (Stewart et al. 2021). In other studies (Fearnbach et al. 2011), authors suggest that nutritional stress is linked to a longer term decrease in body size in the population. In addition, the high trophic level and longevity of the population has predisposed them to accumulate high levels of contaminants that potentially impact health (Krahn *et al.* 2007, 2009). In particular, there is evidence of high levels of flame retardants in young animals (Krahn *et al.* 2007, 2009). High DDT/PCB ratios have been found in Southern Resident killer whales, especially in K and L pods (Krahn *et al.* 2007, NMFS 2019b), which spend more time in California waters where DDTs still persist in the marine ecosystem (Sericano *et al*. 2014).

STATUS OF STOCK

Total documented annual fishery mortality and serious injury for this stock from 2015-~~2019~~ 2020 (zero) is not known to exceed 10% of the calculated PBR (0.13). Given the low PBR level, a single undetected / undocumented fishery mortality or serious injury would exceed 10% of the PBR, thus it is unknown if fishery mortality and serious injury is approaching zero mortality and serious injury rate. The documented annual level of human-caused mortality and serious injury for the most-recent 5-year period includes the death of L95 (fungal infection related to a satellite-tag) and J34 (vessel strike), or 0.4 whales annually, which exceeds the PBR (0.13). Southern Resident killer whales were formally listed as "endangered" under the ESA in 2005 and consequently the stock is automatically considered as a "strategic" stock under the MMPA. This stock was considered "depleted" (68 FR 31980, May 29, 2003) prior to its 2005 listing under the ESA (70 FR 69903, November 18, 2005).

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CUVIER'S BEAKED WHALE (*Ziphius cavirostris*): California/Oregon/Washington Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Cuvier's beaked whales are distributed widely throughout deep waters of all oceans (MacLeod *et al.* 2006). Off the U.S. west coast, this species is the most commonly encountered beaked whale (Figure 1). No seasonal changes in distribution are apparent from stranding records, and morphological evidence is consistent with the existence of a single eastern North Pacific population from Alaska to Baja California, Mexico (Mitchell 1968). For the Marine Mammal Protection Act (MMPA) stock assessment reports, Cuvier's beaked whales within the Pacific U.S. Exclusive Economic Zone are divided into three discrete, non-contiguous areas: 1) waters off California, Oregon and Washington (this report), 2) Alaskan waters, and 3) Hawaiian waters.

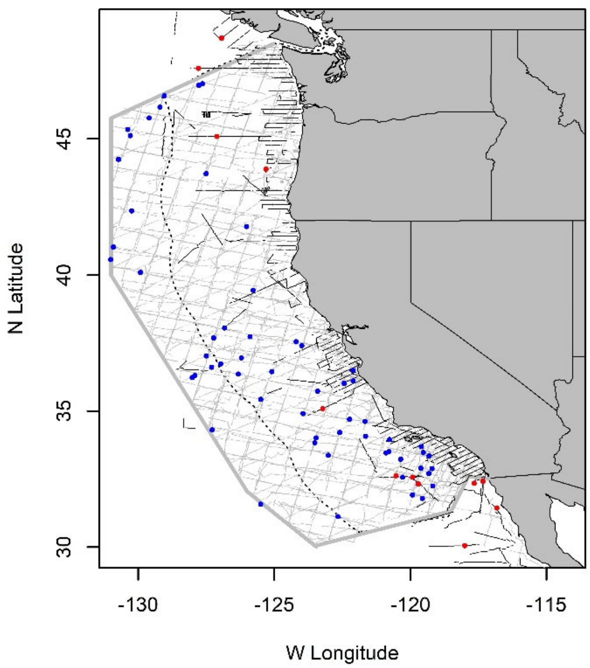

Figure 1. Cuvier's beaked whale sightings based on shipboard surveys off California, Oregon, and Washington, 1991-2018. Dashed line represents U.S. EEZ, thin lines indicate completed transect effort (gray = 1991-2014, black = 2018). Sightings from the 2018 survey are shown in red.

POPULATION SIZE

Although Cuvier's beaked whales have been sighted along the U.S. west coast on ~~several~~ most vessel-based line transect surveys ~~utilizing both aerial and shipboard platforms~~, the rarity of sightings has ~~historically precluded reliable population estimates. Early~~resulted in ~~relatively~~ imprecise abundance estimates ~~incorporating Beaufort-specific detection probability correction factors for availability bias~~ (Barlow 2016, Moore and Barlow 2017). ~~were imprecise and negatively biased by an unknown amount because of the large proportion of time this species spends submerged, and because ship surveys before 1996 covered only California waters, and thus did not include animals off Oregon/Washington~~. Furthermore, survey data include a large number of unidentified beaked whale sightings that are probably either *Mesoplodon* sp. or Cuvier's beaked whales (*Ziphius cavirostris*). ~~A line-transect survey of U.S. west coast waters in 2014 yielded an abundance estimate of 3,775 (CV=0.68) Cuvier's beaked whales (Barlow 2016). The same analysis also provided estimates for previous years dating back to 1991, but did not evaluate trends in abundance.~~ A trend-based analysis of line-transect data from surveys conducted between 1991 and 2014 provided a range of estimates from 2,242 to 4,860 Cuvier's beaked whales with coefficients of variation between 0.59 and 0.67 (Moore and Barlow 2017). ~~provides new estimates of Cuvier's beaked whale abundance (Moore and Barlow 2017). The trend-model analysis incorporates information from the entire 1991-2014 time series for each annual estimate of abundance, and given the strong evidence of a decreasing abundance trend over that time (Moore and Barlow 2013, 2017), the best estimate of abundance is represented by the model-averaged estimate for 2014. Based on this analysis, the best (50th percentile) estimate of abundance for Cuvier's beaked whales in 2014 in waters off California, Oregon and Washington is 3,274~~

~~(CV= 0.67) whales, which is similar to the line-transect estimate of 3,775 (CV=0.68) whales in 2014 estimated by Barlow (2016). The lower estimates of Cuvier's beaked whale abundance provided by Moore and Barlow (2017) compared with the Moore and Barlow (2013) estimates are due to a higher trackline detection probability (*g(0)*) value, based on new Beaufort sea state-specific *g(0)* analysis published by Barlow (2015).~~ Barlow et al. (2021) developed ~~A~~a new ~~acoustic~~ method ~~of~~for estimating Cuvier's beaked whale density and abundance, using a modified point-transect distance sampling framework applied to passive acoustic data collected on drifting hydrophone arrays. ~~from the unique acoustic signature of this species, in combination with drifting hydrophone arrays and point transect methods was reported by Barlow *et al.* (2021).~~ They estimated the abundance of Cuvier's beaked whales in 2016 to be 5,454 whales (CV=0.27, 95% CI = 3,151 – 8,907), which is higher than any previous line-transect estimate, with better precision. ~~The new method incorporates estimates of acoustic availability that indicate hydrophones are capturing the acoustic presence of this species during approximately 9% of their dive cycles.~~ Barlow *et al.* (2021) note that the largest source of uncertainty in their estimates is estimation of the effective area surveyed by floating hydrophones.

Minimum Population Estimate

~~Based on the analysis by Moore and Barlow (2017), the minimum population estimate (defined as the log-normal 20th percentile of the abundance estimate) for Cuvier's beaked whales in California, Oregon, and Washington is 2,059 animals.~~ The minimum population estimate is based on the lower 20th percentile of the posterior distribution reported in Barlow *et al.* (2021), or 4,214 whales.

Current Population Trend

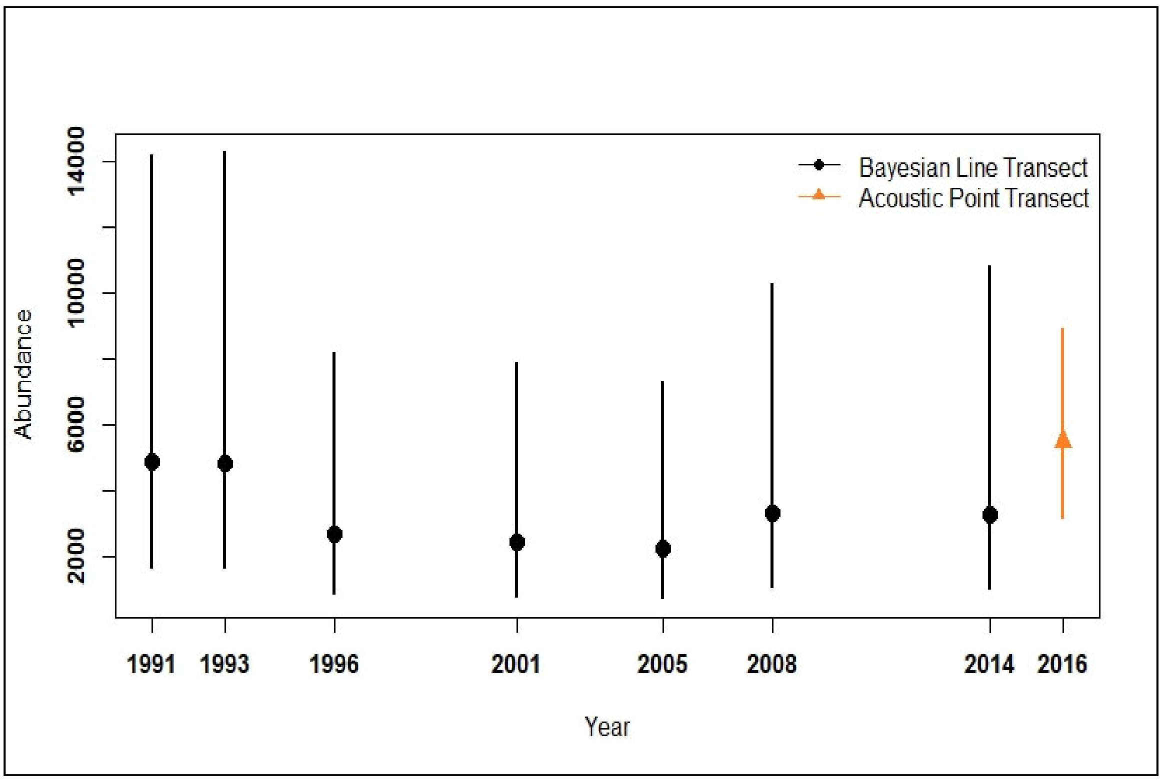

Figure 2. Abundance estimates for Cuvier's beaked whales in the California Current, 1991-~~2014~~2016 (Moore and Barlow 2017, Barlow *et al.* 2021). For each year, the Bayesian posterior median (●) and mean (▲) abundance estimates are shown, along with 95% CRIs.

There is substantial evidence, based on line-transect survey data and the historical stranding record off the U.S. west coast, that the estimated abundance of Cuvier's beaked whales in waters off California, Oregon and Washington ~~is~~ was lower between 2001 and 2014 than in the early 1990s (Moore and Barlow 2013, 2017, ~~Figure~~ Fig. 2). Statistical analysis of line-transect survey data from 1991 - 2014 indicates a 0.85 probability of decline during this period (Moore and Barlow 2017), with the mean annual rate of population change estimated to have been − 3.0% per year (95% CRI: -10% to +3%, regression model results), although abundance throughout the 2000s appears fairly stable, and estimates have not been updated following the 2018 survey. The 2016 acoustic based estimate represents the highest point estimate of the time series (Fig. 2), but it is unknown if this reflects differences in methodology between line transect and acoustic methods, a true increase in abundance, or both. ~~-~~Patterns in the historical stranding record alone provide limited information about beaked whale abundance trends, but the stranding record appears generally consistent rather than at-odds with results of the line-transect survey analysis. Regional stranding networks along the Pacific coast of the U.S. and Canada originated during the 1980s, and beach coverage and reporting rates are thought to have increased throughout the 1990s and in to the early 2000s. Therefore, for a stable or increasing population, an overall increasing trend in stranding reports between the 1980s and 2000s would be expected. Patterns of Cuvier's beaked whale strandings data are highly variable across stranding network regions, but an overall increasing trend from the 1980s through 2000s is not evident within the California Current area, contrary to patterns for Baird's beaked whales (Moore and Barlow 2013) and for cetaceans in general (e.g., Norman *et al.* 2004, Danil *et al.* 2010). Taylor *et al*. (2007) highlighted difficulties in assessing trends in abundance for beaked whales from visual surveys due to the rarity of sightings and relative imprecision of estimates. The addition of a new acoustically-derived abundance estimate for 2016 that is higher than all previous line-transect estimates (Barlow *et al*. 2021) does not aid in the assessment of trends for this stock, as there are no comparable acoustic estimates that overlap with the line-transect estimates. Barlow *et al.* (2021) note the great potential to estimate trends in abundance with greater precision using acoustic methods, based on documenting changes in acoustic encounter rates through time.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No information on current or maximum net productivity rates is available for this species.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (~~2,059~~ 4,214) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a species of unknown status with no known fishery mortality; Wade and Angliss 1997), resulting in a PBR of ~~21~~ 42 Cuvier's beaked whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

The California swordfish drift gillnet fishery has been the only fishery historically known to interact with this stock. Prior to the introduction of acoustic pingers into the fishery in 1996, there were 21 Cuvier's beaked whales observed entangled in approximately 3,300 drift gillnet fishery sets: 1992 (six animals), 1993 (three), 1994 (six) and 1995 (six) (Julian and Beeson 1998). Since acoustic pinger use, no Cuvier's beaked whales have been observed entangled in over ~~5,400~~ 5,900 observed fishing sets (Barlow and Cameron 2003, Carretta *et al.* 2008, Carretta and Barlow 2011, Carretta ~~*et al.* 2017~~2021). New model-based estimates of bycatch based on regression trees identify the use of acoustic pingers, latitude, and sea surface temperature ~~and longitude~~ as ~~two~~ three variables influencing the bycatch of Cuvier's beaked whales in the fishery (Carretta ~~*et al.* 2017~~2021). Mean annual takes in Table 1 are based ~~only~~ on ~~2011-2015~~ 2015-2019 data. Although no Cuvier's beaked whales were observed entangled in the most recent 5-year time period, bycatch models produced a negligible estimate of bycatch for this 5-year period of ~~0.1~~ 0.3 (CV=~~2.8~~1.4) whales. This results in an average estimated annual mortality of ~~0.02~~ 0.06 (CV=~~2.8~~ 1.4) Cuvier's beaked whales.

Table 1. Summary of available information on the incidental mortality and serious injury of Cuvier's beaked whales (California/ Oregon/Washington Stock) in commercial fisheries that might take this species. Mean annual takes are based on ~~2011-2015~~ 2016-2020 data~~ unless noted otherwise~~.

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed Mortality + ReleasedAlive	Estimated Annual Mortality / Mortality + Entanglements	Mean Annual Takes (CV in parentheses)
CA/OR thresher shark/swordfish drift gillnet fishery	observer data	~~2011~~ ~~2012~~ ~~2013~~ ~~2014~~ ~~2015~~	~~20%~~ ~~19%~~ ~~37%~~ ~~24%~~ ~~20%~~	~~0~~ ~~0~~ ~~0~~ ~~0~~ ~~0~~		
		~~2011-2015~~	**~~24%~~**	**~~0~~**	**~~0.1 (2.8)~~**	**~~0.02 (2.8)~~**
		2016-2020	21%	0	0.3 (1.4)	0.06 (1.4)
Minimum total annual takes						~~0.02 (2.8)~~ 0.06 (1.4)

Gillnets have been documented to entangle marine mammals off Baja California (Sosa-Nishizaki *et al.* 1993), but no recent bycatch data from Mexico are available.

Other mortality

Anthropogenic sound sources, such as military sonar and seismic testing have been implicated in the mass strandings of beaked whales, including atypical events involving multiple beaked whale species (Simmonds and Lopez-Jurado 1991, Frantiz 1998, Anon. 2001, Jepson *et al.* 2003, Cox *et al.* 2006). While D'Amico *et al.* (2009) note that most mass strandings of beaked whales are unassociated with documented sonar activities, lethal or sub-lethal effects of such activities would rarely be documented, due to the remote nature of such activities and the low probability that an injured or dead beaked whale would strand. Filadelpho *et al.* (2009) reported statistically significant correlations between military sonar use and mass strandings of beaked whales in the Mediterranean and Caribbean Seas, but not in Japanese and Southern California waters, and hypothesized that regions with steep bathymetry adjacent to coastlines are more conducive to stranding events in the presence of sonar use. In Hawaiian waters, Faerber & Baird (2010) suggest that the probability of stranding is lower than in some other regions due to nearshore currents carrying animals away from beaches, and that stranded animals are less likely to be detected due to low human population density near many of Hawaii's beaches. Actual and simulated sonar are known to interrupt the foraging dives and echolocation activities of tagged beaked whales (Tyack *et al.* 2011, DeRuiter *et al.* 2013). Cuvier's beaked whales tagged and tracked during simulated mid-frequency sonar exposure showed avoidance reactions, including prolonged diving, cessation of echolocation click production associated with foraging, and directional travel away from the simulated sonar source (DeRuiter *et al.* 2013). Blainville's beaked whale presence was monitored on hydrophone arrays before, during, and after sonar activities on a Caribbean military range, with evidence of avoidance behavior: whales were detected throughout the range prior to sonar exposure, not detected in the center of the range coincident with highest sonar use, and gradually returned to the range center after the cessation of sonar activity (Tyack *et al.* 2011). Fernández *et al.* (2013) report that there have been no mass strandings of beaked whales in the Canary Islands following a 2004 ban on sonar activities in that region. The absence of beaked whale bycatch in California drift gillnets following the introduction of acoustic pingers into the fishery implies additional sensitivity of beaked whales to anthropogenic sound (Carretta *et al.* 2008, Carretta and Barlow 2011, Carretta 2022).

STATUS OF STOCK

The status of Cuvier's beaked whales in California, Oregon and Washington waters relative to OSP is not known, but Moore and Barlow (2013) indicated a substantial likelihood of population decline in the California Current since the early 1990s, at a mean rate of -2.9% per year, which corresponds to trend-fitted abundance levels in 2008 (most recent survey) being at 61% of 1991 levels. New trend estimates also indicate evidence of a population decline between 1990 and 2014, with an 85% probability of a decline at a mean rate of -3.0% per year (Moore and Barlow 2017). Cuvier's beaked whales are not listed as "threatened" or "endangered" under the Endangered Species Act, nor designated as "depleted" under the MMPA. However, the long-term decline in Cuvier's beaked whale abundance in the California Current reported by Moore and Barlow (2013, 2017), and the degree of decline (trend-fitted 2014 abundance at approximately 67% of 1991 levels) suggest that this stock may be below its carrying capacity. Assessing changes in abundance for any species may also be confounded by distributional shifts within the California Current related to ocean-warming (Cavole *et al.* 2015). Given that the stock is not currently ESA listed or designated as depleted, and human-caused mortality is below PBR, it is not strategic. Moore and Barlow (2013) ruled out bycatch as a cause of the decline in Cuvier's beaked whale abundance and suggest that impacts from anthropogenic sounds such as naval sonar and deepwater ecosystem changes within the California Current are plausible hypotheses warranting further investigation. The average annual ~~known~~ estimated human-caused mortality between ~~2011 and 2015~~ 2016 and 2020 is negligible (~~0.02~~ 0.06 whales annually in the drift gillnet fishery) and reflects a small probability that true bycatch in this fishery may be greater than the zero observed from approximately ~~5,400~~ fishing sets since 1996 (Carretta ~~*et al.* 2017~~2021). The total fishery mortality and serious injury for this stock is less than 10% of the PBR and thus is considered to be insignificant and approaching zero. The impacts of anthropogenic sound on beaked whales remains a concern (Barlow and Gisiner 2006, Cox *et al.* 2006, Hildebrand *et al.* 2005, Weilgart 2007).

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Revised 09/12/2022 (New SAR)

Humpback Whale (*Megaptera novaeangliae kuzira*)
Central America / Southern Mexico - California-Oregon-Washington Stock

Stock Definition and Geographic Range

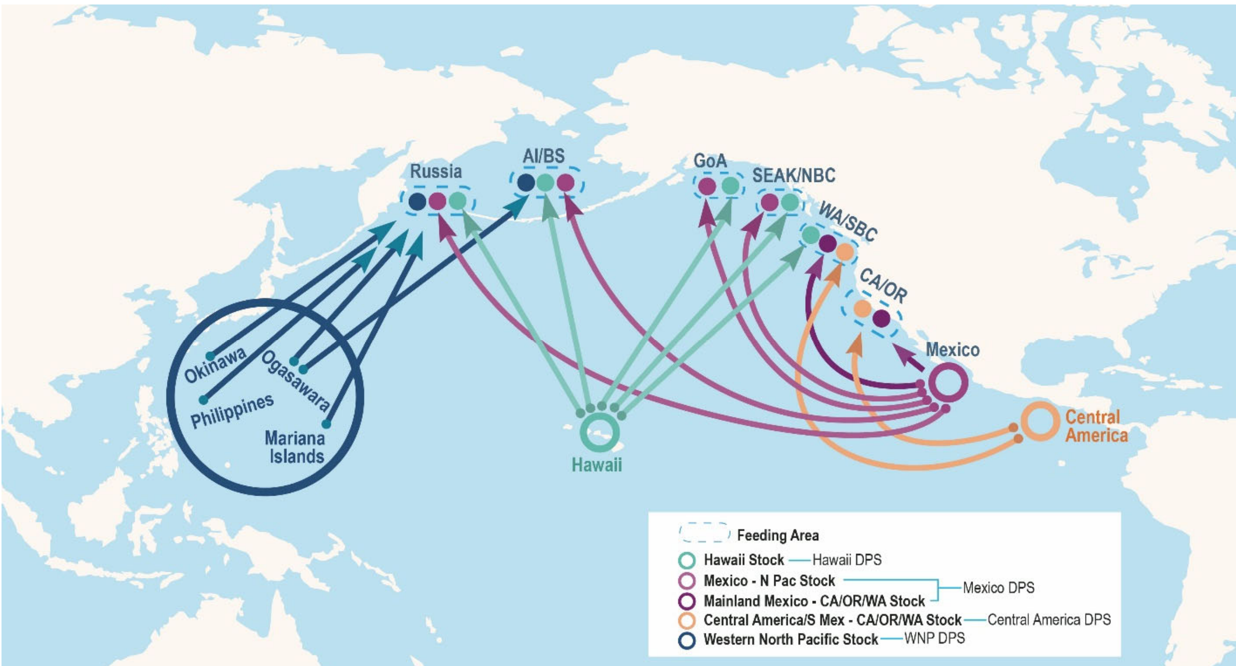

Figure 1. Pacific basin map showing wintering areas of five humpback whale stocks mentioned in this report. Also shown are summering feeding areas mentioned in the text. High-latitude summer feeding areas include Russia, Aleutian Islands / Bering Sea (AI/BS), Gulf of Alaska (GoA), Southeast Alaska / 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 **Central America/Southern Mexico – California-Oregon-Washington stock** (Figure 2). In previous marine mammal stock assessments, humpback whales that summer and feed off California, Oregon, and Washington were treated as a single stock ("California-Oregon-Washington"), that included whales from three DPSs (Central America, Mexico, Hawaiʻi) defined by separate wintering areas. Whales from the Hawaiʻi DPS previously included in the "California-Oregon-Washington" stock are now included in the Hawai'i stock report. The previous "California-Oregon-Washington" stock also included multiple DIPs (Central America – California-Oregon-Washington DIP and Mainland Mexico – California-Oregon-Washington DIP), which is inconsistent with management goals under the MMPA (NMFS 2019).

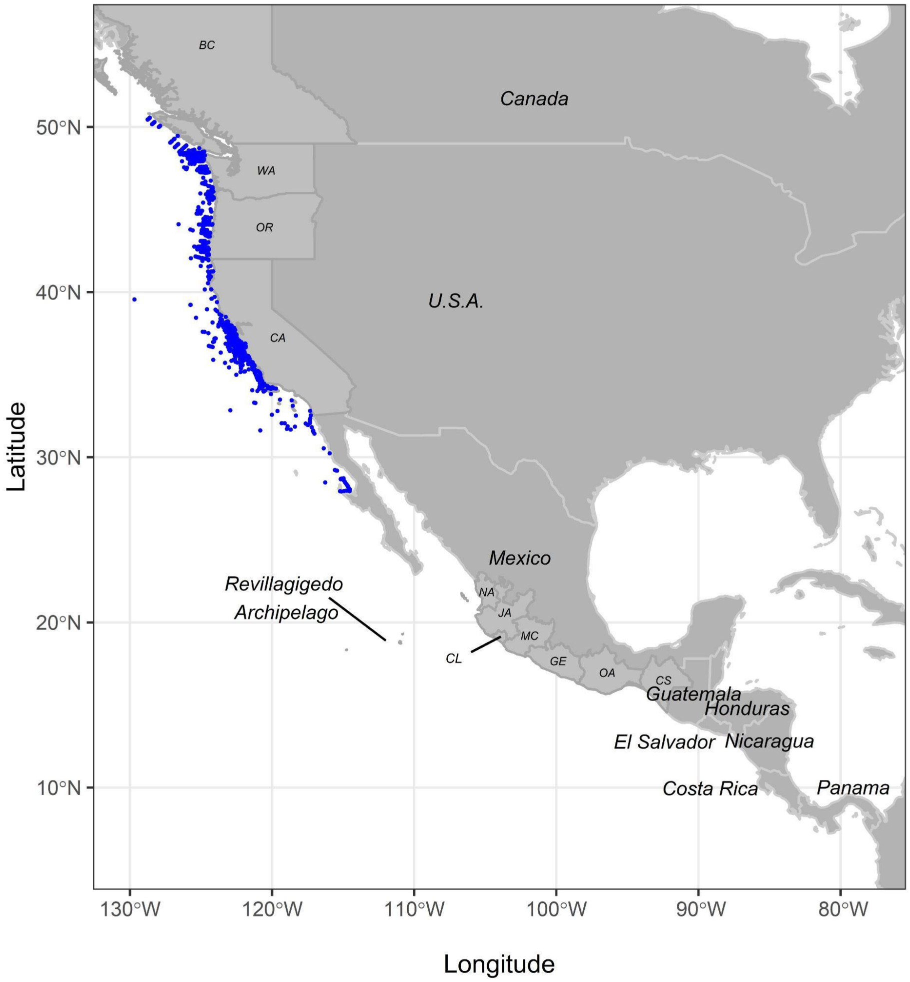

Figure 2. Wintering and summering areas for the Central America / Southern Mexico - CA-OR-WA stock of humpback whales. The primary wintering areas of the Central America / Southern Mexico - CA-OR-WA stock include the Pacific coasts of Nicaragua, Honduras, El Salvador, Guatemala, Panama, Costa Rica, with animals sometimes sighted as far north as Michoacán and Colima. Primary summering areas of whales from this stock include California and Oregon, with only a few individuals identified in the northern Washington/southern British Columbia feeding areas. Summering area sightings from 1991 - 2018 NMFS/SWFSC research vessel line-transect surveys are shown as blue dots and primarily represent whales from two stocks: the Central America / Southern Mexico - CA-OR-WA stock and Mainland Mexico - CA-OR-WA stock, although small numbers of whales from the Hawai'i stock also have been matched to WA and Southern British Columbia (Wade 2021). Country and state names abbreviations from north to south are: BC = British Columbia, WA = Washington state, OR = Oregon, CA = California, U.S.A. = United States of America, NA = Nayarit, JA = Jalisco, CL = Colima, MC = Michoacán, GE = Guerrero, OA = Oaxaca, and CS = Chiapas.

Population Size

Curtis *et al.* (2022) estimated the population size of whales wintering in southern Mexico and Central America using spatial capture-recapture methods based on photographic data collected between 2019 and 2021. Their estimate of abundance is 1,494 (CV=0.167) whales and this represents the best estimate of abundance for the Central America / Southern Mexico - CA-OR-WA stock of humpback whales.

Minimum Population Estimate

The minimum population estimate for this stock is taken as the lower 20th percentile of the capture-recapture estimate from Curtis *et al.* (2022), or 1,282 whales.

Current Population Trend

The 2019-2021 abundance estimate for the Central America / Southern Mexico - CA/OR/WA stock (1,494, CV=0.167) is approximately double the estimate derived from 2004-06 data that do not include whales from southern Mexico (755 whales, CV=0.242) (Wade 2021). Given the time elapsed between the two estimates, if the increase were due purely to population growth, it would suggest an annual growth rate of approximately 4.7% (Curtis *et al.* 2022), which is lower than the 8.2% annual increase observed for all humpback whales off the U.S. West Coast since the late 1980s (Calambokidis and Barlow 2020). Given the inclusion of whales from southern Mexico in the current estimate, Curtis *et al.* (2022) derived a population growth rate for Central America / Southern Mexico whales based on differences between the 2004-2006 estimate and the current estimate by excluding whales in southern Mexico waters in the spatial recapture model. This yields an annual growth rate of 1.8% (SD = 2.3%) for the Central America / Southern Mexico - CA/OR/WA stock of humpback whales; however, the estimate has high uncertainty (Curtis *et al.* 2022).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Calambokidis and Barlow (2020) estimated that humpback whale abundance increased approximately 8.2% annually in the California Current since the late 1980s, based on mark-recapture estimates largely restricted to whales summering in California and Oregon waters. However, these estimates include whales from two stocks; the Central America / Southern Mexico - CA/OR/WA stock and the Mainland Mexico - CA/OR/WA stock. The current net productivity rate for the Central America / Southern Mexico - CA/OR/WA stock is unknown. However, the theoretical maximum net productivity rate can be taken to be at least as high as the maximum observed for the combined stocks, or 8.2% annually (Calambokidis and Barlow 2020), though it could be higher if one of the stocks is growing faster than another.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (1,282) times one half the estimated population growth rate for this stock of humpback whales (½ of 8.2%) times a recovery factor of 0.1 (for an endangered stock with Nmin < 1,500; NMFS 2016), resulting in a PBR of 5.2. Because this stock spends approximately half its time outside the U.S. Exclusive Economic Zone (EEZ), the PBR in U.S. waters is 2.6 whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Human-caused mortality and serious injury of humpback whales observed in California, Oregon, and Washington waters primarily includes whales from two stocks: the Central America / Southern Mexico – CA-OR-WA stock and the Mainland Mexico – CA-OR-WA stock. Additionally, a small number of whales from the Hawai‘i stock summer in Washington state waters (Wade *et al.* 2021). To assess human-caused mortality and serious injury of the Central America / Southern Mexico – CA-OR-WA stock, total mortality and serious injury from CA-OR-WA waters is prorated to reflect the fraction of CA-OR-WA humpback whale abundance represented by the Central America / Southern Mexico – CA-OR-WA stock. Where multiple stocks share a summering area and estimates of anthropogenic mortality and serious injury (MSI) exist, but stock specific-abundance estimates are unavailable to determine the relative proportion of each stock in that mixed-stock area, total regional MSI may be apportioned among stocks based on knowledge of movement probabilities between summering and wintering areas for each stock, such as those estimated by Wade (2021). However, if abundance estimates are available for multiple stocks sharing a summering area (*e.g*. two stocks that use the U.S. West Coast EEZ in summer; Curtis *et al.* 2022), then MSI assigned to each stock may be more directly determined based on the ratio of overall stock abundances within that region. This is consistent with guidelines for assessing marine mammal stocks which state: "When one or more deaths or serious injuries cannot be assigned directly to a stock, then those deaths or serious injuries may be partitioned among stocks within the appropriate geographic area, provided there is sufficient information to support such partitioning (e.g., based on the relative abundances of stocks within the area).” (NMFS 2016). This is accomplished using the ratio of Central America / Southern Mexico – CA-OR-WA stock abundance reported by Curtis *et al.* (2022) to U.S. West Coast abundance reported by Calambokidis and Barlow (2020) (Table 2). This ratio (0.30) serves as a point estimate for prorating human-caused mortality in U.S. waters for this stock. Because this stock is listed as endangered, the upper 95% confidence limit of the abundance ratio (0.42) is used as the proration factor. Two other methods that may be used to prorate human-caused mortality and serious injury to stock include use of summering to wintering area movement probabilities reported by Wade (2021) and genetic mixed-stock apportionments from CA-OR summering areas to Central America reported by Lizewski *et al.* (2021). For purposes of this stock assessment report, the abundance ratio approach is favored, as it is based directly on the estimated proportion of estimated U.S. West Coast abundance that is composed of Central America / Southern Mexico – CA-OR-WA stock whales. The same proration method is applied to all anthropogenic sources of mortality and serious injury in CA-OR-WA waters (see subsequent sections). Additional insight into the fraction of anthropogenic impacts attributable to each stock in this region comes from a study comparing resighting histories of entangled vs non-entangled humpback whales (Tackaberry *et al.* 2022). Of 16 entangled whales documented in central California waters that were photographically matched in wintering areas and assigned to a DPS, 37.5% (n = 6) were matched to the Central American DPS and 62.5% (n = 10) to the Mexican DPS (none were matched to the Hawai‘i DPS).

Table 2. Options for prorating total U.S. West Coast human-caused mortality and serious injury to the Central America / Southern Mexico – CA-OR-WA stock, based on **1)** the ratio of Central America / Southern Mexico – CA-OR-WA stock abundance (Curtis *et al.* 2022) to total U.S. West Coast abundance (Calambokidis and Barlow 2020). Abundance ratios and their distributions are calculated using posterior Bayesian distributions from Curtis *et al.* (2022) estimates and simulated lognormal distributions for Calambokidis and Barlow (2020) estimates; **2)** movement probabilities of whales from CA-OR summering areas to Central America reported by Wade (2021); **3)** genetic mixed-stock analysis apportionments from CA-OR summering areas to Central America reported by Lizewski *et al.* (2021). The option used to prorate in this report is shown in bold.

Cen. America / S. Mexico CA-OR-WA Abundance	U.S. West Coast Abundance	**Ratio Cen. America / S. Mexico - CA-OR-WA to U.S. West Coast Abundance (L95%, U95%)**	Movement Probability Summering to Wintering Area (L95%, U95%)	Genetic mixed-stock apportionment (L95%, U95%)
1,494 (CV=0.167)	4,973 (CV=0.048)	**0.30 (0.22, 0.42)**	0.423 (0.251, 0.615)	0.553 (0.27, 0.67)

Fishery Information

Table 3. Sources of serious injury and mortality of humpback whales in California, Oregon, and Washington commercial fisheries for the period 2016-2020, unless noted otherwise (Carretta 2022, Carretta *et al.* 2022, Jannot *et al.* 2021). Records also include entanglements detected outside of U.S. waters confirmed to involve California, Oregon, and Washington commercial fisheries. Most cases are derived from opportunistic strandings and at-sea sightings of entangled whales. Also included are records of entangled *unidentified whales* prorated to humpback whale based on location, depth, and time of year (Carretta 2018). Sources derived from systematic observer programs with statistical estimates of bycatch and uncertainty are shown with coefficients of variation (CV). Totals in the first three numerical columns include whales from two stocks: the Central America / Southern Mexico – CA-OR-WA stock and the Mainland Mexico – CA-OR-WA stock. Totals are prorated to the Central America / Southern Mexico – CA-OR-

WA stock in the last column, based on a proration factor = 0.42, or the U95% confidence limit of stock abundance ratios shown in Table 2.

Fishery Source	Observed and Reported Interactions (% observer coverage if applicable)	∑ Total CA-OR-WA Mortality and Serious injury (CV if applicable)	Mean Annual Mortality and Serious Injury, (CV if applicable)	**Central America / Southern Mexico – CA-OR-WA stock prorated totals**
Unidentified Fishery	58	43.75	8.75	**3.7**
Dungeness Crab Pot (California)	34	23.75	4.75	**2.0**
Unidentified pot/trap fishery	13	9.50	1.9	**0.8**
Dungeness Crab Pot (Washington)	7	5.50	1.1	**0.46**
Unidentified fishery interactions involving *unidentified whales* prorated to humpback whale	7	4.7	0.94	**0.39**
Gillnet Fishery (unidentified)	6	2	0.40	**0.17**
California Spot Prawn Fishery	5	3.25	0.65	**0.27**
Dungeness Crab Pot Fishery (Oregon)	2	1.75	0.35	**0.15**
WA/OR/CA Limited Entry Sablefish Pot (observer program) †*	1 (31% - 72%)	0.5 (> 0.8)	0.1 (> 0.8)	**0.04 (>0.8)**

WA/OR/CA Open Access Sablefish Pot (observer program) †**	1 (7% - 12%)	7.3 (> 0.8)	1.5 (> 0.8)	**0.63 (>0.8)**
Dungeness Crab Pot Fishery (commercial, state unknown)	2	2	0.4	**0.17**
WA/OR/CA Sablefish Pot Fishery *and* CA/OR Coonstripe Shrimp Pot***	1	0.0	0.0	**0.0**
CA swordfish and thresher shark drift gillnet fishery (observer program)****	0 (21%)	0.1 (4.7)	0.02 (4.7)	**0.008 (4.7)**
Totals CA-OR-WA waters	137	104.1 (> 0.8)	20.9 (> 0.8)	**8.8 (>0.8)**

† At-sea sightings of entangled whales in the WA/OR/CA Sablefish Pot fisheries that were not recorded in observer programs during 2016-2020 (2) are included in mean annual mortality and serious injury totals because observer data are used to estimate total entanglements for two separate sablefish pot fisheries in this category (Jannot *et al.* 2021). These two records are not included in 'Observed Interactions'.

* Jannot *et al.* (2021) report one humpback entanglement in this fishery in 2014, over an observation period spanning 2002 – 2019 where 13% - 72% of landings were observed. This estimate is based on 2015-2019 data, the most-recent 5-year period for which estimates are available.

** Jannot *et al.* (2021) report one humpback entanglement in this fishery in 2016, over an observation period spanning 2002 – 2019 where 2% - 12% of landings were observed. This estimate is based on 2015-2019 data, the most-recent 5-year period for which estimates are available.

*** One observation of a whale entangled in gear from 2 fisheries. This was a non-serious injury due to intervention and complete removal of entangling gear.

**** There were no observed entanglements during 2016-2020, however the model-based estimate of bycatch is based on pooling 1990-2000 data, resulting in a small positive estimate (Carretta 2022).

Vessel Strikes

There were 14 observed vessel strike cases involving humpback whales in CA-OR-WA waters during 2016-2020, totaling 13.2 deaths and/or serious injuries, or 2.6 whales per year (Carretta *et al.* 2022). However, most vessel strikes are likely undetected and thus we use estimates of vessel strike mortality reported by Rockwood *et al.* (2017) for this region. Vessel strike mortality was estimated for humpback whales in the U.S. West Coast EEZ (Rockwood *et al.* 2017), using an encounter theory model (Martin *et al.* 2016) combining species distribution models of whale density (Becker *et al.* 2016), vessel traffic characteristics (size + speed + spatial use), and whale movement patterns obtained from satellite-tagged animals in the region to estimate whale/vessel interactions resulting in mortality. The estimated number of annual vessel strike deaths was 22 humpback whales, though this includes only the period July – November when whales are most likely to be present in the U.S. West Coast EEZ and the season that overlaps with survey effort used in species distribution models (Becker *et al.* 2016, Rockwood *et al.* 2017). This estimate is based on an assumption of a moderate level of vessel avoidance by humpback whales, as measured by the behavior of satellite-tagged whales in the presence of vessels (McKenna *et al.* 2015). Based on estimates of 22 deaths due to vessel strikes annually, the number attributed to the Central America / Southern Mexico - CA-OR-WA stock during 2016-2020 is 22 x 0.42 = 9.2 whales per year. The estimated mortality of 9.2 humpback whales annually due to vessel strikes represents approximately 0.6% of the stock's estimated population size (9.2 deaths / 1,494 whales). The ratio of mean annual observed to estimated vessel strike deaths and serious injuries of humpback whales during 2016-2020 is 2.6 / 22 = 0.11, implying that vessel strike counts from opportunistic observations represent a small fraction of overall incidents.

Vessel strikes in U.S. West Coast EEZ waters continue to impact large whales (Redfern *et al.* 2013; 2019; Moore *et al.* 2018). A complex of diverse vessel types, speeds, and destination ports all contribute to variability in vessel traffic and these factors may be influenced by economic and regulatory changes. For example, Moore *et al.* (2018) found that primary routes traveled by vessels changed when emission control areas (ECAs) were established off the U.S. West Coast. They also found that large vessels typically reduced their speed by 3-6 kts in ECAs between 2008 and 2015. The speed reductions are thought to be a strategy to reduce operating costs associated with more expensive, cleaner burning fuels required within the ECAs. In contrast, Moore *et al.* (2018) noted that some vessels increased speed when transiting longer routes to avoid the ECAs. Further research is ongoing to understand how variability in vessel traffic affects vessel strike risk and mitigation strategies, though Redfern *et al.* (2019) note that a combination of vessel speed reductions and expansion of areas to be avoided should be considered. Rockwood *et al.* (2017) note that 82% of humpback whale vessel strike mortalities occur within 10% of the region, implying that vessel strike mitigation measures may be effective if applied over relatively small regions.

Other human-caused mortality and serious injury

Non-commercial sources of anthropogenic mortality and serious injury, including tribal fisheries, recreational fisheries, and marine debris (including research buoys) are responsible for a small fraction of all reported cases annually (Carretta *et al.* 2022). These sources and case totals are summarized in Table 4 and account for 0.44 deaths / serious injuries annually to the Central America / Southern Mexico - CA-OR-WA stock of humpback whales.

Table 4. Non-commercial fishery sources of anthropogenic mortality and serious injury observed and reported during 2016-2020 in CA-OR-WA waters (Carretta *et al.* 2022). Totals are prorated to the Central America / Southern Mexico – CA-OR-WA stock in this report, based on a proration factor = 0.42, or the upper 95th percentile of stock abundance ratios shown in Table 2.

Source	Observed Interactions	Total Mortality and Serious Injury	Mean Annual Mortality and Serious Injury	**Central America / Southern Mexico – CA-OR-WA stock prorated totals**
Gillnet fishery (tribal)	3	2.5	0.5	**0.21**
Dungeness crab pot fishery (recreational)	2	1	0.2	**0.08**
Hook And Line Fishery	1	0.75	0.15	**0.06**
Marine Debris	1	1	0.2	**0.08**
Spot Prawn Trap / Pot (recreational)	1	0 (non-serious injury)	0	**0**

Totals CA-OR-WA waters	8	5.25	1.05	**0.44**

Historic whaling

Approximately 15,000 humpback whales were taken from the North Pacific from 1919 to 1987 (Tonnessen and Johnsen 1982), and, of these, approximately 8,000 were taken from the west coast of Baja California, California, Oregon and Washington (Rice 1978). Shore-based whaling apparently depleted the humpback whale stock off California twice: once prior to 1925 (Clapham *et al.* 1997) and again between 1956 and 1965 (Rice 1974). There has been a prohibition on taking humpback whales since 1966.

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 2016c). 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).

Seven important feeding areas for humpback whales are identified off the U.S. west coast by Calambokidis *et al.* (2015), including five in California, one in Oregon, and one in Washington. Humpback whales have increasingly reoccupied areas inside of Puget Sound (the 'Salish Sea'), a region where they were historically abundant prior to whaling (Calambokidis *et al.* 2017).

STATUS OF STOCK

The Central America / Southern Mexico - CA-OR-WA stock of humpback whales is a DIP delineated from the 'Central America DPS' of humpback whales listed as endangered under the ESA (Bettridge *et al.* 2015, Taylor *et al.* 2021), and is therefore considered 'depleted' and 'strategic' under the MMPA. Total annual human-caused serious injury and mortality of humpback whales is the sum of commercial fishery (8.8/yr) + estimated vessel strikes (9.2/yr), + non-commercial sources (0.44/yr), or 18.4 humpback whales annually. Total commercial fishery mortality and serious injury (8.8/yr) is greater than the calculated PBR (2.6) for this stock, thus, it is not approaching zero mortality and serious injury rate. There is no estimate of the undocumented fraction of anthropogenic injuries and deaths to humpback whales on the U.S. West Coast, but for vessel strikes, a comparison of observed vs. estimated annual vessel strikes suggests that approximately 10% of vessel strikes are documented. The stock is estimated to have grown at 1.8% annually (SD = 2.3%) between 2004-2006 and 2019-2021, based on differences between estimates from Wade (2021) and Curtis *et al.* (2022) that account for inclusion / exclusion of whales from southern Mexico in the respective studies, but this estimate has high uncertainty. Habitat concerns include sensitivity to anthropogenic sound sources.

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Humpback Whale (*Megaptera novaeangliae kuzira*) Mainland Mexico - California-Oregon-Washington Stock

Stock Definition and Geographic Range

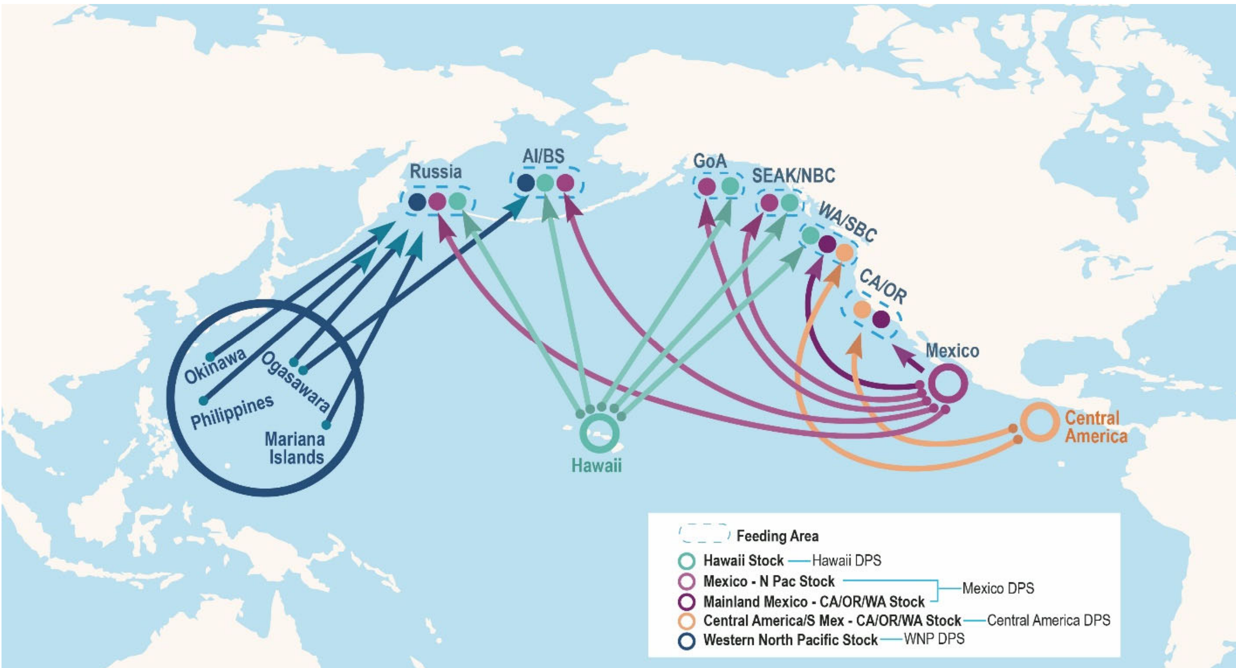

Figure 1. Pacific basin map showing wintering areas of five humpback whale stocks mentioned in this report. Also shown are summering feeding areas mentioned in the text. High-latitude summer feeding areas include Russia, Aleutian Islands / Bering Sea (AI/BS), Gulf of Alaska (GoA), Southeast Alaska / 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 (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 **Mainland Mexico – California-Oregon-Washington stock** (Figure 2). In previous marine mammal stock assessments, humpback whales that summer and feed off California, Oregon, and Washington were treated as a single stock (“California-Oregon-Washington”), but included whales from three DPSs (Central America, Mexico, Hawai‘i) defined by separate wintering areas. Whales from the Hawai‘i DPS previously included in the “California-Oregon-Washington” stock are now included in the Hawai‘i stock report. The previous “California-Oregon-Washington stock” also included multiple DIPs (Central

America – California-Oregon-Washington DIP and Mainland Mexico – California-Oregon-Washington DIP), which is inconsistent with management goals under the MMPA (NMFS 2019).

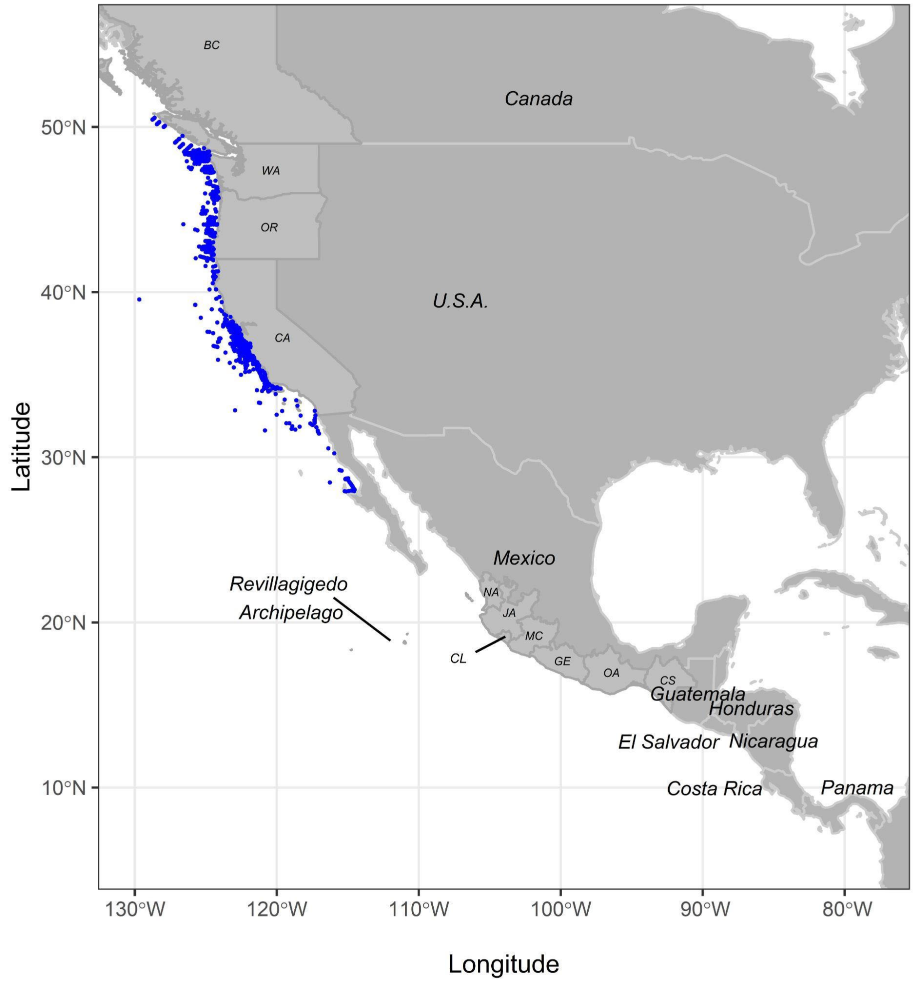

Figure 2. Wintering and summering areas for the Mainland Mexico - CA-OR-WA stock of humpback whales. The primary wintering areas of the Mainland Mexico - CA-OR-WA stock include the mainland Mexico states of Nayarit and Jalisco, with some animals seen as far south as Colima and Michoacán. Summer destinations for whales in the Mainland Mexico - CA-OR-WA stock include U.S. West Coast waters of California, Oregon, Washington, Southern British Columbia, Alaska, and the Bering Sea. Summering area sightings from 1991 - 2018 NMFS/SWFSC research vessel line-transect surveys are shown as blue dots and primarily represent whales from two stocks: the Central America / Southern Mexico - CA-OR-WA stock and Mainland Mexico - CA-OR-WA stock, although small numbers of whales from the Hawai'i stock also have been matched to WA and Southern British Columbia (Wade 2021). Country and state names abbreviations from north to south are: BC = British Columbia, WA = Washington state, OR = Oregon, CA = California, U.S.A. = United States of America, NA = Nayarit, JA = Jalisco, CL = Colima, MC = Michoacán, GE = Guerrero, OA = Oaxaca, and CS = Chiapas.

Population Size

Curtis *et al.* (2022) estimated the population size of whales wintering in southern Mexico and Central America using spatial capture-recapture methods based on photographic data collected between 2019 and 2021. Their estimate of abundance for the Central America / Southern Mexico – CA-OR-WA DIP is 1,494 (CV=0.167) whales. Given the availability of this estimate and a recent estimate of total abundance in the U.S. West Coast EEZ of 4,973 (CV=0.048) whales from mark-recapture (Calambokidis and Barlow 2020), they also estimated the abundance of whales from the Mainland Mexico – CA-OR-WA DIP as the difference, resulting in a mean of 3,479 animals

(CV=0.099). This may be an underestimate, because the total abundance estimate provided in Calambokidis and Barlow (2020) did not include photo-IDs off Washington state. However, it should be noted that a species distribution model estimate for 2018 based on line-transect data from CA + OR + WA waters resulted in a lower estimate of 4,784 whales (CV=0.31) (Becker *et al.* 2020). Of those two estimates, the mark-recapture estimate of Calambokidis and Barlow (2020) has been previously used to represent U.S. West Coast abundance, as it is more precise, while the species distribution model reflects only whale densities and oceanographic conditions within the study area during summer and autumn of 2018. The best estimate of abundance for the Mainland Mexico – CA-OR-WA stock of humpback whales is therefore considered to be the difference between the mark-recapture estimates of Calambokidis and Barlow (2020) and the Central America / Southern Mexico DIP reported by Curtis *et al.* (2022), or 3,479 animals (CV=0.099).

Minimum Population Estimate

The minimum population estimate for this stock is taken as the lower 20th percentile of the 'difference' estimate from Curtis *et al.* (2022) cited above, or 3,185 whales.

Current Population Trend

Calambokidis and Barlow (2020) report that humpback whale abundance appears to have increased within the California Current at approximately 8.2% annually since the late 1980s. This is consistent with observed increases for the entire North Pacific from ~1,200 whales in 1966 to 18,000 - 20,000 whales during 2004 to 2006 (Calambokidis et al. 2008). However, two stocks of humpback whales utilize this region and a stock-specific population trend for the Mainland Mexico – CA-OR-WA stock of humpbacks has not been estimated.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Calambokidis and Barlow (2020) estimated that humpback whale abundance increased approximately 8.2% annually in the California Current since the late 1980s, based on mark-recapture estimates largely restricted to whales summering in California and Oregon waters. However, these estimates include whales from two stocks; the Central America / Southern Mexico - CA/OR/WA stock and the Mainland Mexico - CA/OR/WA stock. The current net productivity rate for the Mainland Mexico - CA/OR/WA stock is unknown. However, the theoretical maximum net productivity rate can be taken to be at least as high as the maximum observed for the combined stocks, or 8.2% annually (Calambokidis and Barlow 2020), though it could be higher if one of the stocks is growing faster than another.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (3,185) times one half the estimated population growth rate for this stock of humpback whales (½ of 8.2%) times a recovery factor of 0.5, for a threatened stock with increasing population trend (NMFS 2016), resulting in a PBR of 65. Because this stock spends approximately half its time outside the U.S. Exclusive Economic Zone (EEZ), the PBR in U.S. waters is 32.5 whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Human-caused mortality and serious injury of humpback whales observed in California, Oregon, and Washington waters primarily includes whales from two stocks: the Central America / Southern Mexico – CA-OR-WA stock and the Mainland Mexico – CA-OR-WA stock. Additionally, a small number of whales from the Hawai'i stock summer in Washington state waters (Wade *et al.* 2021). To assess anthropogenic impacts to the Mainland Mexico – CA-OR-WA stock, total mortality and serious injury from CA-OR-WA waters is prorated to reflect the fraction of CA-OR-WA humpback whale abundance represented by the Mainland Mexico – CA-OR-WA stock. Where multiple stocks share a summering area and estimates of anthropogenic mortality and serious injury (MSI) exist, but stock specific-abundance estimates are unavailable to determine the relative proportion of each stock in that mixed-stock area, total regional MSI may be apportioned among stocks based on knowledge of movement probabilities between summering and wintering areas for each stock, such as those estimated by Wade (2021). However, if abundance estimates are available for multiple stocks sharing a summering area (*e.g*. two stocks that use the U.S. West Coast EEZ in summer; Curtis *et al.* 2022), then MSI assigned to each stock may be more directly determined based on the ratio of overall stock abundances within that region. This is consistent with guidelines for assessing marine mammal stocks which state: "When one or more deaths or serious injuries cannot be assigned directly to a stock, then those deaths or serious injuries may be partitioned among stocks within the appropriate geographic area, provided there is sufficient information to support such partitioning (e.g., based on the relative abundances of stocks within the area)." (NMFS 2016). This is accomplished using the ratio of Mainland Mexico – CA-OR-WA stock abundance reported by Curtis *et al.* (2022) to U.S. West Coast abundance reported by Calambokidis and Barlow (2020) (Table 2). This ratio (0.70) serves as a point estimate for prorating human-caused mortality for this stock. Because this stock is listed as threatened, the point estimate of the abundance ratio (0.70) is used as the proration factor. Two other methods that may be used to prorate human-caused mortality and serious injury to stock include use of summering to wintering area movement probabilities reported by Wade (2021) and genetic mixed-stock apportionments from CA-OR summering areas to Mainland Mexcio reported by Lizewski *et al.* (2021). For purposes of this stock assessment report, the abundance ratio approach is favored, as it is based directly on the estimated proportion of estimated U.S. West Coast abundance that is composed of Mainland Mexico – CA-OR-WA stock whales. The same proration method is applied to all anthropogenic sources of mortality and serious injury in CA-OR-WA waters (see subsequent sections). Additional insight into the fraction of anthropogenic impacts attributable to each stock in this region comes from a study comparing resighting histories of entangled vs non-entangled humpback whales (Tackaberry *et al.* 2022). Of 16 entangled whales documented in central California waters that were photographically matched in wintering areas and assigned to a DPS, 37.5% (n = 6) were matched to the Central American DPS and 62.5% (n = 10) to the Mexican DPS (none were matched to the Hawai‘i DPS).

Table 2. Options for prorating total U.S. West Coast human-caused mortality and serious injury to the Mainland Mexico – CA-OR-WA stock, based on **1)** the ratio of Mainland Mexico – CA-OR-WA stock abundance (Curtis *et al.* 2022) to total U.S. West Coast abundance (Calambokidis and Barlow 2020). Abundance ratios and their distributions are calculated using posterior Bayesian distributions from Curtis *et al.* (2022) estimates and simulated lognormal distributions for Calambokidis and Barlow (2020) estimates; **2)** movement probabilities of whales from CA-OR summering areas to Mainland Mexico reported by Wade (2021); **3)** genetic mixed-stock analysis apportionments from CA-OR summering areas to Mainland Mexico reported by Lizewki *et al.* (2021). The option used to prorate in this report is shown in bold.

Mainland Mexico - CA-OR-WA Abundance	U.S. West Coast Abundance	**Ratio Mainland Mexico - CA-OR-WA to U.S. West Coast Abundance (L95%, U95%)**	Movement Probability Summering to Wintering Area (L95%, U95%)	Genetic mixed-stock apportionment (L95%, U95%)
3,479 (CV=0.099)	4,973 (CV=0.048)	**0.70 (0.56, 0.86)**	0.577 (0.358, 0.737)	0.447 (0.29, 0.72)

Fishery Information

Table 3. Sources of serious injury and mortality of humpback whales in California, Oregon, and Washington commercial fisheries for the period 2016-2020, unless noted otherwise (Carretta 2022, Carretta *et al.* 2022, Jannot *et al.* 2021). Records also include entanglements detected outside of U.S. waters confirmed to involve California, Oregon, and Washington commercial fisheries. Most cases are derived from opportunistic strandings and at-sea sightings of entangled whales. Also included are records of entangled *unidentified whales* prorated to humpback whale based on location, depth, and time of year (Carretta 2018). Sources derived from systematic observer programs with statistical estimates of bycatch and uncertainty are shown with coefficients of variation (CV). Totals in the first three numerical columns include whales from two stocks: the Central America / Southern Mexico – CA-OR-WA stock and the Mainland Mexico – CA-OR-WA stock. Totals are prorated to the Mainland Mexico – CA-OR-WA stock in the last column, based on a proration factor = 0.70, or the point estimate of stock abundance ratios shown in Table 2.

Fishery Source	Observed Interactions (% observer coverage if applicable)	∑ Total CA-OR-WA Mortality and Serious injury (CV if applicable)	Mean Annual Mortality and Serious Injury, (CV if applicable)	**Mainland Mexico – CA-OR-WA stock prorated totals**
Unidentified Fishery	58	43.75	8.75	**6.1**
Dungeness Crab Pot (California)	34	23.75	4.75	**3.3**
Unidentified pot/trap fishery	13	9.50	1.9	**1.3**
Dungeness Crab Pot (Washington)	7	5.50	1.1	**0.77**
Unidentified fishery interactions involving *unidentified whales* prorated to humpback whale	7	4.7	0.94	**0.66**
Gillnet Fishery (unidentified)	6	2.00	0.40	**0.28**
California Spot Prawn Fishery	5	3.25	0.65	**0.46**
Dungeness Crab Pot Fishery (Oregon)	2	1.75	0.35	**0.25**
WA/OR/CA Limited Entry Sablefish Pot (observer program) †*	1 (31% - 72%)	0.5 (> 0.8)	0.1 (> 0.8)	**0.07 (>0.8)**
WA/OR/CA Open Access Sablefish Pot (observer program) †**	1 (7% - 12%)	7.3 (> 0.8)	1.5 (> 0.8)	**1.05 (>0.8)**

Dungeness Crab Pot Fishery (commercial, state unknown)	2	2.00	0.4	**0.28**
WA/OR/CA Sablefish Pot Fishery *and* CA/OR Coonstripe Shrimp Pot***	1	0.0	0.0	**0.0**
CA swordfish and thresher shark drift gillnet fishery (observer program)****	0 (21%)	0.1 (4.7)	0.02 (4.7)	**0.014 (4.7)**
Totals CA-OR-WA waters	137	104.1 (> 0.8)	20.9 (> 0.8)	**14.6 (>0.8)**

† At-sea sightings of entangled whales in the WA/OR/CA Sablefish Pot fisheries that were not recorded in observer programs during 2016-2020 (2) are included in mean annual mortality and serious injury totals because observer data are used to estimate total entanglements for two separate sablefish pot fisheries in this category (Jannot *et al.* 2021). These two records are not included in 'Observed Interactions'.

* Jannot *et al.* (2021) report one humpback entanglement in this fishery in 2014, over an observation period spanning 2002 – 2019 where 13% - 72% of landings were observed. This estimate is based on 2015-2019 data, the most-recent 5-year period for which estimates are available.

** Jannot *et al.* (2021) report one humpback entanglement in this fishery in 2016, over an observation period spanning 2002 – 2019 where 2% - 12% of landings were observed. This estimate is based on 2015-2019 data, the most-recent 5-year period for which estimates are available.

*** One observation of a whale entangled in gear from 2 fisheries. This was a non-serious injury due to intervention and complete removal of entangling gear.

**** There were no observed entanglements during 2016-2020, however the model-based estimate of bycatch is based on pooling 1990-2000 data, resulting in a small positive estimate (Carretta 2022).

Vessel Strikes

There were 14 observed vessel strike cases involving humpback whales in CA-OR-WA waters during 2016-2020, totaling 13.2 deaths and/or serious injuries, or 2.6 whales per year (Carretta *et al.* 2022). However, most vessel strikes are likely undetected and thus we use estimates of vessel strike mortality reported by Rockwood *et al.* (2017) for this region. Vessel strike mortality was estimated for humpback whales in the U.S. West Coast EEZ (Rockwood *et al.* 2017), using an encounter theory model (Martin *et al.* 2016) combining species distribution models of whale density (Becker *et al.* 2016), vessel traffic characteristics (size + speed + spatial use), and whale movement patterns obtained from satellite-tagged animals in the region to estimate whale/vessel interactions resulting in mortality. The estimated number of annual vessel strike deaths was 22 humpback whales, though this includes only the period July – November when whales are most likely to be present in the U.S. West Coast EEZ and the season that overlaps with survey effort used in species distribution models (Becker *et al.* 2016, Rockwood *et al.* 2017). This estimate is based on an assumption of a moderate level of vessel avoidance by humpback whales, as measured by the behavior of satellite-tagged whales in the presence of vessels (McKenna *et al.* 2015). Based on estimates of 22 deaths due to vessel strikes annually, the number attributed to the Mainland Mexico - CA-OR-WA stock during 2016-2020 is 22 x 0.70 = 15.4 whales per year. The estimated mortality of 15.4 humpback whales annually due to vessel strikes represents approximately 0.4% of the stock's estimated population size (15.4 deaths / 3,479 whales). The ratio of mean annual observed to estimated vessel strike deaths and serious injuries of humpback whales during 2016-2020 is 2.6 / 22 = 0.11, implying that vessel strike counts from opportunistic observations represent a small fraction of overall incidents.

Vessel strikes in U.S. West Coast EEZ waters continue to impact large whales (Redfern *et al.* 2013; 2019; Moore *et al.* 2018). A complex of diverse vessel types, speeds, and destination ports all contribute to variability in vessel traffic and these factors may be influenced by economic and regulatory changes. For example, Moore *et al.* (2018) found that primary routes travelled by vessels changed when emission control areas (ECAs) were established off the U.S. West Coast. They also found that large vessels typically reduced their speed by 3-6 kts in ECAs between 2008 and 2015. The speed reductions are thought to be a strategy to reduce operating costs associated with more expensive, cleaner burning fuels required within the ECAs. In contrast, Moore *et al.* (2018) noted that some vessels increased speed when transiting longer routes to avoid the ECAs. Further research is ongoing to understand how variability in vessel traffic affects vessel strike risk and mitigation strategies, though Redfern *et al.* (2019) note that a combination of vessel speed reductions and expansion of areas to be avoided should be considered. Rockwood *et al.* (2017) note that 82% of humpback whale vessel strike mortalities occur within 10% of the region, implying that vessel strike mitigation measures may be effective if applied over relatively small regions.

Other human-caused mortality and serious injury

Non-commercial sources of anthropogenic mortality and serious injury, including tribal fisheries, recreational fisheries, and marine debris (including research buoys) are responsible for a small fraction of all reported cases annually (Carretta *et al.* 2022). These sources and case totals are summarized in Table 4 and account for 0.74 deaths / serious injuries annually to the Mainland Mexico - CA-OR-WA stock of humpback whales.

Table 4. Non-commercial fishery sources of anthropogenic mortality and serious injury observed and reported during 2016-2020 (Carretta *et al.* 2022). Totals are prorated to the Mainland Mexico – CA-OR-WA stock in this report, based on a proration factor = 0.70, or the point estimate of stock abundance ratios shown in Table 2.

Source	Observed Interactions	Total Mortality and Serious Injury	Mean Annual Mortality and Serious Injury	**Mainland Mexico – CA-OR-WA stock prorated totals**
Gillnet fishery (tribal)	3	2.5	0.5	**0.35**
Dungeness crab pot fishery (recreational)	2	1	0.2	**0.14**
Hook And Line Fishery	1	0.75	0.15	**0.11**
Marine Debris	1	1	0.2	**0.14**
Spot Prawn Trap / Pot (recreational)	1	0 (non-serious injury)	0	**0**
Totals CA-OR-WA waters	8	5.25	1.05	**0.74**

Historic whaling

Approximately 15,000 humpback whales were taken from the North Pacific from 1919 to 1987 (Tonnessen and Johnsen 1982), and, of these, approximately 8,000 were taken from the west coast of Baja California, California, Oregon and Washington (Rice 1978). Shore-based whaling apparently depleted the humpback whale stock off

California twice: once prior to 1925 (Clapham *et al.* 1997) and again between 1956 and 1965 (Rice 1974). There has been a prohibition on taking humpback whales since 1966.

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 2016c). 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).

Seven important feeding areas for humpback whales are identified off the U.S. west coast by Calambokidis *et al.* (2015), including five in California, one in Oregon, and one in Washington. Humpback whales have increasingly reoccupied areas inside of Puget Sound (the 'Salish Sea'), a region where they were historically abundant prior to whaling (Calambokidis *et al.* 2017).

STATUS OF STOCK

The Mainland Mexico - CA-OR-WA stock of humpback whales is a DIP delineated from the 'Mexico DPS' of humpback whales 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 humpback whales is the sum of commercial fishery (14.6/yr) + estimated vessel strikes (15.4/yr), + non-commercial sources (0.74/yr), or 30.7 humpback whales annually. Total commercial fishery mortality and serious injury (14.6/yr) is > 10% of the calculated PBR (32.5) for this stock, thus takes are not approaching zero mortality and injury rate. There is no estimate of the undocumented fraction of anthropogenic injuries and deaths to humpback whales on the U.S. West Coast, but for vessel strikes, a comparison of observed vs. estimated annual vessel strikes suggests that approximately 10% of vessel strikes are documented. There is no direct estimate of population trend for this stock, but Calambokidis and Barlow (2020) estimated a 7.5% annual increase between 1989 – 2018 for all humpback whales utilizing CA + OR waters, which includes animals from two stocks: Central America / Southern Mexico – CA-OR-WA and Mainland Mexico – CA-OR-WA. Habitat concerns include sensitivity to anthropogenic sound sources.

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Appendix 1. Pacific reports revised in 2022 are highlighted. S=strategic stock, N=non-strategic stock. unk=unknown, undet=undetermined, n/a=not applicable.

Species (Stock)	N_{est}	CV N_{est}	N_{min}	R_{max}	Fr	PBR	Annual Human-Caused Mortality and Serious Injury	Annual Commercial Fishery Mortality and Serious Injury	Status	Recent Abundance Surveys			Revised
California sea lion (U.S.)	257,606	n/a	233,515	0.12	1	14,011	≥321	≥197	N	2008	2013	2014	2018
Harbor seal (California)	30,968	n/a	27,348	0.12	1	1,641	43	30	N	2004	2009	2012	2014
Harbor seal (Oregon/Washington Coast)	unk	unk	unk	0.12	1	undet	10.6	7.4	N	1999			2013
Harbor seal (Washington Northern Inland Waters)	unk	unk	unk	0.12	1	undet	9.8	2.8	N	1999			2013
Harbor seal (Southern Puget Sound)	unk	unk	unk	0.12	1	undet	3.4	1	N	1999			2013
Harbor seal (Hood Canal)	unk	unk	unk	0.12	1	undet	0.2	0.2	N	1999			2013
Northern Elephant Seal (California Breeding)	187,386	n/a	85,369	0.12	1	5,122	13.7	5.3	N	2005	2010	2013	2021
Guadalupe Fur Seal (Mexico)	34,187	n/a	31,019	0.137	0.5	1,062	≥3.8	≥1.2	S	2008	2009	2013	2019
Northern Fur Seal (California) (California)	14,050	n/a	7,524	0.12	1	451	1.8	≥0.8	N	2010	2011	2013	2015
Monk Seal (Hawaii)	~~1,437~~ 1,465	0.03	~~1,376~~ 1,431	0.07	0.1	~~4.8~~ 5.0	~~≥4.6~~ ≥4.0	~~≥2.0~~ ≥2.2	S	~~2017~~ 2018	~~2018~~ 2019	~~2019~~ 2020	~~2021~~ 2022
Harbor porpoise (Morro Bay)	4,191	0.56	2,698	0.096	0.5	65	0	0	N	2008	2011	2012	2021
Harbor porpoise (Monterey Bay)	3,760	0.561	2,421	0.058	0.5	35	≥0.2	≥0.2	N	2011	2012	2013	2021
Harbor porpoise (San Francisco - Russian River)	7,777	0.62	4,811	0.061	0.5	73	≥0.4	≥0.4	N	2014	2016	2017	2021
Harbor porpoise (Northern CA/Southern OR)	24,685	0.41	17,713	0.04	1	354	0	1	N	2011	2014	2016	2021
Harbor porpoise (Northern OR/Washington Coast)	21,487	0.44	15,123	0.04	0.5	151	≥3.0	≥3.0	N	2002	2010	2011	2013
Harbor porpoise (Washington Inland Waters)	11,233	0.37	8,308	0.04	0.4	66	≥7.2	≥7.2	N	2013	2014	2015	2016
Dall's porpoise (California/Oregon/Washington)	16,498	0.61	10,286	0.04	0.48	99	≥0.66	≥0.66	N	2008	2014	2018	2021
Pacific white-sided dolphin (California/Oregon/Washington)	34,999	0.222	29,090	0.04	0.48	279	7	4	N	2008	2014	2018	2021

Appendix 1. Pacific reports revised in 2022 are highlighted. S=strategic stock, N=non-strategic stock. unk=unknown, undet=undetermined, n/a=not applicable.

Species (Stock)	N_{est}	CV N_{est}	N_{min}	R_{max}	Fr	PBR	Annual Human-Caused Mortality and Serious Injury	Annual Commercial Fishery Mortality and Serious Injury	Status	Recent Abundance Surveys			Revised
Risso's dolphin (California/Oregon/Washington)	6,336	0.32	4,817	0.04	0.48	46	≥3.7	≥3.7	N	2005	2008	2014	2016
Common Bottlenose dolphin (California Coastal)	453	0.06	346	0.04	0.48	2.7	≥2.0	≥1.6	N	2009	2010	2011	2016
Common Bottlenose dolphin (California/Oregon/Washington Offshore)	3,477	0.696	2,048	0.04	0.48	19.7	≥0.82	≥0.82	N	2008	2014	2018	2021
Striped dolphin (California/Oregon/Washington)	29,988	0.3	23,448	0.04	0.48	225	≥4.0	≥4.0	N	2008	2014	2018	2021
Common dolphin, short-beaked (California/Oregon/Washington)	1,056,308	0.21	888,971	0.04	0.5	8,889	≥30.5	≥30.5	N	2008	2014	2018	2021
Common dolphin, long-beaked (California)	83,379	0.216	69,636	0.04	0.48	668	≥29.7	≥26.5	N	2008	2014	2018	2021
Northern right whale dolphin (California/Oregon/Washington)	29,285	0.72	17,024	0.04	0.48	163	≥6.6	≥6.6	N	2008	2014	2018	2021
Killer whale (Eastern N Pacific Offshore)	300	0.1	276	0.04	0.5	2.8	0	0	N	2010	2011	2012	2018
Killer whale (Eastern N Pacific Southern Resident)	~~72~~ 74	n/a	~~72~~ 74	0.035	0.1	0.13	≥0.4	0	S	~~2018~~ 2019	~~2019~~ 2020	~~2020~~ 2021	~~2021~~ 2022
Short-finned pilot whale (California/Oregon/Washington)	836	0.79	466	0.04	0.48	4.5	1.2	1.2	N	2005	2008	2014	2016
Baird's beaked whale (California/Oregon/Washington)	1,363	0.53	894	0.04	0.5	8.9	≥0.2	0	N	2008	2014	2018	2021
Mesoplodont beaked whales (California/Oregon/Washington)	3,044	0.54	1,967	0.04	0.5	20	0.1	0.1	N	2005	2008	2014	2017
Cuvier's beaked whale (California/Oregon/Washington)	~~3,274~~ 5,454	~~0.67~~ 0.27	~~2,059~~ 4,214	0.04	0.5	~~21~~ 42	<0.1	<0.1	N	~~2005~~ 2008	~~2008~~ 2014	~~2014~~ 2016	~~2017~~ 2022
Pygmy Sperm whale (California/Oregon/Washington)	4,111	1.12	1,924	0.04	0.5	19.2	0	0	N	2005	2008	2014	2016

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Species (Stock)	N_{est}	CV N_{est}	N_{min}	R_{max}	Fr	PBR	Annual Human-Caused Mortality and Serious Injury	Annual Commercial Fishery Mortality and Serious Injury	Status	Recent Abundance Surveys			Revised
Dwarf sperm whale (California/Oregon/Washington)	unk	unk	unk	0.04	0.5	undet	0	0	N	2005	2008	2014	2016
Sperm whale (California/Oregon/Washington)	1,997	0.57	1,270	0.04	0.1	2.5	0.6	0.64	S	2005	2008	2014	2019
Gray whale (Eastern N Pacific)	26,960	0.05	25,849	0.062	1	801	131	9.3	N	2011	2015	2016	2020
Gray whale (Western N Pacific)	290	n/a	271	0.062	0.1	0.12	unk	unk	S	2014	2015	2016	2020
Humpback whale (Central America / Southern Mexico - California-Oregon-Washington)	1,494	0.167	1,282	0.082	0.1	2.6	18.4	8.8	S	2019	2020	2021	2022
Humpback whale (Mainland Mexico - California-Oregon-Washington)	3,479	0.099	3,185	0.082	0.5	32.5	30.7	14.6	S	2016	2017	2018	2022
Blue whale (Eastern N Pacific)	1,898	0.085	1,767	0.04	0.2	4.1	≥ 19.5	≥ 1.54	S	2016	2017	2018	2021
Fin whale (California/Oregon/Washington)	11,065	0.405	7,970	0.04	0.5	80	≥ 43.6	≥ 0.64	S	2008	2014	2018	2021
Sei whale (Eastern N Pacific)	519	0.4	374	0.04	0.1	0.75	≥ 0.2	≥ 0.2	S	2005	2008	2014	2018
Minke whale (California/Oregon/Washington)	915	0.792	509	0.04	0.4	4.1	≥ 0.59	≥ 0.59	N	2008	2014	2018	2021
Bryde's whale (Eastern Tropical Pacific)	unk	unk	unk	0.04	0.5	undet	unk	unk	N	n/a	n/a	n/a	2015
Rough-toothed dolphin (Hawai'i)	76,375	0.41	54,804	0.04	0.5	548	0	0	N	2002	2010	2017	2020
Rough-toothed dolphin (American Samoa)	unk	unk	unk	0.04	0.5	undet	unk	unk	unk	n/a	n/a	n/a	2010
Risso's dolphin (Hawai'i)	7,385	0.22	6,150	0.04	0.5	61	0	0	N	2002	2010	2017	2020
Common Bottlenose dolphin (Hawai'i Pelagic)	unk	unk	unk	0.04	0.5	undet	0	0	N	2002	2010	2017	2017
Common Bottlenose dolphin (Kaua'i and Ni'ihau)	unk	unk	97	0.04	0.5	1	unk	unk	N	2003	2012	2015	2017
Common Bottlenose dolphin (O'ahu)	unk	unk	n/a	0.04	0.5	undet	unk	unk	N	2002	2003	2006	2017

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Species (Stock)	N_{est}	CV N_{est}	N_{min}	R_{max}	Fr	PBR	Annual Human-Caused Mortality and Serious Injury	Annual Commercial Fishery Mortality and Serious Injury	Status	Recent Abundance Surveys			Revised
Common Bottlenose dolphin (4 Islands Region)	unk	unk	n/a	0.04	0.5	undet	unk	unk	N	2002	2003	2006	2017
Common Bottlenose dolphin (Hawai'i Island)	unk	unk	91	0.04	0.5	0.9	unk	unk	N	2002	2003	2006	2017
Pantropical Spotted dolphin (Hawai'i Pelagic)	39,798	0.51	26,548	0.04	0.5	265	0	0	N	2002	2010	2017	2020
Pantropical Spotted dolphin (O'ahu)	unk	unk	unk	0.04	0.5	undet	unk	unk	N			n/a	2017
Pantropical Spotted dolphin (4 Islands Region)	unk	unk	unk	0.04	0.5	undet	unk	unk	N			n/a	2017
Pantropical Spotted dolphin (Hawai'i Island)	unk	unk	unk	0.04	0.5	undet	≥ 0.2	≥ 0.2	N			n/a	2017
Spinner dolphin (Hawai'i Island)	665	0.09	617	0.04	0.5	6.2	≥ 1.0	unk	N	2010	2011	2012	2018
Spinner dolphin (O'ahu / 4 Islands Region)	n/a	n/a	n/a	0.04	0.5	undet	≥ 0.4	unk	N	1998	2002	2007	2018
Spinner dolphin (Kaua'i and Ni'ihau)	n/a	n/a	n/a	0.04	0.5	undet	unk	unk	N	1995	1998	2005	2018
Spinner dolphin (Hawai'i Pelagic)	unk	unk	unk	0.04	0.5	undet	0	0	N		2002	2010	2018
Spinner dolphin (Kure / Midway)	unk	unk	unk	0.04	0.5	undet	unk	unk	N		1998	2010	2018
Spinner dolphin (Pearl and Hermes Reef)	unk	unk	unk	0.04	0.5	undet	unk	unk	N			n/a	2018
Spinner dolphin (American Samoa)	unk	unk	unk	0.04	0.5	undet	unk	unk	unk			n/a	2010
Striped dolphin (Hawai'i Pelagic)	35,179	0.23	29,058	0.04	0.5	291	0	0	N	2002	2010	2017	2020
Fraser's dolphin (Hawai'i)	40,960	0.7	24,068	0.04	0.5	241	0	0	N	2002	2010	2017	2020
Melon-headed whale (Hawaiian Islands)	40,647	0.74	23,301	0.04	0.5	233	0	0	N	2002	2010	2017	2020
Melon-headed whale (Kohala Resident)	unk	unk	unk	0.04	0.5	undet	0	0	N	2002	2010	2017	2020

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Species (Stock)	N_{est}	CV N_{est}	N_{min}	R_{max}	Fr	PBR	Annual Human-Caused Mortality and Serious Injury	Annual Commercial Fishery Mortality and Serious Injury	Status	Recent Abundance Surveys			Revised
Pygmy killer whale (Hawai'i)	10,328	0.75	5,885	0.04	0.5	59	0	0	N	2002	2010	2017	2020
False killer whale (NW Hawaiian Islands)	477	1.71	178	0.04	0.4	1.4	0.1	0.1	N	2002	2010	2017	2021
False killer whale (Hawai'i Pelagic)	2,086	0.35	1,567	0.04	0.5	16	9.8	9.8	N	2002	2010	2017	2021
False killer whale (Main Hawaiian Islands Insular)	167	0.14	149	0.04	0.1	0.3	0.03	0.03	S	2013	2014	2015	2021
False killer whale (Palmyra Atoll)	1,329	0.65	806	0.04	0.4	6.4	0.3	0.3	N			2005	2012
False killer whale (American Samoa)	unk	unk	unk	0.04	0.5	undet	unk	unk	unk	n/a	n/a	n/a	2010
Killer whale (Hawai'i)	161	1.06	78	0.04	0.5	0.8	0	0	N	2002	2010	2017	2020
Pilot whale, short-finned (Hawai'i)	12,607	0.18	10,847	0.04	0.4	87	0.9	0.9	N	2002	2010	2017	2020
Blainville's beaked whale (Hawai'i Pelagic)	1,132	0.99	564	0.04	0.5	5.6	0	0	N	2002	2010	2017	2020
Longman's Beaked Whale (Hawai'i)	2,550	0.67	1,527	0.04	0.5	15	0	0	N	2002	2010	2017	2020
Cuvier's beaked whale (Hawai'i Pelagic)	4,431	0.41	3,180	0.04	0.5	32	0	0	N	2002	2010	2017	2020
Pygmy sperm whale (Hawai'i)	42,083	0.64	25,695	0.04	0.5	257	0	0	N	2002	2010	2017	2020
Dwarf sperm whale (Hawai'i)	unk	unk	unk	0.04	0.5	undet	0	0	N	2002	2010	2017	2020
Sperm whale (Hawai'i)	5,707	0.23	4,486	0.04	0.2	18	0	0	S	2002	2010	2017	2020
Blue whale (Central N Pacific)	133	1.09	63	0.04	0.1	0.1	0	0	S		2002	2010	2017
Fin whale (Hawai'i)	203	0.99	101	0.04	0.1	0.2	0	0	S	2002	2010	2017	2020
Bryde's whale (Hawai'i)	602	0.22	501	0.04	0.5	5	0	0	N	2002	2010	2017	2020
Sei whale (Hawai'i)	391	0.9	204	0.04	0.1	0.4	0.2	0.2	S	n/a	2002	2010	2017
Minke whale (Hawai'i)	438	1.05	212	0.04	0.5	2.1	0	0	N	2002	2010	2017	2020
Humpback whale (American Samoa)	unk	unk	150	0.106	0.1	0.4	0	0	S	2006	2007	2008	2009