DRAFT U.S. PACIFIC MARINE MAMMAL STOCK ASSESSMENTS: 2020

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Stock assessment reports and appendices revised in 2020 are highlighted; all others can be found at the NOAA marine mammal stock assessment homepage.

PINNIPEDS

CETACEANS - U.S. WEST COAST

CETACEANS – HAWAII & WESTERN PACIFIC

APPENDICES

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 National Marine Mammal Laboratory (NMML, Seattle, WA), and the Northwest Fisheries Science Center (NWFSC, Seattle, WA). The 2020 Draft Pacific marine mammal stock assessments include revised reports for 28 Pacific marine mammal stocks under NMFS jurisdiction, including 7 "strategic" stocks: Hawaiian monk seal, Southern Resident killer whale, Western North Pacific gray whale, California/Oregon/Washington fin whale, Main Hawaiian Islands Insular false killer whale, Hawaii sperm whale, and Hawaii fin whale. New abundance estimates are available for 21 stocks: Hawaiian monk seal, Southern Resident killer whale, Hawaii rough-toothed dolphin, Hawaii Risso's dolphin, Hawaii pelagic common bottlenose dolphin, Hawaii pelagic pantropical spotted dolphin, Hawaii striped dolphin, Hawaii Fraser's dolphin, Hawaiian Islands melon-headed whale, Hawaii pygmy killer whale, Northwestern Hawaiian Islands false killer whale, Hawaii pelagic false killer whale, Hawaii killer whale, Hawaii short-finned pilot whale, Hawaii Blainville's beaked whale, Hawaii Longman's beaked whale, Hawaii Cuvier's Beaked Whale, Hawaii pygmy sperm whale, Hawaii sperm whale, Hawaii fin whale, Hawaii Bryde's whale, and Hawaii minke whale. Two stocks no longer have current estimates of abundance or estimated Potential Biological Removal levels due to outdated survey data (Kohala Resident melon-headed whale) or a lack of sightings on recent systematic surveys (Hawaii pelagic common bottlenose dolphin). New information on human-caused sources of mortality and serious injury is included for those stocks where new data are available or resulted in a significant change compared with previously-documented levels of anthropogenic mortality and 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 2020 stock assessment reports were reviewed by the Pacific Scientific Review Group (PSRG) at the March 2020 online 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 ~~4/15/2020~~ 8/29/2020

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 ~~1,351~~ 1,437 (95% confidence interval ~~1,294~~ 1,367-~~1,442~~ 1,549; CV = 0.03), (Table 1, Johanos ~~2018a~~ 2019a,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 ~~2017~~2018, total enumeration was achieved ~~only~~ at Laysan and Lisianski Islands, and Kure Atoll, and a capture-recapture estimate was obtained for ~~Pearl and Hermes Reef~~Midway Atoll. At French Frigate Shoals~~, Laysan Island, Lisianski Island, and Midway Atoll~~ and Pearl and Hermes Reef, abundance estimates were obtained using discovery curve analysis~~. As it happened, the median capture-recapture and discovery curve estimates in 2017, when rounded to the nearest integer, were identical to the total number of individuals identified at each site (or N_{min}), respectively~~ (Table 1). Counts at Necker and Nihoa Islands are 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.~~ In 2017, no count was conducted at Necker Island and two counts were conducted at Nihoa Island. The most recent abundance estimate (from 2016) was used for Necker Island.~~

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. In recent years, a small number of surveys of Ni'ihau and nearby Lehua Islands have been 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~~in 2017~~ 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 recent 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).

Table 1. Total and minimum estimated abundance (N_{min}) of Hawaiian monk seals by location in ~~2017~~2018. 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	~~173~~181	~~42~~40	~~215~~221	~~173~~181	40~~42~~	~~215~~221	DC
Laysan	~~197~~200	~~28~~30	~~225~~230	~~197~~200	30~~28~~	~~225~~230	~~DC~~EN
Lisianski	~~133~~130	~~19~~15	~~152~~145	~~133~~130	15~~19~~	~~152~~145	~~DC~~EN
Pearl and Hermes Reef	~~117~~124	~~24~~26	~~141~~150	~~117~~124	26~~24~~	~~141~~150	~~CR~~DC
Midway	~~69~~71	~~12~~13	~~81~~84	~~69~~65	13~~12~~	~~81~~78	~~DC~~CR
Kure	~~90~~91	~~23~~11	~~113~~102	~~90~~91	11~~23~~	~~113~~102	EN
Necker~~[1]~~	~~63~~76	7	~~70~~83	~~53~~64	7~~7~~	~~60~~71	CC
Nihoa	~~65~~100	6	~~71~~106	~~55~~85	6~~6~~	~~61~~91	CC
MHI_(without Ni'ihau/ Lehua)	~~133~~145	~~20~~30	~~153~~175	~~133~~145	30~~20~~	~~153~~175	Min
Ni'ihau/Lehua	~~101~~124	~~14~~7	~~115~~131	85104	7~~14~~	99111	CC
Range-wide	***~~1244~~1252***	***~~195~~185***	***~~1351~~1437***	***~~1130~~1189***	***185~~195~~***	***~~1325~~1374***	

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 (~~1,325~~1,374) are presented in Table 1.

Current Population Trend

Range-wide abundance estimates are available from 2013 to ~~2017~~ 2018 (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-~~2017~~ 2018 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 (1.00, 1.04). Thus, the best estimate is that the population grew at an average rate of about -2% per year from 2013 to ~~2017~~ 2018. ~~Only 5~~Less than 1% of the distribution was below 1, indicating that there is greater than a ~~95~~ 99% chance that the monk seal population increased during 2013-~~2017~~ 2018.

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 ~~2018a~~2019a). Consistent with this value, a life table analysis representing a time

~~[1] No surveys were conducted at Necker Island in 2017, so the values estimated in 2016 were used.~~

when the MHI monk seal population was apparently expanding, yielded an estimated intrinsic population growth rate of 1.07 (Baker *et al*. 2011).

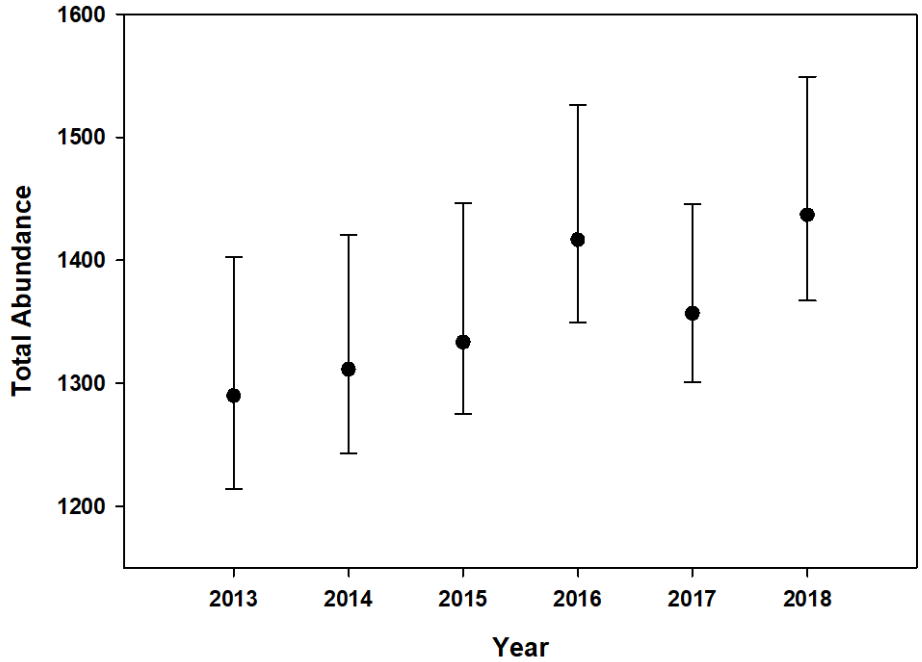

Figure 1. Range-wide abundance of Hawaiian monk seals, 2013-~~2017~~2018. Medians and 95% confidence limits are shown. Estimates prior to 2018 are re-estimated based on new data and represent negligible changes compared with values reported in the final 2019 stock assessment.

POTENTIAL BIOLOGICAL REMOVAL

Using current minimum population size (~~1,325~~ 1,374), R_{max} (0.07) and a recovery factor (F_r) for ESA endangered stocks (0.1), yields a Potential Biological Removal (PBR) of ~~4.6~~ 4.8.

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 ~~2013~~2014-~~2017~~ 2018 (Johanos ~~2018d~~2019d, Mercer 2020). There were no confirmed cases in 2016.

Year	Age/sex	Island	Cause of Death	Comments
2014	Adult male	Oahu	Suspected trauma	Intent unconfirmed
2014	Pup female	Kauai	Skull fracture, blunt force trauma	Likely intentional
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

It is extremely unlikely that all carcasses of intentionally killed monk seals are discovered and reported. Studies of the recovery rates of carcasses for other marine mammal species have shown that the probability of detecting and documenting most deaths (whether from human or natural causes) is quite low (Peltier *et al*. 2012; Williams *et al*. 2011; Perrin *et al*. 2011; Punt and Wade 2010).

Fishery Information

Fishery interactions with monk seals can include direct interaction with gear (hooking or entanglement), seal consumption of discarded 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 ~~2017~~2018, ten ~~21~~ seal hookings were documented ~~(two were inferred from monofilament line extending from seals' mouths)~~, two of which- were classified as serious and eight ~~19~~ as non-serious injuries. Of the non-serious injuries, two ~~6~~ would have been deemed serious had they not been mitigated (Henderson ~~2018a~~2019a, Mercer ~~2018~~2020). The hooks involved included circle, treble and J-hooks of widely varying sizes. Monk seals also interact with nearshore gillnets, and several confirmed deaths have resulted. One confirmed gillnet mortality occurred in 2017, and three mortalities in 2016-2017 are considered suspect net mortalities (Mercer 2018), based on necropsy findings of probable peracute underwater entrapment (drowning) (Moore et al. 2013). In 2018, a fisherman reported releasing a monk seal from a -gillnet he was tending off Oahu. The seal was reportedly lethargic but the event was deemed non-serious because the seal was released and subsequently has been resighted alive. Two seals were entangled in monofilament fishing gear on Oahu in 2018; both were deemed non-serious because they were disentangled, but would have been serious had they not been mitigated. ~~A novel fishery mortality occurred in 2017 when an adult male seal drowned in a submerged mariculture fish pen off the coast of Hawaii Island.~~ No mortality or serious injuries have been attributed to the MHI bottomfish handline fishery (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). Data for MHI bottomfish and nearshore fisheries are based upon incidental observations (i.e., hooked seals and those entangled in active gear). All hookings not clearly attributable to either fishery with certainty were attributed to the bottomfish fishery, and hookings which resulted in injury of unknown severity were classified as serious. 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	~~2013~~ 2014 2015 2016 2017 2018	 observer observer observer observer observer	~~20.4% & 100%~~ 20.8% & 100% 20.6% & 100% 20.1% & 100% 20.4% & 100% 20.4% & 100%	 0 0 0 0 0	 0 0 0 0 0	 0 0 0 0 0	0 (0)
MHI Bottomfish	~~2013~~ 2014 2015 2016 2017 2018	Incidental observations of seals	none	0 0 0 0 0	n/a	0 0 0 0 0	n/a
Nearshore	~~2013~~ 2014 2015 2016 2017 2018	Incidental observations of seals	none	~~0~~ 1 3 0 3 2	n/a	~~15 (6)~~ 13 (9) 8 (2) 11 (6) 19(6) 11(4)	≥~~1.4~~ 1.8
Mariculture	~~2013~~ 2014 2015 2016 2017 2018	Incidental Observation	none	~~0~~ 0 0 0 1 0	n/a	0 0 0 0 0	0.2 (2.2)
Minimum total annual takes							≥ ~~1.6~~ 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 being hooked and entangled in the MHI at a rate that has not been reliably assessed but is certainly greater than zero. The information above represents only reported direct interactions, and without directed observation effort, the true interaction rate cannot be estimated. 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 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 ~~9~~ ten documented ~~mortalities~~deaths (one of which occurred at Kure Atoll in 2018) (Henderson 2001; Henderson ~~2018b~~2019b, Mercer 2020). 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. 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)
2014	0	5(4)
2015	0	12(8)
2016	0	3(2)
2017	0	11(8)
2018	1	13(4)

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. 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 (2014-2018) five monk seal deaths (representing a minimum average of one death per year) have been directly attributed to toxoplasmosis (Mercer 2020). All 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, 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. 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~~ infectious disease effects on monk seal demographic trends are low relative to other stressors. ~~However, land-to-sea transfer of *Toxoplasma gondii*, a protozoal parasite shed in the feces of cats, is of growing concern. 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). Eight monk seal mortalities (and 1 suspect mortality) have been directly attributed to toxoplasmosis from 2001 to 2017. The number of mortalities from this pathogen are likely underrepresented, given that more seals disappear each year than are found dead and examined. 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. 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. Furthermore~~However, ~~the consequences of~~ a disease outbreak introduced from livestock, feral animals, pets or other carrier wildlife ~~may~~ 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. ~~A major habitat issue involves l~~Loss of terrestrial habitat at French Frigate Shoals is a serious threat to the viability of the resident monk seal population. Prior to 2018~~, where some~~ pupping and resting islets ~~have~~ 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 ~~may~~ 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 ~~and there are discussions of USFWS supporting the extension of monk seal field camps to allow for entrapment mitigation beyond the regular spring/summer field season.~~.

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. 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 (~~2013-2017~~2014-2018) was at least ~~3~~4.8~~.0~~ animals, which equals PBR, including fishery-related mortality in nearshore gillnets, hook-and-line gear, and mariculture (≥~~1.6~~2.0/yr, Table 3), intentional killings and other human-caused mortalities (≥1.~~4~~6/yr, Table 2), entanglement in marine debris (≥0.2/yr, Table 4), and deaths due to toxoplasmosis (≥ 1.0/yr).

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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).

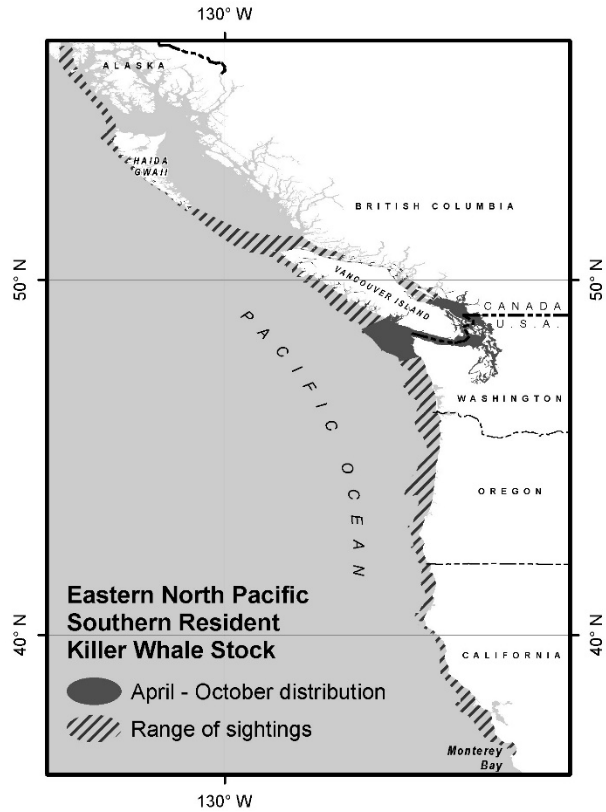

Figure 1. Approximate April - October distribution of the Eastern North Pacific Southern Resident killer whale stock (shaded area) and range of sightings (diagonal lines).

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 2019a, 2019b): "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 outer coastal waters off Washington and Vancouver Island, especially in the area between Grays Harbor and the Columbia River (Ford et al. 2000, Hanson et al. 2017), but travel 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 ~~75~~ 73 whales in ~~2018~~ 2019 (Fig. 2; Ford *et al.* 2000; Center for Whale Research ~~2018~~ 2019). 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 ~~2017~~ 2018 through 1 July ~~2018~~ 2019 includes ~~no~~ two new calves and the deaths of a juvenile female, two young adult males, and a ~~two old male~~ post-reproductive female.

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 ~~75~~ 73 animals.

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 ~~75~~ 73 animals as of the ~~2018~~ 2019 census (Ford *et al.* 2000; Center for Whale Research ~~2018~~2019).

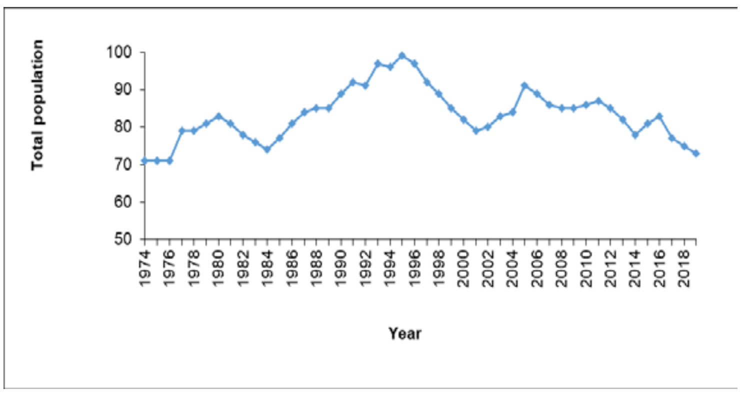

Figure 2. Population of Eastern North Pacific Southern Resident stock of killer whales, 1974-~~2018~~ 2019. Each year's count includes animals first seen and first missed; a whale is considered first missed the year after it was last seen alive (Ford *et al.* 2000; Center for Whale Research ~~2018~~ 2019).

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 (~~75~~73) 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 2014-2018 (Carretta 2020, Carretta *et al.* 2020).

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.

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). 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). 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). 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 ~~2013-2017~~ 2014-2018 (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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GRAY WHALE (*Eschrichtius robustus*): Eastern North Pacific Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Once common throughout the Northern Hemisphere, the gray whale was extinct in the Atlantic by the early 1700s (Fraser 1970; Mead and Mitchell 1984), but recent ~~single~~ sightings in the Mediterranean Sea in 2010 and off Namibia in 2013 are documented (Scheinin *et al.* 2011, Elwen and Gridley 2013). Gray whales are ~~only~~ commonly found in the North Pacific. Genetic ~~comparisons~~ studies indicate there are distinct "Eastern North Pacific" (ENP) and "Western North Pacific" (WNP) population stocks, with differentiation in both mtDNA haplotype and microsatellite allele frequencies (LeDuc *et al.* 2002; Lang *et al.* 2011a; Weller *et al.* 2013). Brüniche-Olsen *et al.* (2018a) used nuclear single nucleotide polymorphisms (SNPs) from whales sampled off Sakhalin and Mexico breeding lagoons to conclude that genetic differentiation between the two regions was small, but statistically-significant, despite the presence of admixed individuals. These authors conclude that gray whale population structure is not determined by simple geography and may be in flux due to evolving migratory dynamics. Contemporary gray whale genomes, both eastern and western, contain less nucleotide diversity than most other marine mammals and evidence of inbreeding is greater in the Western Pacific than in the Eastern Pacific populations (Brüniche-Olsen *et al.* 2018b).

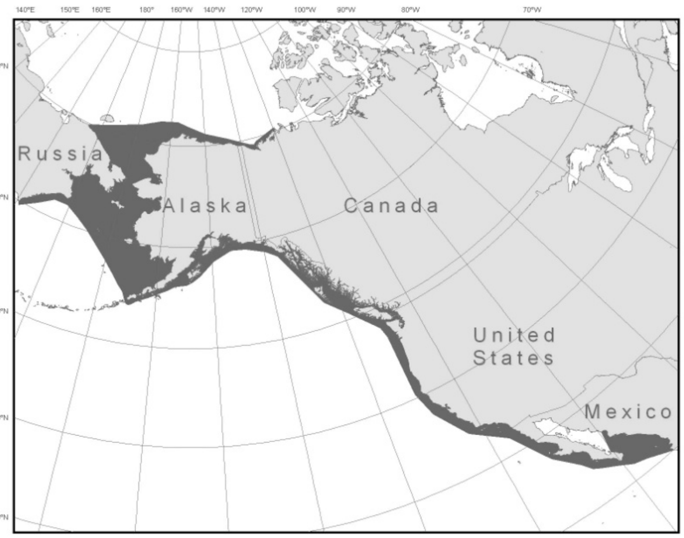

Figure 1. Approximate distribution of the Eastern North Pacific stock of gray whales (shaded area).

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

Tagging, photo-identification and genetic studies show that some whales identified in the WNP off Russia have been observed in the ENP, including coastal waters of Canada, the U.S. and Mexico (Lang 2010; Mate *et al.* 2011; Weller *et al.* 2012; Urbán *et al.* 2013, Mate *et al.* 2015, Urbán *et al.* 2019). Photographs of 379 individuals identified on summer feeding grounds off Russia (316 off Sakhalin; 150 off Kamchatka), were compared to 10,685 individuals identified in Mexico breeding lagoons. A total of 43 matches were found, including the following links: 14 Sakhalin-Kamchatka-Mexico, 25 Sakhalin-Mexico, and 4 Kamchatka-Mexico (Urban *et al.* 2019). The number of whales documented moving between the WNP and ENP represents 14% of gray whales identified off Sakhalin Island and Kamchatka according to Urban *et al.* (2019). ~~In combination, these studies have documented approximately 30 gray whales observed in both the WNP and ENP. Despite this geographic overlap, significant mtDNA and nDNA differences are found between whales in the WNP and those summering in the ENP (LeDuc *et al.* 2002; Lang *et al.* 2011a).~~

In 2010, the IWC Standing Working Group on Aboriginal Whaling Management Procedure noted that different names had been used to refer to gray whales feeding along the Pacific coast, and agreed to designate animals that spend the summer and autumn feeding in coastal waters of the Pacific coast of North America from California to southeast Alaska as the "Pacific Coast Feeding Group" or PCFG (IWC 2012). This definition was further refined for purposes of abundance estimation, limiting the geographic range to the area from northern California to northern

British Columbia (from 41°N to 52°N), and limiting the temporal range from June 1 to November 30, and counting only those whales seen in more than one year within this geographic and temporal range (IWC 2012). The IWC adopted this definition in 2011, but noted that “not all whales seen within the PCFG area at this time will be PCFG whales and some PCFG whales will be found outside of the PCFG area at various times during the year.” (IWC 2012).

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

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

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

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

The IWC Scientific Committee ~~has conducted a series of~~completed annual (2014-2018) range-wide workshops on the status of North Pacific gray whales. The primary objectives ~~was not to determine a single 'best' stock structure hypothesis (unless definitively supported by existing data) but rather~~ were to identify plausible stock structure hypotheses ~~consistent with the suite of available data. The goal is to~~ and create a foundation for developing range-wide conservation advice. ~~The primary hypotheses deemed as most plausible considered two separate 'breeding stocks' or biological populations (western and eastern). These hypotheses include: (a) "Hypothesis 3a" which assumes that while two breeding stocks (western and eastern) may once have existed, the western breeding stock is extirpated. Whales show matrilineal fidelity to feeding grounds, and the eastern breeding stock includes three feeding aggregations: Pacific Coast Feeding Group, Northern Feeding Group, and a Western Feeding Group; and (b) "Hypothesis 5a" which assumes that both breeding stocks are extant and that the western breeding stock feeds off both coasts of Japan and Korea and in the northern Okhotsk Sea west of the Kamchatka Peninsula. Whales feeding off Sakhalin include both whales that are part of the extant western breeding stock and remain in the western North Pacific year-round, plus whales that are part of the Eastern breeding stock and migrate between Sakhalin and the eastern North Pacific.~~ The Scientific Committee reported on the plausibility of various stock structure hypotheses in 2020 (IWC 2020). There are up to three feeding groups or aggregations: the Pacific Coast Feeding Group (PCFG), the Western Feeding Group (WFG), and the North Feeding Group (NFG). The PCFG is defined above. The WFG consists of whales that feed off Sakhalin Island as documented via photo-ID. The NFG includes whales found feeding in the Bering and Chukchi Seas where photo-ID and genetic data are sparse. The IWC also considers up to three extant breeding stocks: the Western Breeding Stock (WBS), the Eastern Breeding Stock (EBS), and a third unnamed stock that includes WFG whales interbreeding largely with each other while migrating to the Mexican wintering grounds. The IWC summarizes three 'high plausibility' hypotheses as follows: **Hypothesis 3a** is characterized by maternal feeding ground fidelity, one migratory route/wintering region used by Sakhalin whales, and random mating. Under this hypothesis, a single breeding stock (EBS) exists that includes three feeding groups: NFG, PCFG, and WFG. Areas off Southern Kamchatka and the Northern Kuril Islands are used by some whales that belong to the WFG and some whales that belong to the NFG. Although two breeding stocks (WBS and EBS) may once have existed, the WBS is assumed to have been extirpated. **Hypothesis 4a** is characterized by maternal feeding ground fidelity, one migratory route/wintering region used by Sakhalin whales, and non-random mating. Under this hypothesis, two breeding stocks exist (EBS and WBS) and overwinter in Mexico. One breeding stock includes NFG and PCFG whales, and the second breeding stock includes WFG whales that mate largely with each other while migrating to Mexico. Areas off Southern Kamchatka and the Northern Kuril Islands are used by some whales that belong to the breeding stock comprised of WFG whales and some whales that belong to the NFG. Although a third breeding stock (the WBS) may once have existed, under this hypothesis the WBS is assumed to have been extirpated. **Hypothesis 5a** is characterized by maternal feeding ground fidelity, two migratory routes/wintering grounds used by Sakhalin whales, and random mating. Under this hypothesis, two breeding stocks exist: EBS and WBS. The EBS includes three feeding groups: PCFG, NFG, and the WFG that feeds off Northeastern Sakhalin Island. The WBS whales feed in the Okhotsk Sea and off Northeastern Sakhalin Island, Southern Kamchatka, and the Northern Kuril Islands and then migrate to the South China Sea to overwinter. Under this hypothesis, areas off Southern Kamchatka and the Northern Kuril Islands are used by the WFG, the NFG, and the feeding whales that are part of the WBS.

POPULATION SIZE

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

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

Eastern North Pacific gray whales experienced an unusual mortality event (UME) beginning in 2019, which continued into 2020, when large numbers of emaciated whales stranded from Mexico to Alaska (NOAA 2020a) (Figure 3). Necropsies conducted on a subset of stranded whales indicated that many animals showed evidence of nutritional stress. NOAA is coordinating an independent team of scientists to review the stranding data and samples as part of the Working Group on Marine Mammal Unusual Mortality Events. NOAA continues to monitor the gray whale population through abundance and calf production surveys. Abundance surveys are underway during the 2019-2020 southbound migration and an annual calf production survey (conducted annually since 1994) is planned in 2020. The current UME is similar to that of 1999 and 2000, when large numbers of emaciated animals also stranded along the west coast of North America (Moore *et al.*, 2001; Gulland *et al.*, 2005). Stranding numbers during the 1999-2000 UME exceeded that of the 2019-2020 UME, although estimated population size at the time of the 1999-2000 UME was between 15,000 to 18,000 animals, compared with the current estimate of >26,000 whales (Figure 2, right panel). During the 1999-2000 UME ~~Over~~ ≥60% of the dead whales were adults, compared with previous years when calf strandings were more common. Several factors following ~~this~~ the 1999-2000 UME suggest that the high mortality rate observed was a short-term, acute event: 1) in 2001 and 2002, strandings decreased to levels below UME levels (Gulland *et al.*, 2005); 2) average calf production returned to levels seen before 1999; and 3) in 2001, living whales no longer appeared emaciated. Oceanographic factors that limited food availability for gray whales were identified as likely causes of the UME (LeBouef *et al.* 2000; Moore *et al.* 2001; Minobe 2002; Gulland *et al.* 2005), with resulting declines in survival rates of adults during this period (Punt and Wade 2012). Investigations on the causes of the 2019-2020 UME may yield similar conclusions. The ENP gray whale population has recovered to levels seen prior to the UME of 1999-2000 and the current estimate of abundance is the highest ~~that has been recorded~~ in the 1967-2015 time series (Fig. 2).

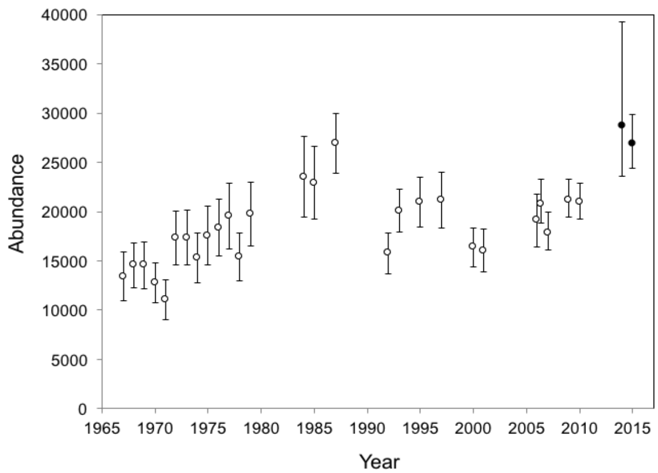

Figure 2. Estimated abundance of Eastern North Pacific gray whales from NMFS counts of migrating whales past Granite Canyon, California. Open circles represent abundance estimates and 95% confidence intervals reported by Laake *et al.* (2012) and Durban *et al.* (2015). Closed circles represent estimates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

Minimum Population Estimate

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

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

Current Population Trend

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

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

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

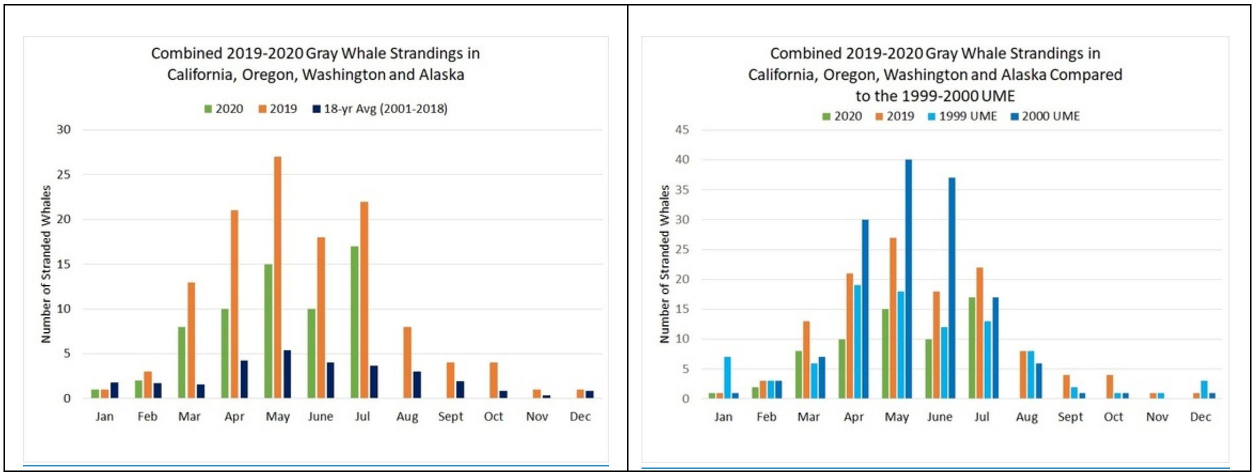

Figure 3. Combined 2019-2020 gray whale strandings in California, Oregon, Washington and Alaska, compared with 18-year average stranding numbers (left panel). Number of gray whale strandings compared between the 1999-2000 and 2019-2020 UME events (right panel). Figure source: NOAA 2020a. Data updated as of 8/4/2020.

POTENTIAL BIOLOGICAL REMOVAL

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

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

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

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

Fisheries Information

The California large-mesh drift gillnet fishery for swordfish and thresher shark includes ~~4~~ five observed entanglement records of gray whales from ~~8,845~~ 9,085 observed fishing sets ~~over the 27-year period~~ from1990-~~2016~~ 2018 (Carretta ~~*et al.* 2018a~~ 2020). The estimated bycatch of gray whales in this fishery for the most recent 5-year period is ~~2.1 (CV=0.76)~~ 2.6 (CV=0.37) whales, or ~~0.4~~ 0.52 whales annually (Carretta ~~*et al.* 2018a~~2020). By comparison, the more coastal set gillnet fishery for halibut and white seabass has no observations of gray whale entanglements from over 10,000 observed sets for the same time period. This compares with ~~11~~ 13 opportunistically documented unidentified gillnet fishery entanglements of gray whales in U.S. west coast waters during the most recent 5 year period of ~~2012-2016~~2014-2018, including one self-report from a set gillnet vessel operator (~~Carretta *et al.* 2018b~~ Carretta 2020, Carretta *et al.* 2020). ~~The origin of the gillnet gear for the remaining 10 entanglements is unknown.~~ Alaska gillnet fisheries also interact with gray whales, but these fisheries largely lack observer programs. Some gillnet entanglements involving gray whales along the coasts of Washington, Oregon, and California may involve gear set in Alaska and/or Mexican waters and carried south and/or north during the annual migration.

Table 1. Entanglement mortality and serious injury of gray whales, ~~2012-2016~~ 2014-2018 (Carretta ~~*et al.* 2018a, 2018b~~2020, Carretta *et al.* 2020). ~~Fractional bycatch estimates in swordfish drift gillnets during 2014-2016 result from a model that incorporates all years of observer data for bycatch prediction, thus bycatch estimates can be positive even when no bycatch is observed.~~ Entanglement in ~~other~~ most fisheries is derived from strandings and at-sea sightings of entangled whales and thus represent minimum impacts because they are documented opportunistically (Carretta *et al.* ~~2018b~~2020). Mortality and injury information, where possible, is assigned to either the ENP gray whale stock or PCFG whales. Total ~~ENP~~ mortality and injury of ENP gray whales ~~also~~ includes records attributable to PCFG gray whales, ~~as PCFG gray whales are included in the~~ because abundance estimates and calculated PBR for ENP gray whales ~~and thus, the calculated PBR for ENP gray whales also~~ includes PCFG ~~animals~~whales.

Fishery Name	Year(s)	Data Type	Percent Observer Coverage	Observed mortality (+ serious injury)	Estimated mortality (CV)	Mean annual takes ~~2012-2016~~2014-2018 (CV)
CA/OR thresher shark/swordfish drift gillnet	~~2012~~ ~~2013~~ ~~2014~~ ~~2015~~ ~~2016~~ ~~2012-2016~~ 2014-2018	observer	~~19%~~ ~~37%~~ ~~24%~~ ~~20%~~ ~~18%~~ ~~23%~~ 21%	~~0 (0)~~ ~~1 (0)~~ ~~0 (0)~~ ~~0 (0)~~ ~~0 (0)~~ ENP 1 (0)	~~0 (n/a)~~ ~~1 (n/a)~~ ~~0.1 (5.9)~~ ~~0.7 (2.1)~~ ~~0.5 (2.4)~~ ~~2.1 (0.76)~~ 2.6 (0.37)	~~0.4 (0.76)~~ 0.52 (0.37) (ENP stock)
CA halibut and white seabass set gillnet	~~2012-2016~~ 2014-2018	vessel self-report in 2015	n/a	ENP 0 (0.75)	n/a	ENP 0.15 (n/a)
CA Dungeness crab pot		strandings + sightings	n/a	ENP ~~2 (1.75)~~ 1 (0.75) ~~PCFG 1 (0)~~	n/a	ENP ~~0.75~~0.35 (n/a) ~~PCFG 0.2 (n/a)~~
OR Dungeness crab pot				~~ENP 0 (0.75)~~		~~ENP 0.15 (n/a)~~
WA Dungeness crab pot				ENP 3 (1.75) PCFG 0 (0.75)		ENP 0.95 (n/a) PCFG 0.15 (n/a)
~~**Cod pot fishery**~~				~~ENP 0 (0.75)~~		~~ENP 0.15 (n/a)~~
Unidentified pot/trap fishery				ENP ~~1 (8.75)~~ 1 (3.75) PCFG ~~0 (1.5)~~ 0 (1.5)		ENP ~~1.9 (n/a)~~ 0.95 (n/a) PCFG ~~0.3 (n/a)~~ 0.3 (n/a)
Unidentified gillnet fishery				ENP ~~3 (5.5)~~ 1 (9.5)		ENP ~~1.7~~ 2.1 (n/a)
Unidentified fishery interactions *involving gray whales*				ENP ~~2 (13)~~ 3 (15.25) PCFG ~~0 (1)~~ 1 (1)		ENP ~~3.0~~ 3.65 (n/a) PCFG ~~0.2~~ 0.4 (n/a)
Unidentified fishery interactions involving *unidentified whales* prorated to gray whale				ENP 0 (2.9) PCFG 0 (1.2)		ENP 0.6 (n/a) PCFG 0.2 (n/a)
~~**Marine debris entanglement**~~				~~ENP 1 (0.75)~~		~~ENP 0.35 (n/a)~~
~~**Tribal crab pot gear**~~	~~2012-2016~~	~~self-report~~	n/a	~~ENP 0 (0.75)~~ ~~PCFG 0 (0.75)~~		~~ENP 0.15 (n/a)~~ ~~PCFG 0.15 (n/a)~~
Totals				ENP ~~10 (32.75)~~ 10 (34.65) PCFG ~~1 (3.25)~~ 1 (4.45)		ENP ~~8.7~~ 9.3 (n/a) PCFG ~~0.85~~1.1 (n/a)

Entanglement in commercial pot and trap fisheries ~~along the U.S. west coast~~ is another source of gray whale mortality and serious injury (Carretta *et al.* 2018b, 2020). Most data on human-caused mortality and serious injury of gray whales are from strandings, including at-sea reports of entangled animals alive or dead (Carretta *et al.* 2018b, 2020). Strandings represent only a fraction of actual gray whale deaths (natural or human-caused), as reported by Punt and Wade (2012), who estimated that only 3.9% to 13.0% of gray whales that die in a given year end up stranding and being reported. This estimate of carcass detection, however, also included sparsely-populated coastlines of Baja California, Canada, and Alaska, for which the rate of carcass detection ~~would be~~ is expected to be low. Since most U.S. cases of human-caused serious injury and mortality are documented from Washington, Oregon, and California waters, the Punt and Wade (2012) estimate of carcass recovery is not applicable to ~~most documented cases~~U.S. West Coast waters. An appropriate correction factor for undetected anthropogenic mortality and serious injury of gray whales is unavailable.

A summary of human-caused mortality and serious injury from fishery ~~and marine debris~~ sources is given in Table 1 for the most recent 5-year period of ~~2012 to 2016~~ 2014 to 2018 (Carretta *et al.* 2018b, 2020). Total observed and estimated entanglement-related human-caused mortality and serious injury for ENP gray whales is ~~8.7~~ 9.3 whales annually, which includes PCFG entanglements (Table 1). The mean annual entanglement-related serious injury and mortality level for PCFG gray whales is ~~0.85~~ 1.1 whales ~~, based on one observed death in CA Dungeness crab pot gear and three serious injuries in other fishing gear~~ (Table 1). ~~In addition to the mortality and serious injury totals listed above, there were 5 non-serious entanglement injuries of gray whales (Carretta *et al.* 2018b). Three non-serious injuries involved ENP gray whales, each with one record associated with the following sources: CA Dungeness crab pot fishery, unknown Dungeness crab pot fishery, and unidentified fishery interaction. During the same period, there were two non-serious injuries involving PCFG whales, one in tribal crab pot gear and the other in an unidentified gillnet fishery.~~

Gray whale serious injuries in unidentified fishing gear during 2014-2018 totaled 20.25, or 4 whales annually (Table 1, Carretta *et al*. 2020). Additionally, there were 21 *unidentfied whale* entanglements during 2014-2018, of which, 4.1 were prorated as gray whales using the method reported by Carretta (2018). ~~Unidentified whales represent approximately 15% of entanglement cases along the U.S. West Coast, (Carretta 2018). Observed entanglements may lack species IDs due to rough seas, distance from whales, or a lack of cetacean identification expertise. In previous stock assessments, these unidentified entanglements were not assigned to species, which results in underestimation of entanglement risk , especially for commonly-entangled species. To remedy this negative bias, a cross-validated species identification model was developed from known-species entanglements ('model data'). The model is based on several variables (location + depth + season + gear type + sea surface temperature) collectively found to be statistically-significant predictors of known-species entanglement cases (Carretta 2018). The species model was used to assign species ID probabilities for 21 unidentified whale entanglement cases ('novel data') during 2012-2016. The sum of species assignment probabilities for this 5-year period result in an additional 5.8 gray whale entanglements for 2012-2016.~~ Of these ~~5.8~~ 4.1 entanglements, ~~only 0.8~~ 1.2 occurred within the geographic and seasonal limit range ~~and seasonal limits~~ considered to represent PCFG gray whales. ~~, while the remaining 5 are considered to be ENP gray whales~~. Unidentified whale entanglements typically involve whales seen at-sea with unknown gear configurations that are prorated to represent 0.75 serious injuries per entanglement case. Thus it is estimated that at least ~~5 x 0.75 = 3.75~~ 3.9 x 0.75 = 2.9 additional ENP gray whale and ~~0.8 x 0.75 = 0.6~~ 1.2 x 0.75 = 0.9 PCFG serious injuries ~~are represented~~ occurred from the 21 unidentified whale entanglement cases during ~~2012-2016~~2014-2018. This represents ~~0.75~~ 0.6 ENP gray whales and ~~0.1~~ 0.2 PCFG gray whales annually. The ~~0.1 PCFG~~ 5-year total of 2.9 prorated ENP gray whale serious injuries between 2014-2018 includes 1.2 prorated PCFG serious injuries ~~annually are added to ENP totals~~ as PCFG whales are included in abundance and PBR calculations for the larger ENP stock. ~~Thus, unidentified whale entanglements represent 0.85 ENP gray whales annually.~~ Total ENP gray whale serious injury and mortality from Table 1 totals ~~8.7~~ 9.3 whales annually, and 1.1 annually for PCFG gray whales. ~~, plus 0.85 annually from prorated unidentified whale entanglements, or 9.6 ENP whales annually~~.

Subsistence/Native Harvest Information

Subsistence hunters in Russia and the United States have traditionally harvested whales from the ENP stock in the Bering Sea, although only the Russian hunt has persisted in recent years (Huelsbeck 1988; Reeves 2002). ~~In 2005, the Makah Indian Tribe requested authorization from NOAA/NMFS, under the MMPA and the Whaling Convention Act, to resume limited hunting of gray whales for ceremonial and subsistence purposes in the coastal portion of their usual and accustomed (U&A) fishing grounds off Washington State (NMFS 2015). The spatial overlap of the Makah U&A and the summer distribution of PCFG whales has management implications. The hunt proposal by the Makah Tribe includes time/area restrictions designed to reduce the probability of killing a PCFG whale and to focus the hunt on whales migrating to/from feeding areas to the north. The Makah proposal also includes catch limits for PCFG whales that result in the hunt being terminated if these limits are met. Also, observations of gray whales moving between the WNP and ENP highlight the need to estimate the probability of a gray whale observed in the WNP being taken during a Makah hunt (Moore and Weller 2013). NMFS has prepared a draft environmental impact statement (DEIS) on the proposed hunt (NMFS 2015) and the IWC has evaluated the potential impacts of the proposed hunt and other human-caused mortality sources on PCFG whales. The IWC concluded, with certain qualifications, that the proposed hunt meets the Commission's conservation objectives (IWC 2013). The Scientific Committee has continued to investigate stock structure of north Pacific gray whales and has convened five workshops on the subject between 2014 and 2018. The objective of the workshops has been to develop a series of range-wide stock structure hypotheses, using all available data sources (*e.g.* photo-ID, genetics, tagging), that can be tested within a modelling framework (IWC 2017).~~ NMFS has proposed to grant a waiver of the Marine Mammal Protection Act's moratorium on the take of marine mammals to allow the Makah Indian Tribe to take a limited number of Eastern North Pacific gray whales (NOAA 2019, 2020a, 2020b). The proposed rule includes a potential maximum removal of an average of 2.5 whales annually over a 10-year period (NOAA 2019). Proposed regulations include considerations of the estimated probabilities of a Makah hunt taking a WNP gray whale (Moore and Weller 2018) and safeguards to minimize the probability of taking either WNP or PCFG whales. Moore and Weller (2018) estimated the probability of striking ≥1 WNP gray whale in a single year (based on 3 strikes annually) at 0.012 (95% CRI 0.006 – 0.019), and for a 10-year hunt, the probability is 0.058 (95% CRI 0.030 – 0.93). These probabilities may change as additional information on WNP population size and numbers of WNP whales using U.S. waters becomes available. A formal hearing occurred in November 2019 and NMFS is awaiting a recommended decision from the Administrative Law Judge overseeing that hearing (NOAA 2020b). The IWC Scientific Committee reviewed the proposed U.S. management plan for the Makah hunt of gray whales and stated that "the performance of the Management Plan was adequate to meet the Commission's conservation objectives for the Pacific Coast Feeding Group, Western Feeding Group and Northern Feeding Group gray whales" (IWC 2018).

In 2018, the IWC approved a 7-year quota (2019-2025) of 980 gray whales landed, with an annual cap of 140, for Russian and U.S. (Makah Indian Tribe) aboriginals based on the joint request and needs statements submitted by the U.S. and the Russian Federation. The U.S. and the Russian Federation have agreed that the quota will be shared with an average annual harvest of 135 whales by the Russian Chukotka people and 5 whales by the Makah Indian Tribe. Total takes by the Russian hunt during the past five years were: ~~143 in 2012, 127 in 2013,~~ 124 in 2014, 125 in 2015, ~~and~~ 120 in 2016, 119 in 2017 and 107 in 2018 (International Whaling Commission). There were no whales taken by the Makah Indian Tribe during that period because their hunt request is still under review. Based on this information, the annual subsistence take averaged ~~128~~ 119 whales during the 5-year period from ~~2012 to 2016~~ 2014 to 2018. The IWC reports a total of ~~3,787~~ 4,013 gray whales harvested from annual aboriginal subsistence hunts for the ~~32~~ 34-year period 1985 to ~~2016~~2018, which includes struck and lost whales. The estimated population size of ENP gray whales has increased during this same period (Fig. 2).

Other Mortality

Ship strikes are a source of mortality and serious injury for gray whales. During the most recent five-year period, ~~2012-2016~~ 2014-2018, serious injury and mortality of ENP gray whales attributed to ship strikes totaled ~~4~~ 9 animals (~~including 4~~ 7 deaths and 2 ~~non-~~ serious injuries) or ~~0.8~~1.8 whales annually (Carretta *et al.* ~~2018b~~2020). Total ship strike serious injury and mortality of gray whales observed in the PCFG range and season was ~~2~~ 3 animals, or ~~0.4~~ 0.6 whales per year (Carretta *et al.* ~~2018b~~2020). Ship strikes attributed to PCFG whales are also included in ENP totals. Additional mortality from ship strikes probably goes unreported because the whales either do not strand, are undetected, or lack obvious signs of trauma.

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

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

HABITAT CONCERNS

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

~~Evidence indicates that the~~ The Arctic climate is changing significantly, resulting in ~~a~~ reductions in sea ice cover that are likely to affect gray whale populations (Johannessen *et al.* 2004, Comiso *et al.* 2008, Perryman *et al.* 2002, Gailey *et al.* 2020). For example, the summer range of gray whales has greatly expanded ~~in the past decade~~ (Rugh *et al.* 2001). Bluhm and Gradinger (2008) examined the availability of pelagic and benthic prey in the Arctic and concluded that pelagic prey is likely to increase while benthic prey is likely to decrease in response to climate change. They noted that marine mammal species that exhibit trophic plasticity (such as gray whales, which feed on both benthic and pelagic prey) will adapt better than trophic specialists. Annual sea ice conditions in arctic foraging grounds have been linked to variability in gray whale calf survival and production in both Western (Gailey *et al.* 2020), and Eastern (Perryman *et al.* 2002) North Pacific populations. Following years of high sea-ice coverage on foraging grounds, calf survival and production decline. Decreased spatial and temporal access to foraging grounds as a result of heavy ice cover is hypothesized as the responsible factor.

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

STATUS OF STOCK

In 1994, the ENP stock of gray whales was removed from the List of Endangered and Threatened Wildlife (the List), as it was no longer considered endangered or threatened under the Endangered Species Act (NMFS 1994). Punt and Wade (2012) estimated the 2009 ENP population was at 85% of carrying capacity (K) and at 129% of the maximum net productivity level (MNPL), with a probability of 0.884 that the population ~~is~~ was above MNPL and therefore within the range of its optimum sustainable population (OSP).

The unusual mortality event (UME) of 2019-2020 resulted in elevated levels of stranded gray whales in poor body condition. NOAA continues to monitor this population through calf production surveys during the northbound migration and abundance surveys during the southbound migration (see Population Size). Even though the stock is within OSP, abundance will fluctuate as the population adjusts to natural and human-caused factors affecting carrying capacity (Punt and Wade 2012). It is expected that a population close to or at carrying capacity will be more susceptible to environmental fluctuations (Moore *et al.* 2001). The correlation between gray whale calf production and environmental conditions in the Bering Sea may reflect this (Perryman *et al.* 2002; Perryman and Weller 2012). Overall, the population nearly doubled in size over the first 20 years of monitoring, and has fluctuated for the last 30 years, with a recent increase to over 26,000 whales. Carrying capacity for this stock was estimated at 25,808 whales in 2009 (Punt and Wade 2012), however the authors noted that carrying capacity was likely to vary with environmental conditions.

Based on ~~2012-2016~~ 2014-2018 data, the estimated annual level of human-caused mortality and serious injury for ENP gray whales includes Russian harvest (~~128~~ 119), mortality and serious injury from commercial fisheries (~~9.6~~ 9.3), marine debris (~~0.35~~ 0.4), ship strikes (~~0.8~~ 1.8), and illegal hunts (0.2) totals ~~139~~ 131 whales per year, which does not exceed the PBR (801). Therefore, the ENP stock of gray whales is not classified as a strategic stock.

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

PCFG gray whales do not currently have a formal status under the MMPA. Abundance estimates of PCFG whales increased from 1998 through 2004, remained stable during 2005-2010, and have steadily increased from 2011-2015 (Calambokidis *et al.* 2017). Total annual human-caused mortality of PCFG gray whales from 2014 to 2018 ~~during the period 2012 to 2016~~ includes mortality and serious injuries due to commercial fisheries (1.1/yr ~~0.7/yr~~), ~~tribal fisheries (0.15/yr)~~, and ship strikes (~~0.4~~ 0.6/yr), ~~plus unidentified whale entanglements assigned as PCFG gray whales (0.1)~~, ~~or 1.35~~ 1.7 whales annually. This does not exceed the calculated PBR level of 3.5 whales for this population. However, ~~Levels~~ observed levels of human-caused mortality and serious injury ~~resulting~~ from commercial fisheries and ship strikes for both ENP and PCFG whales represent minimum estimates ~~as recorded by stranding networks or at-sea sightings~~ because not all cases are detected or documented.

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

STOCK DEFINITION AND GEOGRAPHIC RANGE

Gray whales occur along the eastern and western margins of the North Pacific. In the western North Pacific (WNP), gray whales feed during summer and fall in the Okhotsk Sea off northeast Sakhalin Island, Russia, and off southeastern Kamchatka in the Bering Sea (Weller *et al.* 1999, 2002; Vertyankin *et al.* 2004; Tyurneva *et al.* 2010; Burdin *et al.* 2017; Figure 1). Historical evidence indicates that the coastal waters of eastern Russia, the Korean Peninsula and Japan were once part of the migratory route in the WNP and that areas in the South China Sea may have been used as wintering grounds (Weller *et al.* 2002; Weller *et al.* 2013a). Present day records of gray whales off Japan (Nambu *et al.* 2010; Nakamura *et al.* 2017a; Nakamura *et al.* 2017b) and China are infrequent (Wang 1984; Zhu 2002; Wang *et al.* 2015) and the last known record from Korea was in 1977 (Park 1995; Kim *et al.* 2013). While recent observations of gray whales off the coast of Asia remain sporadic, observations off Japan, mostly from the Pacific coast, appear to be increasing in the past two decades (Nakamura *et al.* 2017b).

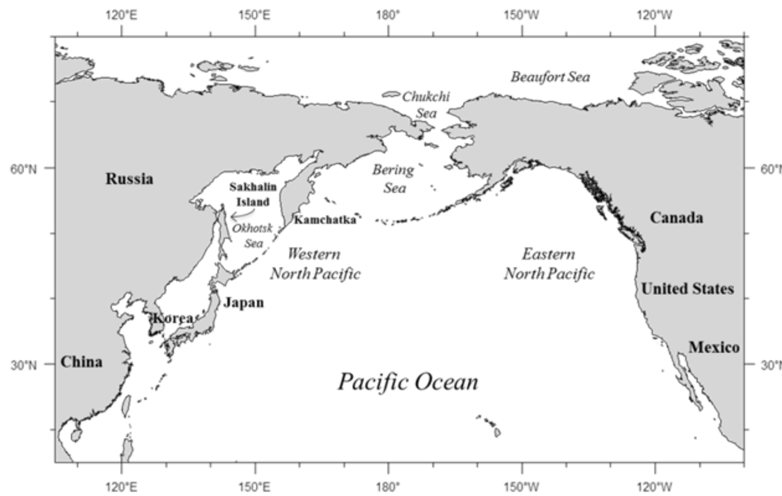

Figure 1. Range map of the Western North Pacific Stock of gray whales, including summering areas off Russia and wintering areas in the western and eastern Pacific.

Information from tagging, photo-identification and genetic studies show that some whales identified in the WNP off Russia have been observed in the eastern North Pacific (ENP), including coastal waters of Canada, the U.S. and Mexico (Lang 2010; Weller *et al.* 2012; Urbán *et al.* 2013, Mate *et al.* 2015, Urbán *et al.* 2019). Photographs of 379 individuals identified on summer feeding grounds off Russia (316 off Sakhalin; 150 off Kamchatka), were compared to 10,685 individuals identified in Mexico breeding lagoons. A total of 43 matches were found, including the following area matches: 14 Sakhalin-Kamchatka-Mexico, 25 Sakhalin-Mexico, and 4 Kamchatka-Mexico (Urban *et al.* 2019). The number of whales documented moving between the WNP and ENP represents 14% of gray whales identified off Sakhalin Island and Kamchatka according to Urban *et al.* (2019). ~~In combination, these studies have recorded about 30 gray whales observed in both the WNP and ENP.~~ Some whales that feed off Sakhalin Island in summer migrate east across the Pacific to the west coast of North America in winter, while others migrate south to waters off Japan and China (Weller *et al.* 2016). Cooke *et al.* (2019) note that the fraction of the WNP population that migrates to the ENP is estimated at 45-80% and note "therefore it is likely that a western breeding population that migrates through Asian waters still exists." These authors further state that at least 20% of WNP gray whales probably migrate elsewhere, likely to wintering areas in Asian waters. ~~Cooke (2015) estimated that 37-100% of the whales feeding off Sakhalin Island could potentially migrate to the coast of North America or, in other words, at most 63% could migrate solely within the WNP.~~ Despite these estimates of cross-basin movements, analysis of photo-identification data, including data on mother-calf pairs and paternity assessments, suggest that gray whales summering in the WNP may constitute a demographically self-contained subpopulation where mating occurs at least preferentially and possibly exclusively within the subpopulation (Broker *et al.* 2020, Cooke *et al.* 2017, IUCN 2018). Despite the observed movements of some gray whales between the WNP and ENP, significant differences in their mitochondrial and nuclear DNA exist (LeDuc *et al.* 2002; Lang *et al.* 2011). Taken together, these observations indicate that not all gray whales in the WNP share a common wintering ground. Brüniche-Olsen *et al.* (2018a) reassessed the genetic differentiation of gray whales feeding off Sakhalin and ENP whales from the Mexican breeding lagoons using nuclear Single Nucleotide Polymorphisms (SNPs). The degree of differentiation between these two regions was small but significant despite the existence of some admixed individuals. In conclusion, these authors suggested that gray whale population structure is not currently determined by simple geography and may be in flux as a result of emerging migratory dynamics. Contemporary gray whale genomes, both eastern and western, contain less nucleotide diversity than most other marine mammals and evidence of inbreeding is greater in the Western Pacific than in the Eastern Pacific populations (Brüniche-Olsen et al. 2018b).

In 2012, the National Marine Fisheries Service convened a scientific task force to appraise the currently recognized and emerging stock structure of gray whales in the North Pacific (Weller *et al.* 2013b). The charge of the task force was to evaluate gray whale stock structure as defined under the Marine Mammal Protection Act (MMPA) and implemented through the National Marine Fisheries Service's Guidelines for Assessing Marine Mammal Stocks (GAMMS; NMFS 2005). Significant differences in both mitochondrial and nuclear DNA between whales sampled off Sakhalin Island (WNP) and whales sampled in the ENP provided convincing evidence that resulted in the task force advising that WNP gray whales should be recognized as a population stock under the MMPA and GAMMS guidelines. Given the interchange of some whales between the WNP and ENP, including seasonal occurrence of WNP whales in U.S. waters, the task force agreed that a stand-alone WNP gray whale population stock assessment report was warranted.

The IWC Scientific Committee ~~has conducted a series of~~ completed annual (2014-2018) range-wide workshops on the status of North Pacific gray whales. The primary objectives of these meetings ~~was not to determine a single 'best' stock structure hypothesis (unless definitively supported by existing data) but rather~~ were to identify plausible stock structure hypotheses ~~consistent with the suite of data available. The goal is to~~ and create a foundation for developing range-wide conservation advice. ~~The primary hypotheses deemed as most plausible considered two separate 'breeding stocks' or biological populations (western and eastern). These hypotheses include: (a) Hypothesis 3a which assumes that while two breeding stocks (western and eastern) may once have existed, the western breeding stock is extirpated. Whales show matrilineal fidelity to feeding grounds, and the eastern breeding stock includes three feeding aggregations: Pacific Coast Feeding Group, Northern Feeding Group, and a Western Feeding Group; and (b) Hypothesis 5a which assumes that both breeding stocks are extant and that the western breeding stock feeds off both coasts of Japan and Korea and in the northern Okhotsk Sea west of the Kamchatka Peninsula. Whales feeding off Sakhalin include both whales that are part of the extant western breeding stock and remain in the western North Pacific year-round, and whales that are part of the Eastern breeding stock and migrate between Sakhalin and the eastern North Pacific.~~ The Scientific Committee reported on the plausibility of various stock structure hypotheses in 2020 (IWC 2020). There are up to three feeding groups or aggregations: the Pacific Coast Feeding Group (PCFG), the Western Feeding Group (WFG), and the North Feeding Group (NFG). The PCFG is defined in the stock assessment report for Eastern North Pacific gray whale. The WFG consists of whales that feed off Sakhalin Island as documented via photo-ID. The NFG includes whales found feeding in the Bering and Chukchi Seas where photo-ID and genetic data are sparse. The IWC also considers up to three extant breeding stocks: the Western Breeding Stock (WBS), the Eastern Breeding Stock (EBS), and a third unnamed stock that includes WFG whales interbreeding largely with each other while migrating to the Mexican wintering grounds. The IWC summarizes three 'high plausibility' hypotheses as follows: **Hypothesis 3a** is characterized by maternal feeding ground fidelity, one migratory route/wintering region used by Sakhalin whales, and random mating. Under this hypothesis, a single breeding stock (EBS) exists that includes three feeding groups: NFG, PCFG, and WFG. Areas off Southern Kamchatka and the Northern Kuril Islands are used by some whales that belong to the WFG and some whales that belong to the NFG. Although two breeding stocks (WBS and EBS) may once have existed, the WBS is assumed to have been extirpated. **Hypothesis 4a** is characterized by maternal feeding ground fidelity, one migratory route/wintering region used by Sakhalin whales, and non-random mating. Under this hypothesis, two breeding stocks exist (EBS and WBS) and overwinter in Mexico. One breeding stock includes NFG and PCFG whales, and the second breeding stock includes WFG whales that mate largely with each other while migrating to Mexico. Areas off Southern Kamchatka and the Northern Kuril Islands are used by some whales that belong to the breeding stock comprised of WFG whales and some whales that belong to the NFG. Although a third breeding stock (the WBS) may once have existed, under this hypothesis the WBS is assumed to have been extirpated. **Hypothesis 5a** is characterized by maternal feeding ground fidelity, two migratory routes/wintering grounds used by Sakhalin whales, and random mating. Under this hypothesis, two breeding stocks exist: EBS and WBS. The EBS includes three feeding groups: PCFG, NFG, and the WFG that feeds off Northeastern Sakhalin Island. The WBS whales feed in the Okhotsk Sea and off Northeastern Sakhalin Island, Southern Kamchatka, and the Northern Kuril Islands and then migrate to the South China Sea to overwinter. Under this hypothesis, areas off Southern Kamchatka and the Northern Kuril Islands are used by the WFG, the NFG, and the feeding whales that are part of the WBS.

POPULATION SIZE

Estimated population size from photo-ID data for Sakhalin and Kamchatka in 2016 was estimated at 290 whales (90% percentile intervals = 271 – 311) (Cooke 2017, Cooke *et al.* 2018). Of these, 175-192 whales are estimated to be predominantly part of a Sakhalin feeding aggregation. These estimates represent animals in the 1-year plus age category. Cooke (2017) notes that not all of these animals belong to the Western North Pacific stock of gray whales and proposes an upper limit of approximately 100 whales from Sakhalin that could belong to the Western North Pacific breeding population.

Minimum Population Estimate

The minimum population size estimate is taken as the lower 5^{th} percentile of the estimate from Cooke (2017), or 271 animals. This is a more conservative estimate of minimum population size than using the lower 20^{th} percentile of a population estimate, however, Cooke (2017) did not provide such an estimate in his analysis.

Current Population Trend

The combined Sakhalin Island and Kamchatka populations were estimated to be increasing from 2005 through 2016 at an average rate between 2-5% annually (Cooke 2017).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

An analysis of the ENP gray whale population provided an estimate of R_{max} of 0.062, with a 90% probability the value was between 0.032 and 0.088 (Punt and Wade 2012). This value of R_{max} is also applied to WNP gray whales, as it is currently the best estimate of R_{max} available for any gray whale population.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size(271) times one-half the estimated maximum annual growth rate for a gray whale population (½ of 6.2% for the Eastern North Pacific Stock, Punt and Wade 2012), times a recovery factor of 0.1 (for an endangered stock with $N_{min} < 1,500$, Taylor *et al.* 2003), and also multiplied by estimates for the proportion of the stock that uses U.S. EEZ waters (0.575), and the proportion of the year that those animals are in the U.S. EEZ (3 months, or 0.25 years) (Moore and Weller 2013), resulting in a PBR of 0.12 WNP gray whales per year, or approximately 1 whale every 8 years (if abundance and other parameters in the PBR equation remained constant over that time period).

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

The decline of gray whales in the WNP is attributable to commercial hunting off Korea and Japan between the 1890s and 1960s. ~~The p~~ Pre-exploitation abundance of WNP gray whales is unknown, but has been estimated to be between 1,500 and 10,000 individuals (Yablokov and Bogoslovskaya 1984). By 1910, after some commercial exploitation had already occurred, it is estimated that only 1,000 to 1,500 gray whales remained in the WNP population (Berzin and Vladimirov 1981). The basis for how these two estimates were derived, however, is not apparent (Weller *et al.* 2002). By the 1930s, gray whales in the WNP were considered by many to be extinct (Mizue 1951; Bowen 1974).

A significant threat to gray whales in the WNP are incidental catches in coastal net fisheries (Weller *et al.* 2002; Nakamura *et al.* 2017b; Weller *et al.* 2008; Weller *et al.* 2013a; Lowry *et al.* 2018). Between 2005 and 2007, four female gray whales (including one mother-calf pair and one yearling) died in fishing nets on the Pacific coast of Japan. In addition, one adult female gray whale died as a result of a fisheries interaction in November 2011 off Pingtan County, China (Wang *et al.* 2015). An analysis of anthropogenic scarring of gray whales photographed off Sakhalin Island found that at least 18.7% (n=28) of 150 individuals identified between 1994 and 2005 had evidence of previous entanglements in fishing gear but where the scars were acquired is unknown (Bradford *et al.* 2009). Trap nets for Pacific salmon have been deployed in the feeding area off northeastern Sakhalin Island since 2013, resulting in two known entanglements and one probable entanglement mortality (Lowry *et al.* 2018).

Given that some WNP gray whales occur in U.S. waters, there is some probability of WNP gray whales being killed or injured by ship strikes or entangled in fishing gear within U.S. waters.

Subsistence/Native Harvest Information

~~In 2005, the Makah Indian Tribe requested authorization from NOAA/NMFS, under the Marine Mammal Protection Act of 1972 (MMPA) and the Whaling Convention Act, to resume limited hunting of gray whales for~~

~~ceremonial and subsistence purposes in the coastal portion of their usual and accustomed (U&A) fishing grounds off Washington State (NOAA 2015). Observations of gray whales moving between the WNP and ENP highlight the need to estimate the probability of a gray whale observed in the WNP being taken during a hunt by the Makah Tribe (Moore and Weller 2013). Given conservation concerns for the WNP population, the Scientific Committee of the International Whaling Commission (IWC) emphasized the need to estimate the probability of a WNP gray whale being struck during aboriginal gray whale hunts (IWC 2012). Additionally, NOAA is required by the National Environmental Policy Act (NEPA) to prepare an Environmental Impact Statement (EIS) pertaining to the Makah's request. The EIS needs to address the likelihood of a WNP whale being taken during the proposed Makah gray whale hunt.~~ NMFS has proposed to grant a waiver of the Marine Mammal Protection Act's moratorium on the take of marine mammals to allow the Makah Indian Tribe to take a limited number of Eastern North Pacific gray whales (NOAA 2019, 2020a, 2020b). The **proposed rule** includes a potential maximum removal of an average of 2.5 whales annually over a 10-year period (NOAA 2019). Proposed regulations include considerations of the estimated probabilities of a Makah hunt taking a WNP gray whale (Moore and Weller 2018) and safeguards to minimize the probability of taking either WNP or PCFG whales. Moore and Weller (2018) estimated the probability of striking ≥1 WNP gray whale in a single year (based on 3 strikes annually) at 0.012 (95% CRI 0.006 – 0.019), and for a 10-year hunt, the probability is 0.058 (95% CRI 0.030 – 0.93). These probabilities may change as additional information on WNP population size and numbers of WNP whales using U.S. waters becomes available. A formal hearing occurred in November 2019 and NMFS is awaiting a recommended decision from the Administrative Law Judge overseeing that hearing (NOAA 2020b). The IWC Scientific Committee reviewed a proposed U.S. management plan for the Makah hunt of gray whales and stated that "the performance of the Management Plan was adequate to meet the Commission's conservation objectives for the Pacific Coast Feeding Group, Western Feeding Group and Northern Feeding Group gray whales" (IWC 2018).

~~To estimate the probability that a WNP whale might be taken during the proposed Makah gray whale hunt, four alternative models were evaluated. These models made different assumptions about the proportion of WNP whales that would be available for the hunt or utilized different types of data to inform the probability of a WNP whale being taken (Moore and Weller 2013). Based on the preferred model, the probability of striking at least one WNP whale in a single year was estimated to range from 0.006 – 0.012 across different scenarios for the annual number of total gray whales that might be struck. This corresponds to an expectation of ≥ 1 WNP whale strike in one of every 83 to 167 years. This analysis was based on a 2012 abundance estimate of 155 (95% CI 142-165) which is smaller than the 2016 abundance estimate of 290 (90% CI 271-311) whales reported by Cooke (2017).~~

HABITAT ISSUES

Near shore industrialization and shipping congestion throughout the migratory corridors of the WNP gray whale stock represent risks by increasing the likelihood of exposure to pollutants and ship strikes as well as a general degradation of the habitat. In addition, the summer feeding area off Sakhalin Island is a region rich with offshore oil and gas reserves. Two major offshore oil and gas projects now directly overlap or are in near proximity to this important feeding area, and more development is planned in other parts of the Okhotsk Sea that include the migratory routes of these whales. Operations of this nature have introduced new sources of underwater noise, including seismic surveys, increased shipping traffic, habitat modification, and risks associated with oil spills (Weller *et al.* 2002). During the past decade, a Western Gray Whale Advisory Panel, convened by the International Union for Conservation of Nature (IUCN), has been providing scientific advice on the matter of anthropogenic threats to gray whales in the WNP. Ocean acidification could reduce the abundance of shell-forming organisms (Fabry *et al.* 2008, Hall-Spencer *et al.* 2008), many of which are important in the gray whales' diet (Nerini 1984). An unusual mortality event (UME) that began in 2019 and is ongoing (NOAA 2020a) resulted in elevated levels of stranded gray whales in poor body condition, however, it is unknown if oceanographic conditions related to this UME affected WNP and ENP gray whales similarly. Annual sea ice conditions in arctic foraging grounds have been linked to variability in gray whale calf survival and production in both Western (Gailey *et al.* 2020), and Eastern (Perryman *et al.* 2002) North Pacific populations. Following years of high sea-ice coverage on foraging grounds, calf survival and production decline. Decreased spatial and temporal access to foraging grounds as a result of heavy ice cover is hypothesized as the responsible factor.

STATUS OF STOCK

The WNP stock is listed as "Endangered" under the U.S. Endangered Species Act of 1973 (ESA) and is therefore also considered "strategic" and "depleted" under the MMPA. At the time the ENP stock was delisted, the WNP stock was thought to be geographically isolated from the ENP stock. NOAA (2018) initiated a 5-yr Status Review of WNP gray whales to ensure that the listing classification is accurate. This review is ongoing. Documentation of some whales moving between the WNP and ENP indicates otherwise (Lang 2010; Mate *et al.* 2011;

Weller *et al.* 2012; Urbán *et al.* 2013, 2019). Other research findings, however, provide continued support for identifying two separate stocks of North Pacific gray whales, including: (1) significant mitochondrial and nuclear genetic differences between whales that feed in the WNP and those that feed in the ENP (LeDuc *et al.* 2002; Lang *et al.* 2011), (2) recruitment into the WNP stock is almost exclusively internal (Cooke *et al.* 2013), (3) a single nucleotide polymorphism (SNP) study that indicates the gray whale gene pool is differentiated into two populations (Brüniche-Olsen *et al.* 2018a) and (4) the abundance of the WNP stock remains low while the abundance of the ENP stock grew steadily following the end of commercial whaling (Cooke *et al.*2017). As long as the WNP stock remains listed as endangered under the ESA, it ~~will~~ continues to be considered as depleted under the MMPA.

The IWC Scientific Committee ~~has conducted a series of annual (2014-2018) range-wide workshops on the status of North Pacific gray whales. The objective of the workshops has been to develop a series of range-wide~~ stock structure hypotheses are summarized in the Stock Definition and Geographic Range section of this report.~~, using all available data sources (*e.g.* photo-id, genetics, tagging), that can be tested within a modelling framework (IWC 2017).~~ Cooke *et al.* (2017) conducted an ~~updated~~ assessment of gray whales in the WNP using an individually-based stage-structured population model with modified stock definitions that allows for the possibility of multiple feeding/breeding groups. Cooke *et al.* (2017) noted that "there is preferential, but not exclusive, mating within the Sakhalin feeding aggregation. The hypothesis of mating exclusively within the Sakhalin feeding population is just rejected ($p < 0.05$). We conclude that the Sakhalin feeding aggregation is probably not genetically closed but that the Sakhalin and Kamchatka feeding aggregations, taken together, may be genetically closed. However, genetic data from Kamchatka would be required to confirm this." In this scenario, whales identified feeding off Sakhalin represent about 2/3 of the combined Sakhalin Island-Kamchatka subpopulation. Further substructure within the subpopulation was not excluded by Cooke *et al.* (2017), including the possibility of less than 50 mature whales that breed only in the WNP. Other IWC hypotheses include the possibility that the Western Breeding stock has been extirpated (IWC 2020). ~~The IWC analysis is ongoing and the results of Cooke *et al.* (2017) are considered provisional pending further exploration of additional gray whale stock structure hypotheses.~~

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FIN WHALE (*Balaenoptera physalus* ~~*physalus*~~ *velifera*): California/Oregon/Washington Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Fin whales are found from temperate to subpolar oceans worldwide, with a distributional hiatus between the Northern and Southern Hemispheres within 20° to 30° of the equator (Edwards *et al.* 2015). ~~Northern Hemisphere fin whales (*B. physalus physalus*) likely comprise distinct Pacific and Atlantic subspecies (Archer *et al.* 2013~~). Fin whales occur throughout the North Pacific, from the ~~southern~~ northeastern Chukchi Sea (Crance *et al.* 2015) to the Tropic of Cancer (Mizroch *et al.* 2009), but their wintering areas are poorly known. Archer *et al.* (2019a) used mitochondrial DNA and single-nucleotide polymorphisms (SNPs) to demonstrate that North Atlantic and North Pacific genetic samples could be correctly assigned to their respective ocean basins with 99% accuracy. North Pacific whales are recognized as a separate subspecies: *Balaenoptera physalus velifera*. Mizroch *et al.* (2009) described eastern and western North Pacific populations, based on sightings data, catch statistics, recaptures of marked whales, blood chemistry ~~data~~, and acoustics. The two populations are thought to have separate wintering and mating grounds off ~~of~~ Asia and North America and during summer, whales from each population may co-occur near the Aleutian Islands and Bering Sea (Mizroch *et al.* 2009). Non-migratory populations exist in the Gulf of California, based evidence from photo-ID, genetics, satellite telemetry, and acoustics (Thompson *et al.* 1992; Tershy *et al.* 1993; Bérubé *et al.* 2002; Jiménez López *et al.* 2019; Nigenda-Morales 2008; Širović *et al.* 2017) and the East China Sea (Fujino 1960). ~~Evidence of additional subpopulations near Sanriku-Hokkaido and the Sea of Japan exists, based on seasonal catch data and recaptures of marked animals (Mizroch *et al.* 2009).~~ Fin whales are scarce in the eastern tropical Pacific in summer (Wade and Gerrodette 1993) and winter (Lee 1993). Fin whales occur year-round in the Gulf of Alaska (Stafford *et al.* 2007); the Gulf of California (Tershy *et al.* 1993; Bérubé *et al.* 2002); California (Dohl *et al.* 1983; Širović *et al.* 2017); and Oregon and Washington (Moore *et al.* 1998). Fin whales satellite-tagged in the Southern California Bight (SCB) use the region year-round, although they seasonally range to central California and Baja California before returning to the SCB (Falcone and Schorr 2013). The longest satellite track reported by Falcone and Schorr (2013) was a fin whale tagged in the SCB in January 2014. ~~, with t~~ The whale moving south to central Baja California by February and north to the Monterey area by late June. Archer *et al.* (2013) present evidence for geographic separation of fin whale mtDNA clades near Point Conception, California. A significantly higher proportion of 'clade A' is composed of samples from the SCB and Baja California, while 'clade C' is largely represented by samples from central California, Oregon, Washington, and the Gulf of Alaska.

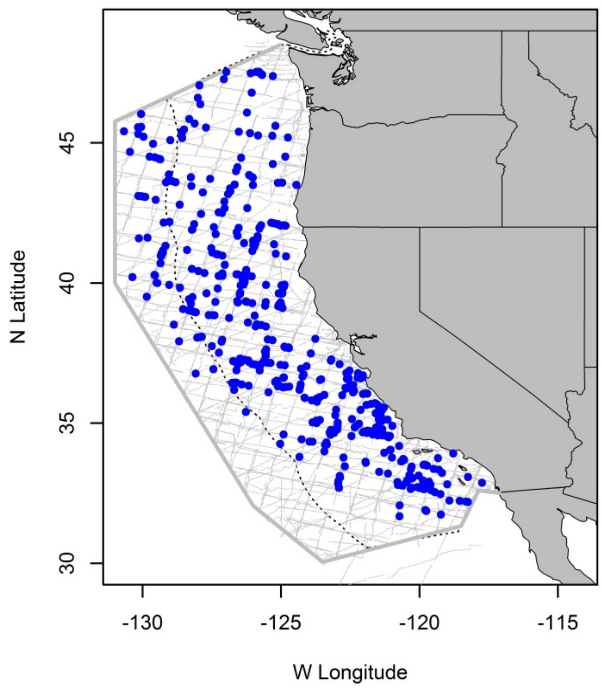

Figure 1. Fin whale sighting locations based on shipboard surveys off California, Oregon, and Washington, 1991-2014. Dashed line represents the U.S. EEZ; thin lines indicate completed transect effort of all surveys combined.

While knowledge of North Pacific fin whale population structure from genetic and movement patterns is limited, passive acoustic data provides another line of evidence to assess population structure. For example, acoustic data (Širović *et al*., 2017; Thompson *et al*., 1992) support prior photo-ID (Tershy *et al.* 1993) and genetic conclusions (Bérubé *et al.* 2002; Nigenda-Morales *et al.* 2008; Rivera-León *et al.* 2019) that a resident fin whale population occurs in the Gulf of California, Mexico. Additionally, acoustic data indicate there may be a resident population in southern California waters, though this may be confounded by seasonal movements in the region (Širović *et al*., 2015, 2017). Oleson *et al*. (2014) report that fin whale songs recorded near Hawaii are similar to those from southern California and the Bering Sea, suggesting movement of animals throughout that range. Song structure throughout the North Pacific is characterized by seasonal and interannual variability (Delarue *et al*., 2013; Oleson *et al*., 2014; Širovic *et al*., 2017; Weirathmueller *et al*., 2017). Similarities of songs within and across years for multiple North Pacific pelagic areas (Hawaii, Bering Sea, Southern California) suggests that a single population may range throughout this oceanic basin; however there is also evidence for multiple song types in the Bering Sea (Delarue *et al*., 2013) and the northeast Pacific, including a possible resident population in inland waters of British Columbia (Koot, 2015). Archer *et al*. (2019b) developed an automated classification method for fin whale note types that revealed analysts have manually misclassified certain fin whale note types near Hawaii, which has implications for stock identification interpretation. These authors found that Hawaii had some of the most distinctive calls, with sequences characterized by "B" type calls with relatively long internote intervals. Archer *et al*. (2019b) also notes the similarity of B sequences from the Gulf of California in spring that match those described by Širović *et al*. (2017) as a "long singlet" pattern found in the southern Gulf of California and southern California Bight. In the Archer *et al*. (2019b) study, the B singlet pattern was most similar to Monterey Bay and northwest Pacific autumn sequences, perhaps reflecting a widespread pattern across populations in the North Pacific, or hinting at some population connectivity between the central and southern U.S. West Coast and southern Gulf of California and the northwest Pacific (Archer *et al*. 2019b). Acoustic evidence also hints at possibly two populations that use the Chuckchi Sea and central Aleutian Islands area that mix seasonally in the southern Bering Sea (Archer *et al*. 2019b). Observed movements of fin whales from the southern and central Bering Sea to the Aleutian Islands and Kamchatka documented from Discovery tag recoveries are consistent with these acoustic findings (Mizroch *et al*. 2009). Further research is necessary to use multiple lines of evidence, such as acoustics, genetics, and satellite telemetry in order to identify population stocks in the North Pacific (Martien *et al.* 2020).

Insufficient data exists to determine population structure, but from a conservation perspective it may be risky to assume panmixia in the North Pacific. This report covers the stock of fin whales found along the coasts of California, Oregon, and Washington within 300 nmi of shore (Fig. 1). Because fin whale abundance appears lower in winter/spring in California (Dohl *et al.* 1983; Forney *et al.* 1995) and in Oregon (Green *et al.* 1992), it is likely that the distribution of this stock extends seasonally outside these coastal waters. The Marine Mammal Protection Act (MMPA) stock assessment reports recognize three stocks of fin whales in the North Pacific: (1) the California/Oregon/Washington stock (this report), (2) the Hawaii stock, and (3) the Northeast Pacific stock.

POPULATION SIZE

The pre-whaling population of fin whales in the North Pacific was estimated to be 42,000-45,000 (Ohsumi and Wada 1974). In 1973, the North Pacific population was estimated to have been reduced to 13,620-18,680 (Ohsumi and Wada 1974), of which 8,520-10,970 were estimated to belong to the eastern Pacific stock. The best estimate of fin whale abundance in California, Oregon, and Washington waters out to 300 nmi is 9,029 (CV=0.12) whales, based on a trend analysis of 1991-2014 line-transect data (Nadeem *et al.* 2016; Fig. 2). This estimate is based on similar methods applied to this population by Moore and Barlow (2011). However, the new abundance estimate is significantly higher than earlier estimates because the new analysis incorporates lower estimates of $g(0)$, the trackline detection probability (Barlow 2015). 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 an increasing abundance trend over that time (Moore and Barlow 2011, Nadeem *et al.* 2016), the best estimate of abundance is represented by the estimate for the most recent year, or 2014. This is probably an underestimate because it excludes some fin whales that could not be identified in the field and were recorded as "unidentified rorqual" or "unidentified large whale".

Minimum Population Estimate

The minimum population estimate for fin whales is taken as the lower 20th percentile of the posterior distribution of 2014 abundance estimate, or 8,127 whales.

Current Population Trend

Indications of recovery in CA coastal waters date back to 1979/80 (Barlow 1994), but there is now strong evidence that fin whale abundance increased in the California Current between 1991 and 2008 based on analysis of line transect surveys conducted in the California Current between 1991 and 2014 (Nadeem *et al.* 2016, Fig. 2). Abundance in waters out to 300 nmi off the coast of California approximately doubled between 1991 and 1993, from approximately 1,744 (CV = 0.25) to 3,369 (CV= 0.21), suggesting probable immigration of animals into the area. Across the entire study area (waters off California, Oregon, and Washington), the mean annual abundance increase was 7.5%, although abundance appeared stable between 2008 and 2014. In all, there has been a roughly 5-fold abundance increase between 1991 and 2014. Since 2005, the abundance increase has been driven by increases off northern California, Oregon and Washington, while numbers off Central and Southern California have been stable (Nadeem *et al.* 2016). Zerbini *et al.* (2006) found similar evidence of increasing fin whale abundance in Alaskan waters at a rate of 4.8% annually between 2001 and 2003.

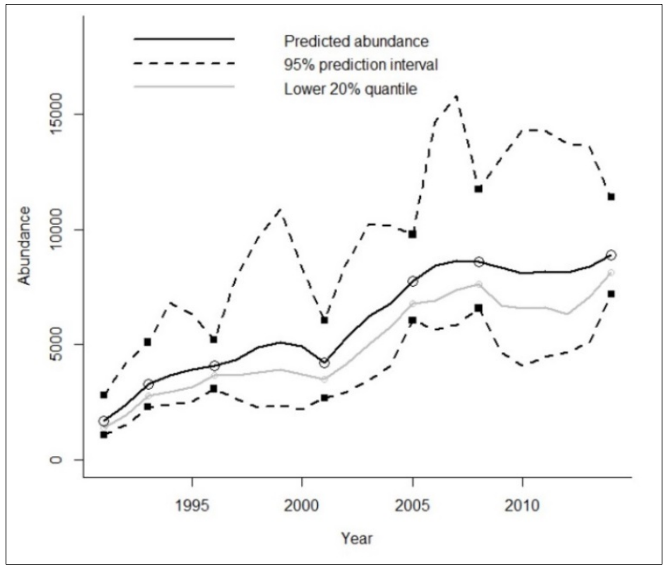

Figure 2. Trend-based estimates of fin whale abundance, 1991- 2014, with 95% Bayesian credible intervals (Nadeem *et al*. 2016).

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

Estimated annual rates of increase in the California Current (California, Oregon, and Washington waters) averaged 7.5% from 1991 to 2014 (Nadeem *et al.* 2016). However, it is unknown how much of this growth is due to immigration rather than birth and death processes. A doubling of the abundance estimate in California waters between 1991 and 1993 cannot be explained by birth and death processes alone, and movement of individuals between U.S. west coast waters and other areas (e.g., Alaska, Mexico) have been documented (Mizroch *et al.* 1984).

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (8,127) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.5 (for an endangered species, with N_{min} > 5,000 and CV_{Nmin} < 0.50, Taylor *et al.* 2003), resulting in a PBR of 81 whales.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fisheries Information

The California large-mesh drift gillnet fishery for swordfish and thresher shark includes one observed entanglement record (in 1999) of a fin whale from 9,085 observed fishing sets during 1990 - 2018 (Carretta 2020). The estimated bycatch of fin whales in this fishery for the most recent 5-year period is zero whales (Carretta 2020). ~~One fin whale death (in 1999) was observed in the California swordfish drift gillnet fishery from 8,845 observed sets between 1990 and 2016 (Carretta *et al.* 2018a.). Although no fin whales have been observed taken in the fishery since 1999, new model-based bycatch estimates include a very small estimate of 0.1 whales (CV=3.7) for the most recent 5-year period, 2012-2016 (Carretta *et al.* 2018b). The~~

~~large CV of this estimate is due to the mean estimate being very small. This estimate is based on inclusion of 26 years of observer data spanning 1990-2016 and reflects a very low long-term observed bycatch rate scaled up to levels of unobserved fishing effort.~~

~~One fin whale sighted at-sea was determined to be seriously injured (line cutting into the whale) as a result of interactions with unknown fishing gear during 2012-2016 (Carretta *et al.* 2018b). Including systematic fishery observations in the CA swordfish drift gillnet fishery and opportunistic sightings of fishery-related injuries, the mean annual serious injury and mortality of fin whales for 2012-2016 is ≥ 0.5 whales (Table 1). 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.~~

In addition to drift gillnets, fin whales ~~have been~~ are observed entangled in longline gear. One fin whale was observed entangled in 2015 in the Hawaii shallow-set longline fishery in waters between the U.S. West Coast and Hawaiian EEZs. The entanglement was assigned a non-serious injury, based on the animal being cut free of the gear ~~and only~~ with superficial wounds caused by the line (Bradford 2018). The stock identity of this whale is unknown.

Three fin whale serious injuries were documented in unidentified fishing gear during 2014-2018, or 0.6 whales annually (Carretta *et al.* 2020). Additionally, there were 21 *unidentfied whale* entanglements during this period, of which, 0.46 were prorated as fin whales using the method reported by Carretta (2018). ~~Unidentified whales represent approximately 15% of entanglement cases along the U.S. West Coast, (Carretta 2018). Observed entanglements may lack species IDs due to rough seas, distance from whales, or a lack of cetacean identification expertise. In previous stock assessments, these unidentified entanglements were not assigned to species, which results in underestimation of entanglement risk, especially for commonly-entangled species. To remedy this negative bias, a cross-validated species identification model was developed from known-species entanglements ('model data'). The model is based on several variables (location + depth + season + gear type + sea surface temperature) collectively found to be statistically-significant predictors of known-species entanglement cases (Carretta 2018). The species model was used to assign species ID probabilities for 21 unidentified whale entanglement cases ('novel data') during 2012-2016. The sum of species assignment probabilities for this 5-year period result in an additional 0.26 fin whale entanglements for 2012-2016.~~ Unidentified whale entanglements typically involve whales seen at-sea with unknown gear configurations that are prorated to represent 0.75 serious injuries per entanglement case. Thus ~~it is estimated that at least~~ approximately ~~0.26~~ 0.46 x 0.75 = ~~0.2~~ 0.35 ~~additional~~ fin whale serious injuries ~~are represented~~ occurred from the 21 unidentified whale entanglement cases during ~~2012-2016~~ 2014-2018 (Table 1). This represents a negligible annual estimate of ~~0.04~~ 0.07 prorated fin whales derived from sightings of unidentified entangled whales. Total mean annual fishery-related serious injury and mortality is the sum of observed (0.6) and prorated (0.07) mean annual deaths and serious injuries, or 0.67 fin whales annually (Table 1).

Table 1. Summary of available information on the incidental mortality and serious injury of fin whales (CA/OR/WA stock) for commercial fisheries that might take this species. ~~The mean annual take estimate for unidentified fishery interactions includes negligible estimates of entanglements from unidentified whale entanglements (Carretta 2018)~~.

Fishery Name	Data Type	Year(s)	Percent Observer Coverage	Observed (or self-reported)	Estimated Mortality (and serious injury)	Mean Annual Mortality and Serious Injury (CV in parentheses)
CA swordfish and thresher shark drift gillnet fishery	~~2012-2016~~ 2014-2018	observer	~~23%~~ 21%	0	~~≥ 0.1 (CV=3.7)~~ 0 (n/a)	~~< 0.1 (CV=3.7)~~ 0 (n/a)
Unidentified fishery interactions involving *fin whales*	~~2012-2016~~ 2014-2018	at-sea sightings	n/a	~~2~~ 3	0 ~~(2)~~ (3)	≥ ~~0.4~~ 0.6
Unidentified fishery interactions involving *unidentified whales* prorated to fin whale	2014-2018	at-sea sightings	n/a	n/a	0 (0.35)	0.07
Minimum total annual takes						≥ ~~0.5~~ 0.67 (n/a)

Ship Strikes

Ship strikes were implicated in the deaths of 8 fin whales from ~~2012-2016~~ 2014-2018 ~~and there was one additional serious injury to an unidentified large whale attributed to a ship strike~~ (Carretta *et al.* ~~2018b~~ 2020). Additional mortality from ship strikes probably goes unreported because the whales do not strand or, if they do, they do not always have obvious signs of trauma. The average observed annual mortality and serious injury due to ship strikes is 1.6 fin whales per year during ~~2012-2016~~ 2014-2018. Documented ship strike deaths and serious injuries are derived from direct counts of whale carcasses and represent minimum impacts. Where evaluated, estimates of detection rates of cetacean carcasses are consistently ~~quite~~ low across different regions and species (<1% to 33%), highlighting that observed numbers underestimate true impacts (Carretta *et al.* 2016, Kraus *et al.* 2005, Williams *et al.* 2011, Prado *et al.* 2013, Wells *et al.* 2015). Ship strike mortality was recently estimated for fin whales in the U.S. West Coast EEZ (Rockwood *et al.* 2017), using an encounter theory model (Martin *et al.* 2016) that combined species distribution models of whale density (Becker *et al.* 2016), vessel traffic characteristics (size + speed + spatial use), along with whale movement patterns obtained from satellite-tagged animals ~~in the region~~ to estimate encounters that would result in mortality. The estimated number of annual ship strike deaths was 43 fin 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 cetacean habitat models generated from line-transect surveys (Becker *et al.* 2016, Rockwood *et al.* 2017). This estimate is based on an assumption of a moderate level of vessel avoidance (55%) by fin whales, as measured by the behavior of satellite-tagged *blue whales* in the presence of vessels (McKenna *et al.* 2015). The estimated mortality of 43 fin whales annually due to ship strikes represents approximately < 0.5% of the estimated population size (43 deaths / 9,029 whales). The results of Rockwood *et al.* (2017) also include a no-avoidance encounter model that results in a worst-case estimate of 95 fin whale ship strike deaths per year, representing approximately 1% of the estimated population size. The authors also note that 65% of fin whale ship strike mortalities occur within 10% of the study area, implying that vessel avoidance mitigation measures can be effective if applied over relatively small regions. The authors of Rockwood *et al.* (2017) also estimated a worst-case ship strike carcass recovery rate of 5% for fin whales, but this estimate was based on a multi-species average from three species (gray, killer and sperm whales). Another way to estimate carcass recovery and/or documentation rates of fin whales killed or seriously injured by vessels is by directly comparing the documented number of ship strike deaths and serious injuries with annual estimates of vessel strikes from Rockwood *et al.* (2017). Comprehensive coast-wide data on ship strike deaths and serious injuries assumed to result in death are compiled in annual reports on observed anthropogenic morality for the ~~10~~12-year period 2007-~~2016~~ 2018 (Carretta *et al.* 2013, 2018~~b~~, 2020). During this ~~10~~ 12-year period, there were ~~15~~ 20 observations of fin whale ship strike deaths and 1 serious injury assumed to result in the death of the whale, or ~~1.6~~ 1.8 fin whales annually. The most conservative estimate of ship strike deaths from Rockwood *et al.* (2017) is 43 whales annually. The ratio of documented ship strike deaths (~~1.6~~1.8/yr) to estimated annual deaths (43) implies a carcass recovery/documentation rate of ~~3.7~~ 4.1%, which is lower than the worst-case estimate of 5% from Rockwood *et al.* (2017). There is uncertainty regarding the estimated number of ship strike deaths, however, it is apparent that carcass recovery rates of fin whales are quite low.

Vessel traffic within the U.S. West Coast EEZ continues to be a ship strike threat to all large whale populations (Redfern *et al.* 2013, Moore *et al.* 2018). However, a complex of vessel types, speeds, and destination ports all contribute to variability in ship traffic, and these factors may be influenced by economic and regulatory changes. For example, Moore *et al.* (2018) found that primary vessel travel routes 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 their speed when they transited longer routes to avoid the ECAs. Further research is necessary to understand how variability in vessel traffic affects ship strike risk and mitigation strategies.

STATUS OF STOCK

Fin whales in the North Pacific were given protected status by the IWC in 1976. Fin whales are formally listed as "endangered" under the Endangered Species Act (ESA), and consequently this stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. The total observed incidental mortality and serious injury (~~2.1~~ 2.5/yr), due to fisheries (~~0.5~~ 0.67/yr, including identified and prorated fin whales), and ship strikes (~~1.6~~ 1.8/yr), is less than the calculated PBR (81). However, observations alone underestimate true impacts due to incomplete detection of vessel strikes and fishery entanglements. Total fishery mortality is less than 10% of PBR and, therefore, may be approaching zero mortality and serious injury rate.

Estimated vessel strike mortality is 43 whales annually, or approximately 0.5% of the estimated population size. As these estimates are model-derived, they are inherently corrected for undocumented and undetected cases, but they represent only a portion of the year (July-December) for which habitat model data are available. The worst-case vessel strike estimate of mortality is 95 whales, based on no avoidance of vessels, or approximately 1% of the estimated population size. Neither vessel strike estimate includes incidents outside of the U.S. West Coast EEZ.

There is strong evidence that the population has increased since 1991 (Moore and Barlow 2011, Nadeem *et al.* 2016). Increasing levels of anthropogenic sound in the world's oceans is a habitat concern for whales, particularly for baleen whales that communicate using low-frequency sound (Croll *et al.* 2002). Behavioral changes associated with exposure to simulated mid-frequency sonar, including no change in behavior, cessation of feeding, increased swimming speeds, and movement away from simulated sound sources has been documented in tagged *blue* whales (Goldbogen *et al.* 2013), but it is unknown if fin whales respond in the same manner to such sounds.

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ROUGH-TOOTHED DOLPHIN (*Steno bredanensis*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Rough-toothed dolphins are found throughout the world in tropical and warm-temperate waters (Perrin *et al.* 2009). They are present around all the main Hawaiian Islands, though are relatively uncommon near Maui and the 4-Islands region (Baird *et al*. 2013) and have been observed close to the islands and atolls at least as far northwest as Pearl and Hermes Reef (Bradford *et al.* 2017). Rough-toothed dolphins were occasionally seen offshore throughout the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands during both 2002, ~~and~~ 2010, and 2017 surveys (Barlow 2006, Bradford et al. 2017, Yano *et al.* 2018; Figure 1). Rough-toothed dolphins have also been documented in American Samoan waters (Oleson 2009).

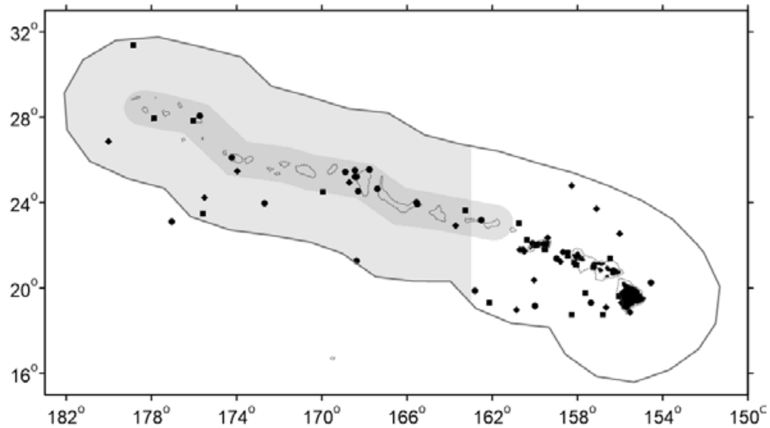

Figure 1. Rough-toothed dolphin sighting locations during the 2002 (~~open~~ diamond~~s~~), ~~and~~ 2010 (circles~~black diamonds~~), and 2017 (squares) shipboard cetacean surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford *et al.* 2017, Yano *et al.* 2018~~; see Appendix 2 for details on timing and location of survey effort~~). Outer line represents approximate boundary of survey area and U.S. EEZ. Dark g~~G~~ray shading indicates ~~area of~~of the original Papahanaumokuakea Marine National Monument, with the lighter gray shading denoting the full 2016 Expansion area. Dotted line represents the 1000 m isobath.

Population structure in rough-toothed dolphins was recently examined using genetic samples from several tropical and sub-tropical island areas in the Pacific. Albertson *et al.* (2016) found significant differentiation in mtDNA and nuDNA from samples collected at Hawaii Island versus all other Hawaiian Island areas sampled. Estimates of differentiation among Kauai, Oahu, and the northwestern Hawaiian Islands (NWHI) were lower and not statistically significant. Based on their result, Albertson et al. (2016) suggest that Hawaii Island warrants designation as a separate island-associated stock. Evaluation of individual rough-toothed dolphin encounters indicate differences in group sizes, habitat use, and behavior between groups seen near Hawaii Island and those seen near Kauai and Niihau (Baird et al 2008).Photographic identification studies suggested that dispersal rates between the islands of Kauai/Niihau and Hawaii do not exceed 2% per year (Baird et al. 2008). Resighting rates off the island of Hawaii are high, with 75% of well-marked individuals resighted on two or more occasions, suggesting high site fidelity and low population size. Movement data from 17 individual rough-toothed dolphins tagged near Kauai and Niihau show all individuals remained associated with Kauai with exception of one individual that moved from Kauai and Oahu and back (Baird 2016). The available genetics, movements, and social affiliation data suggest that there is at least one island-associated stock in the main Hawaiian Islands (MHI). Delineation of island-associated stocks in Hawaii is under review (Martien *et al*. 2016). ~~Rough-toothed dolphins have also been documented in American Samoan waters (Oleson 2009).~~

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there are two Pacific management stocks: 1) The Hawaii Stock (this report), and 2) the American Samoa Stock. The Hawaiian stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from the U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

Encounter data from ~~a 2010~~ shipboard line-transect surveys of the entire Hawaiian Islands EEZ were recently reevaluated for each survey year, resulting in the following abundance estimates of rough-toothed dolphins in the Hawaii EEZ (Bradford *et al. in review*) (Table 1).

Table 1. Line-transect abundance estimates for rough-toothed dolphins derived from surveys of the entire Hawaii EEZ in 2002, 2010, and 2017 (Bradford *et al. in review*).

Year	Abundance	CV	95% Confidence Limits
2017	76,375	0.41	35,286-165,309
2010	74,001	0.39	35,197-155,586
2002	65,959	0.39	31,344-138,803

The updated design-based abundance estimates use sighting data from throughout the central Pacific to estimate the detection function and use Beaufort sea-state-specific trackline detection probabilities for rough-toothed dolphins from Barlow *et al*. (2015). Although previous estimates from the Hawaii EEZ have been published using subsets of this data, Bradford *et al*. (*in review*), uses a consistent approach for estimating all abundance parameters and the resulting estimates are considered the best available for each survey year. Model-based density and abundance estimates were also built for rough-toothed dolphins (Becker *et al. in review*); however, only static geographic and depth variables were selected within the modeling process, precluding evaluation of inter-annual changes in density relative to other dynamic variables. The best estimate is based on the 2017 survey, or 76,375 (CV=0.41). ~~using Beaufort sea-state-specific trackline detection probabilities for rough-toothed dolphins, resulting in an abundance estimate of 72,528 (CV = 0.39) rough-toothed dolphins (Bradford et al. 2017) in the Hawaii stock. A 2002 shipboard line-transect survey of the same area resulted in an abundance estimate of 8,709 (CV=0.45) rough-toothed dolphins (Barlow 2006). Species abundances estimated from the 2002 HICEAS survey used pooled small dolphin, large dolphin, and large whale g(0) (the probability of sighting and recording an animal directly on the track line) estimates stratified by group size (Barlow 1995). Since then, Barlow (2015) developed a more robust method for estimating species-specific g(0) values that are adjusted for the Beaufort sea states that are encountered during a survey. This new method was used for analyzing the data from the 2010 survey, but has not yet been used to analyze the 2002 data.~~ A population estimate for this species has been made in the eastern tropical Pacific (Wade and Gerrodette 1993), but it is not known whether these animals are part of the same population that occurs around the Hawaiian Islands.

Mark-recapture estimates for the islands of Kauai/Nihau and Hawaii were derived from identification photographs obtained between 2003 and 2006, resulting in estimates of 1,665 (CV=0.33) around Kauai/Niihau and 198 (CV=0.12) around the island of Hawaii (Baird *et al*. 2008). Such estimates may be representative of smaller island-associated populations at those island areas.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al*. 1995) of the ~~2010~~ 2017 abundance estimate or ~~52,833~~ 54,804 rough-toothed dolphins within the Hawaiian Islands EEZ.

Current Population Trend

The three available abundance estimates for this stock have broad and overlapping confidence intervals, precluding robust evaluation of population trend for this stock.~~Abundance analyses of the 2002 and 2010 datasets used different g(0) values. The 2002 survey data have not been reanalyzed using this method. This change precludes evaluation of population trends at this time. Assessment of population trend will likely require additional survey data and reanalysis of all datasets using comparable methods.~~

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii stock of rough-toothed dolphins is calculated as the minimum population size within the U.S. EEZ of the Hawaiian Islands (54,804~~52,833~~) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.5 ~~0.4~~ (for a stock of unknown status with no known ~~a~~ Hawaiian Islands EEZ fishery mortality and serious injury ~~rate CV > 0.8~~ ; Wade and Angliss 1997), resulting in a PBR of 548 ~~423~~ rough-toothed dolphins per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Information on fishery-related mortality and serious injury of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Rough-toothed dolphins are known to take bait and catch from several Hawaiian sport and commercial fisheries operating near the main islands (Shallenberger 1981; Schlais 1984; Nitta and Henderson 1993). They have been specifically reported to interact with the day handline fishery for tuna (palu-ahi), the night handline fishery for tuna (ika-shibi), and the troll fishery for billfish and tuna (Schlais 1984; Nitta and Henderson 1993). Baird *et al*. (2008) reported increased vessel avoidance of boats by rough-toothed dolphins off the island of Hawaii relative to those off Kauai or Niihau and attributed this to possible shooting of dolphins that are stealing bait or catch from recreational fisherman off the island of Hawaii (Kuljis 1983). In 2014 ~~One~~a rough-toothed dolphin was observed off the Kona coast trailing 25-30 ft. of heavy line with two plastic jugs attached to the end of the line (Bradford and Lyman ~~in review~~2018). The jugs were cut from the gear when other attempts (through pressure on the line) did not result in the removal of any other line or hooks, though all other trailing gear remained on the dolphin. This dolphin was considered seriously injured based on the amount of trailing gear. The source of the gear is not known. In 2015 a rough-toothed dolphin was observed with line tightly wrapped around and cutting into its left pectoral flipper, with 3-4 ft. of line trailing behind (Bradford and Lyman 2018). This dolphin was considered seriously injured based on information available at the time of report. This dolphin was subsequently sighted twice free of gear in 2018, indicating it survived the entanglement. As such, the serious injury determination has been revised and the dolphin is considered to be not seriously injured (Bradford and Lyman *in review*). Photographs of 52 individuals with greater than 50% of the mouthline photographed showed evidence of injuries consistent with interactions with hook and line fisheries (Welch 2017). No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line fisheries because these fisheries are not observed or monitored for protected species bycatch.

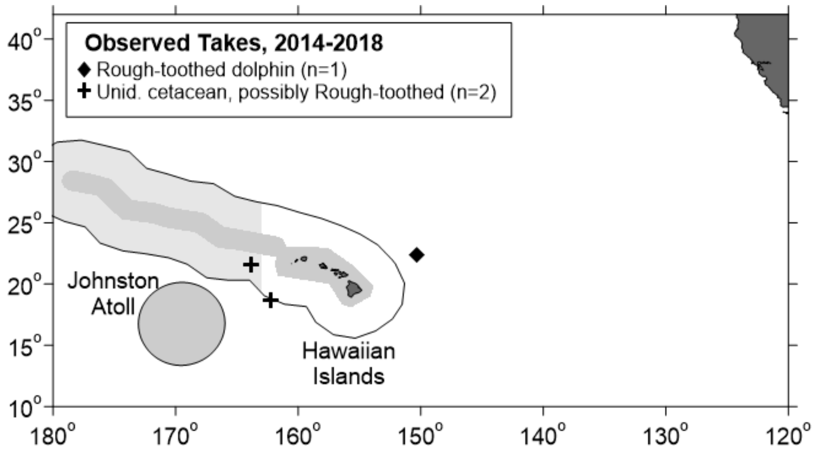

Figure 2. Locations of observed rough-toothed dolphin takes (filled diamonds) and unidentified cetacean that maybe rough-toothed dolphins based on the observer's description (crosses) in the Hawaii-based longline fishery, 2014-2018~~2011-2015~~. Solid lines represent the U. S. EEZ. Gray shading notes areas closed to longline fishing, with the PMNM Expansion area closed since August 2016.~~ Fishery descriptions are provided in Appendix 1.~~

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Between 2014~~2011~~ and 2018~~2015~~, one rough-toothed dolphin was observed hooked or entangled in the ~~SSLL fishery (100% observer coverage) and one in the~~ DSLL fishery (~~20~~18-21% observer coverage) (Bradford 2018a, 2018b, *in review*~~2017~~, Bradford and Forney 2017, McCracken 2019~~2017~~). This interaction ~~Both of these interactions~~ occurred outside~~inside~~ the Hawaiian Islands EEZ and ~~both dolphins were~~was observed dead (Bradford 2018a~~2017, Bradford and Forney 2017~~). Average 5-yr estimates of annual mortality and serious injury for rough-toothed dolphins during ~~2011-2015~~ 2014-2018 are ~~2.1 (CV = 1.1)~~ zero rough-toothed dolphins within the Hawaiian Islands EEZ and 1.0 (CV = 1.6) dolphins outside of U.S. EEZs (Table ~~1~~2, McCracken ~~2017~~2019). Two ~~Four additional~~ unidentified cetaceans were taken in the DSLL fishery~~, and one unidentified cetacean was taken in the SSLL fishery,~~ that were considered to possibly be ~~some of which may have been~~ rough-toothed dolphins, and three additional unidentified cetaceans were taken in the DSLL that were determined only to be unidentified dolphins, some of which may have been rough-toothed dolphins.

Table 2~~1~~. Summary of available information on incidental mortality and serious injury of rough-toothed McCracken 2019~~2017~~). Mean annual takes are based on 2014-2018~~2011-2015~~ data unless indicated otherwise. Information on all observed takes (T) and combined mortality events and serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome.

Fishery Name	Year	Data Type	Percent Observer Coverage	Observed total interactions (T) and mortality events, and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) of rough-toothed dolphins			
				Outside U.S. EEZs		Hawaiian EEZ	
				Obs. T/MSI	Estimated M&SI (CV)	Obs. T/MSI	Estimated M&SI (CV)
Hawaii-based deep-set longline fishery	~~2011~~	Observer data	~~20%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
	~~2012~~		~~20%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
	~~2013~~		~~20%~~	~~0~~	~~0 (-)~~	~~1/1~~	~~5 (0.9)~~
	2014		21%	0	0 (-)	0	0 (-)
	2015		21%	0	0 (-)	0	0 (-)
	2016		20%	1/1	5 (0.9)	0	0 (-)
	2017		20%	0	0 (-)	0	0 (-)
	2018		18%	0	0 (-)	0	0 (-)
Mean Estimated Annual Take (CV)					~~0 (-)~~1.0 (1.6)		~~1.1 (1.1)~~ 0 (-)
Hawaii-based shallow-set longline fishery	~~2011~~	Observer data	~~100%~~	~~0~~	~~0~~	~~0~~	~~0~~
	~~2012~~		~~100%~~	~~0~~	~~0~~	~~0~~	~~0~~
	~~2013~~		~~100%~~	~~0~~	~~0~~	~~1/1~~	~~1~~
	2014		100%	0	0	0	0
	2015		100%	0	0	0	0
	2016		100%	0	0	0	0
	2017		100%	0	0	0	0
	2018		100%	0	0	0	0
Mean Annual Takes (100% coverage)					0		~~1~~0
Minimum total annual takes within U.S. EEZ							~~2.1 (1.1)~~ 0 (-)

STATUS OF STOCK

The Hawaii stock of rough-toothed dolphins is not considered strategic under the 1994 amendments to the MMPA, The status of rough-toothed dolphins in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Rough-toothed dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Two ~~One~~ rough-toothed dolphins have~~s~~ been observed entangled in gear, though no ~~and a 5-yr average of 2.1~~ dolphins have been killed or seriously injured in the deep-set longline fishery. There is no systematic monitoring for interactions with protected species within near-shore fisheries that may take this species, thus total mean annual takes are undetermined. ~~However, the~~The total number of estimated killed or seriously injured rough-toothed dolphin inside (zero) and outside (1.0) of the Hawaiian Islands EEZ ~~(2.3)~~ is ~~significantly lower~~ less than 10% of PBR (548 ~~423~~), such that the fishery-related mortality or serious injuries rate for the entire Hawaii stock can be considered to be insignificant and approaching zero. Island-associated populations of rough-toothed dolphins may experience relatively greater rates of fisheries mortality and serious injury. One rough-toothed dolphin stranded in the main Hawaiian Islands tested positive for *Brucella* (Chernov 2010) and another for *Morbillivirus* (Jacob 2012). *Brucella* is a bacterial infection that if common in the population may limit recruitment by compromising male and female reproductive systems, and can also cause neurological disorders that may result in death (Van Bressem et al. 2009). Although *morbillivus* is known to trigger lethal disease in cetaceans (Van Bressem et al. 2009), its impact on the health of the stranded animal is not known as it was found in only a few tested tissues (Jacob et al. 2016). The presence of *morbillivirus* in 10 species (Jacob *et al*. 2016) and *Brucella* in 3 species (Chernov 2010~~, West unpublished data~~) raises concerns about the history and prevalence of these diseases in Hawaii and the potential population impacts, including cumulative impacts of disease with other stressors. It is not known if *Brucella or*

Morbillivirus are common in the Hawaii stock.

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Revised ~~5/31/2018~~ 8/25/2020

RISSO'S DOLPHIN (*Grampus griseus*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Risso's dolphins are found in tropical to warm-temperate waters worldwide (Perrin *et al.* 2009). Risso's dolphins represent less than 1% of all odontocete sightings in leeward surveys of the main Hawaii Islands from 2000 to 2012 (Baird *et al.* 2013); however, six sightings were made during a 2002 survey~~ and~~, 12 during a 2010 survey, and 12 during a 2017 survey of the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands (Barlow 2006, Bradford et al. 2017, Yano *et al.* 2018; Figure 1). Most sightings of Risso's dolphins occur in deep waters offshore. A single satellite tagged animal moved broadly between offshore waters off Kona, Kohoolawe, and Lanai over a 2 week period (Baird 2016). Sighting, habitat, and limited movement data do not appear to support finer population structure in Hawaiian waters.

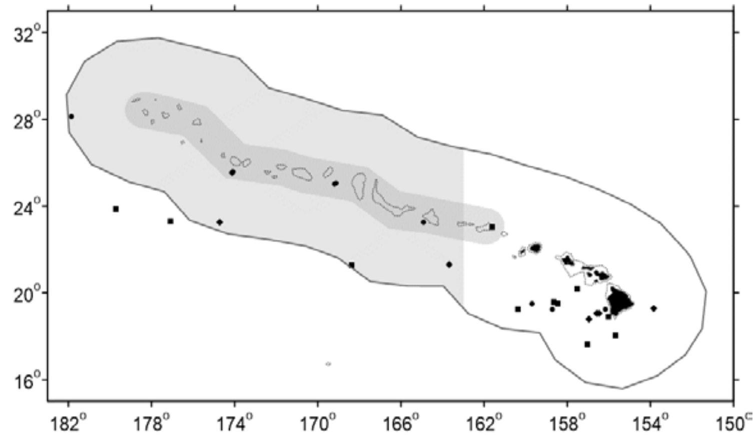

Figure 1. Risso's dolphin sighting locations during the 2002 (~~open~~ diamonds),~~ and~~ 2010 (~~black diamonds~~circle), and 2017 (square) shipboard cetacean surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2017, Yano *et al.* 2018~~; see Appendix 2 for details on timing and location of survey effort~~). Outer line represents approximate boundary of survey area and U.S. EEZ. Dark and light gray shading indicate the original and 2016 Eexpanded area of Papahanaumokuakea Marine National Monument. Dotted line is the 1000 m isobath.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, Risso's dolphins within the Pacific U.S. EEZ are divided into two discrete, non-contiguous areas: 1) Hawaiian waters (this report), and 2) waters off California, Oregon and Washington. The Hawaiian stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

Encounter data from ~~a 2010~~ shipboard line-transect surveys of the entire Hawaiian Islands EEZ was recently reevaluated, resulting in the updated ~~following~~ model-based abundance estimates of Risso's dolphins in the Hawaii EEZ (Becker *et al. in review*) (Table 1).

Table 1. Line-transect abundance estimates for Risso's dolphins derived from surveys of the entire Hawaii EEZ in 2002, 2010, and 2017 (Becker *et al.* in review).

Year	Model-based abundance	CV	95% Confidence Limits
2017	7,385	0.22	4,817-11,322
2010	6,174	0.20	4,159-9,165
2002	6,916	0.21	4,623-10,346

Sighting data from 2002 to 2017 within the Hawaii EEZ were used to derive habitat-based models of animal density for the overall period. The models were then used to predict density and abundance for each survey year based on the environmental conditions within that year (see Forney *et al.* 2015, Becker *et al.* 2016). The modeling framework incorporated Beaufort-specific trackline detection probabilities for Risso's dolphins from Barlow *et al.* (2015).

Bradford *et al.* (*in review*) produced design-based abundance estimates for Risso's dolphins for each survey year that can be used as a point of comparison to the model-based estimates. While on average, the estimates are broadly similar between the two approaches, the annual design-based estimates show much greater variability between years than do the model-based estimates (Figure 2). The model-based approach reduces variability through explicit examination of habitat relationships across the full dataset, while the design-based approach evaluates encounter data for each year separately and thus is more susceptible to the effects of encounter rate variation. Model based-estimates are based on the implicit assumption that changes in abundance are attributed to environmental variability alone due to a lack of data to test for other effects. Despite not fully accounting for inter-annual variation in total abundance, the model-based estimates are considered the best available estimate for each survey year. Previously published design-based estimates for the Hawaii EEZ from 2002 and 2010 surveys (e.g. Barlow 2006, Bradford *et al.* 2017) used a subset of the dataset used by Becker et al. (*in review*) and Bradford *et al.* (*in review*) to derive line-transect parameters, such that these estimates have been superseded by the estimates presented here. The best estimate of abundance is based on the 2017 survey, or 7,385 (CV=0.22). ~~estimates stratified by group size (Barlow 1995). Since then, Barlow (2015) developed a more robust method for estimating species-specific g(0) values that are adjusted for the Beaufort sea states that are encountered during a survey. This new method was used for analyzing the data from the 2010 survey, but has not yet been used to analyze the 2002 data.~~ Population estimates have been made off Japan (Miyashita 1993), in the eastern tropical Pacific (Wade and Gerrodette 1993), and off the U.S. West Coast (Barlow 2016~~and Forney 2007~~), but it is not known whether these animals are part of the same population that occurs around the Hawaiian Islands and in the central North Pacific.

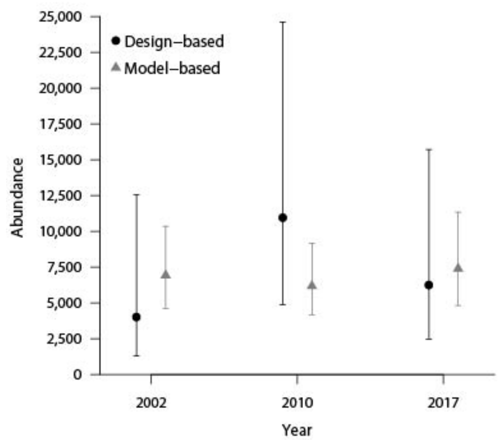

Figure 2. Comparison of design-based (circles, Bradford *et al. in review*) and model-based (triangles, Becker *et al. in* review) estimates of abundance for Risso's dolphins for each survey year (2002, 2010, 2017).

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) of the 2017 ~~2010~~ abundance estimate, or 6,150 ~~8,210~~ Risso's dolphins within the Hawaiian Islands EEZ.

Current Population Trend

The model-based abundance estimates for Risso's dolphins provided by Becker *et al.* (*in review*) do not explicitly allow for examination of population trend other than that driven by environmental factors. Model-based examination of Risso's dolphin trends including sighting data beyond the Hawaii EEZ will be required to more fully examine trend for this stock. ~~Abundance analyses of the 2002 and 2010 datasets used different g(0) values. The 2002 survey data have not been reanalyzed using this method. This change precludes evaluation of population trends at this time. Assessment of population trend will likely require additional survey data and reanalysis of all datasets using comparable methods.~~

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for Hawaiian animals.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii stock of Risso's dolphins is calculated as the minimum population size within the U.S. EEZ of the Hawaiian Islands (6,150 ~~8,210~~) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.5 (for a stock of unknown status with no known fishery mortality and serious injury within the Hawaii EEZ; Wade and Angliss 1997), resulting in a PBR of 61 ~~82~~ Risso's dolphins per year.

HUMAN CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Information on fishery-related mortality and serious injury of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. No interactions between nearshore fisheries and Risso's dolphins have been reported in Hawaiian waters. No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line fisheries because these fisheries are not observed or monitored for protected species bycatch.

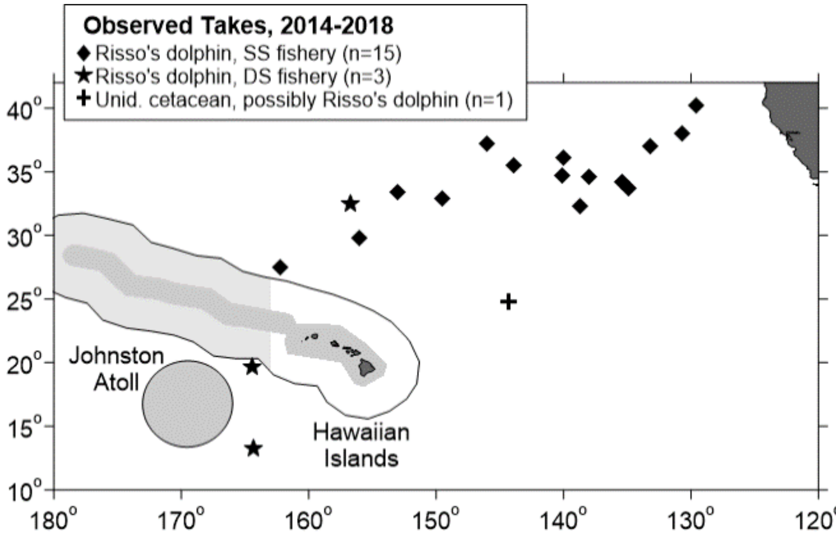

Figure ~~2~~3. Locations of Risso's dolphin takes ~~(filled diamonds)~~ and unidentified cetaceans that may be Risso's dolphins based on the observer's description in Hawaii-based longline fisheries, 2014-2018~~2011-2015~~. Solid lines represent the U.S. EEZs. Gray shading notes areas closed to ~~longline fishing~~commercial fishing, with the PMNM Expansion area closed since August 2016. ~~Fishery descriptions are provided in Appendix 1.~~

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2014~~2011~~ and 2018~~2015~~, 15~~13~~ Risso's dolphins were observed killed or seriously injured in the SSLL fishery (100% observer coverage), and the injury status of one could not be determined based on the observer's description, and 3~~2~~ Risso's dolphins were observed killed or seriously injured in the DSLL fishery (18~~20~~-21% observer coverage) (Figure 3, Bradford 2018a, 2018b, *in review*~~2017~~, Bradford and Forney 2017, McCracken 201~~7~~9). One Risso's dolphin in the DSLL fishery and four in the SSLL fishery were killed, 10 ~~9~~ in the SSLL fishery and 2~~one~~ in the DSLL fishery were considered to have been seriously injured, and the remaining ~~three~~ interactions in the SSLL fishery ~~were determined to be not seriously injured or~~ could not be determined based on an evaluation of the observer's description of the interaction. When otherwise undetermined, the injury status of takes is prorated to serious versus non-serious using the historic rate of serious injury within the observed takes. Average 5-yr estimates of annual mortality and serious injury for 2014-2018 ~~2011-2015~~ are 5.7 ~~5.1~~ (CV = 0.7 ~~0.9~~) Risso's dolphins outside of U.S. EEZs, and 0 within the Hawaiian Islands EEZ (Table ~~1~~2, McCracken ~~2017~~ 2019). One~~Four~~ additional unidentified cetacean, possibly a Risso's dolphin based on the observer's description, and three other unidentified delphinids ~~s~~ were taken in the DSLL fishery~~, and one unidentified cetacean was taken in the SSLL fishery~~, some of which may have been Risso's dolphins.

Table ~~1~~2. Summary of available information on incidental mortality and serious injury of Risso's dolphin (Hawaii stock) in commercial longline fisheries, within and outside of U.S. EEZs (McCracken 201~~7~~9). Mean annual takes are based on 2014-2018~~2011-2015~~ data unless indicated otherwise. Information on all observed takes (T) and combined mortality events & serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome.

Fishery Name	Year	Data Type	Percent Observer Coverage	Observed total interactions (T) and mortality events, and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) of Risso's dolphins			
				Outside U.S. EEZs		Hawaiian EEZ	
				Obs. T/MSI	Estimated M&SI (CV)	Obs. T/MSI	Estimated M&SI (CV)

Hawaii-based deep-set longline fishery	~~2011~~	Observer data	~~20%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
	~~2012~~		~~20%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
	~~2013~~		~~20%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
	2014		21%	0	0 (-)	0	0 (-)
	2015		21%	2/2	10 (0.6)	0	0 (-)
	2016		20%	0	0 (-)	0	0 (-)
	2017		20%	1/1	5 (0.9)	0	0 (-)
	2018		18%	0	0 (-)	0	0 (-)
Mean Estimated Annual Take (CV)					**2.9 (0.7)~~1.9 (0.9)~~**		**0 (-)**
Hawaii-based shallow-set longline fishery	~~2011~~	Observer data	~~100%~~	~~4/3~~	~~3~~	~~0~~	~~0~~
	~~2012~~		~~100%~~	~~0/0~~	~~0~~	~~0~~	~~0~~
	~~2013~~		~~100%~~	~~3/2~~	~~2~~	~~0~~	~~0~~
	2014		100%	6/6[†]	6	0	0
	2015		100%	3/3	3	0	0
	2016		100%	2/2	2	0	0
	2017		100%	2/2	2	0	0
	2018		100%	2/2	2	0	0
Mean Annual Takes (100% coverage)					**2.8~~3.2~~**		**0**
Minimum total annual takes within U.S. EEZ							**0 (-)**

[†] Injury status could not be determined based on information collected by the observer. Injury status is prorated (see text).

STATUS OF STOCK

The Hawaii stock of Risso's dolphins is not considered strategic under the 1994 amendments to the MMPA. The status of Risso's dolphins in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Risso's dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Given the absence of recent recorded fishery-related mortality or serious injuries within the U.S. EEZ, the total fishery mortality and serious injury can be considered to be insignificant and approaching zero. One Risso's dolphin stranded on the MHI tested positive for *Morbillivirus* (Jacob *et al.* 2016). The presence of *morbillivirus* in 10 species of cetacean in Hawaiian waters, all identified as a unique strain of *morbillivirus*, (Jacob *et al.* 2016), raises concerns about the history and prevalence of this disease in Hawaii and the potential population impacts, including cumulative impacts of disease with other stressors.

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Revised ~~5/25/2018~~ 9/3/2020

COMMON BOTTLENOSE DOLPHIN (*Tursiops truncatus truncatus*): Hawaiian Islands Stock Complex- Kauai/Niihau, Oahu, 4-Islands, Hawaii Island, Hawaii Pelagic

STOCK DEFINITION AND GEOGRAPHIC RANGE

Common bottlenose dolphins are widely distributed throughout the world in tropical and warm-temperate waters (Perrin *et al.* 2009). ~~The species is primarily coastal in much of its range, but there are populations in some offshore deepwater areas as well.~~ Bottlenose dolphins are common throughout the Hawaiian Islands, from the island of Hawaii to Kure Atoll (Shallenberger 1981, Baird *et al.* 2013).Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands resulted in 18 sightings in 2002, ~~and~~ 20 sightings in 2010, and 4 sightings in 2017 (Barlow 2006, Bradford *et al.* 2017, Yano *et al.* 2018; Figure 1). In the Hawaiian Islands, bottlenose dolphins are found in shallow inshore waters and deep water (Baird *et al.* 2009).

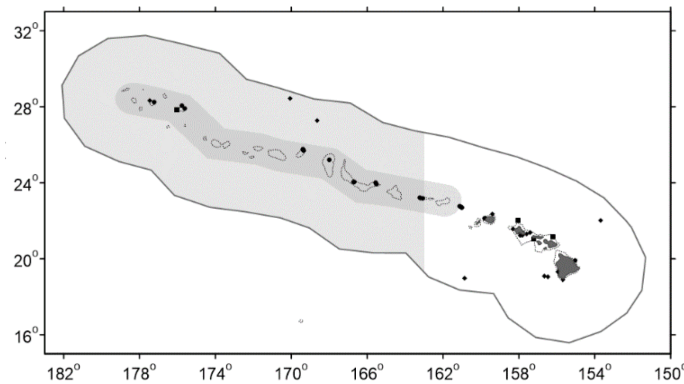

Figure 1. Bottlenose dolphin sighting locations during the 2002 (~~open~~ diamonds), ~~and~~ 2010 (~~black diamonds~~circle), and 2017 (square) shipboard cetacean surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford *et al.* 2017, Yano *et al.* 2018~~; see Appendix 2 for details on timing and location of survey effort~~). ~~Outer line represents approximate boundary of survey area and U.S. EEZ.~~ Dark gray ~~G~~ray shading indicates ~~area of~~of the original Papahanaumokuakea Marine National Monument, with the lighter gray shading denoting the full 2016 Expansion area. Dotted line represents the 1000 m isobaths. Insular stock boundaries are shown in Figure 2.

Separate offshore and coastal forms of bottlenose dolphins have been identified along continental coasts (Ross and Cockcroft 1990; Van Waerebeek *et al.* 1990), and there is evidence that similar onshore-offshore forms may exist in Hawaiian waters (Baird 2016). In their analysis of sightings of bottlenose dolphins in the eastern tropical Pacific (ETP), Scott and Chivers (1990) noted a large hiatus between the westernmost sightings and the Hawaiian Islands. These data suggest that bottlenose dolphins in Hawaiian waters belong to a separate stock from those in the ETP. Furthermore, recent photo-identification and genetic studies off Oahu, Maui, Lanai, Kauai, Niihau, and Hawaii suggest limited movement of bottlenose dolphins between islands and offshore waters (Baird *et al.* 2009; Martien *et al.* 2012). These data suggest the existence of demographically distinct resident populations at each of the four main Hawaiian Island groups – Kauai & Niihau, Oahu, the ‘4-island’ region (Molokai, Lanai, Maui, Kahoolawe), and Hawaii. Genetic data support inclusion of bottlenose dolphins in deeper waters surrounding the main Hawaiian Islands as part of the broadly distributed pelagic population (Martien *et al.* 2012).

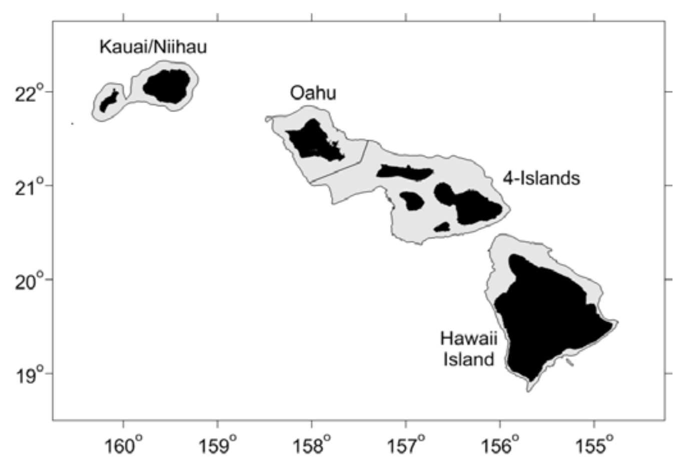

Figure 2. Main Hawaiian Islands insular bottlenose dolphin stock boundaries (gray shading). Areas beyond the 1000 m isobath represent the pelagic stock range.

Over 99% of the bottlenose dolphins linked through photo-identification to one of the insular populations around the main Hawaiian Islands (Baird *et al.* 2009) have been documented in waters of 1000 m or less (Martien and Baird 2009). Based on these data, Martien and Baird (2009) suggested that the boundaries between the insular stocks and the Hawaii Pelagic stock be placed along the 1000 m isobath. Since that isobath does not separate

Oahu from the 4-Islands Region, the boundary between those stocks runs approximately equidistant between the 500 m isobaths around Oahu and the 4-Islands Region, through the middle of Kaiwi Channel. These boundaries (Figure 2) are applied in this report to recognize separate insular and pelagic bottlenose dolphin stocks for management (NMFS 2005). These boundaries may be revised in the future as additional information becomes available. To date, no data are available regarding population structure of bottlenose dolphins in the Northwestern Hawaiian Islands (NWHI), though sightings during the 2010 survey indicate they are commonly found close to the islands and atolls there (Bradford *et al.* 2017). Given the evidence for island resident populations in the main Hawaiian Islands, the larger distances between islands in the NWHI, and the finding of population structure within the NWHI in other dolphin species (Andrews 2010), it is likely that additional demographically independent populations of bottlenose dolphins exist in the NWHI. However, until data become available upon which to base stock designations in this area, the NWHI will remain part of the Hawaii Pelagic Stock.

For the Marine Mammal Protection Act (MMPA) Pacific stock assessment reports, bottlenose dolphins within the Pacific U.S. EEZ are divided into seven stocks: 1) California, Oregon and Washington offshore stock, 2) California coastal stock, and five Pacific Islands Region management stocks (this report): 3) Kauai/Niihau, 4) Oahu, 5) 4-Islands (Molokai, Lanai, Maui, Kahoolawe), 6) Hawaii Island and 7) the Hawaiian Pelagic Stock, including animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters. Because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of the Hawaii pelagic stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005). Estimates of abundance, potential biological removals, and status determinations for the five Hawaiian stocks are presented separately below.

HUMAN CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaii fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. There are at least two reports of entangled bottlenose dolphins dying in gillnets off Maui (Nitta and Henderson 1993, Maldini 2003, Bradford and Lyman 2013). Although gillnet fisheries are not observed or monitored through any State or Federal program, State regulations now ban gillnetting around Maui and much of Oahu and require gillnet fishermen to monitor their nets for bycatch every 30 minutes in those areas where gillnetting is permitted. ~~In 2009 and 2013, a bottlenose dolphin was observed off the Kona coast with hook and line trailing from its mouth. In the latter case, the trailing gear was entangled around the pectoral fin, and appeared to be restricting the animal's movement. The bulk of the trailing gear was cut free by a diver, but the hook and an unknown amount of line remained in the dolphin's mouth. In both cases the dolphins were known to frequent aquaculture pens off the Kona Coast of the island of Hawaii (Bradford and Lyman 2015, in review).~~ In 2018 a bottlenose dolphin calf was observed with a gunshot wound through its melon (Bradford and Lyman *in review*). Although the wound was initially judged to be serious, ten sightings of this animal since the injury was initially observed have indicated the wound is healing and the animal has survived (Harnish et al. 2019). Based on the most recent observations of the animal~~description and photographs or video, both injuries were considered serious~~ the injury is currently considered to be not-serious under the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012). ~~The 2009 animal was resighted in February 2012 without the fish hook and in normal body condition, such that this injury is no longer considered serious. The 2013 animal has not~~

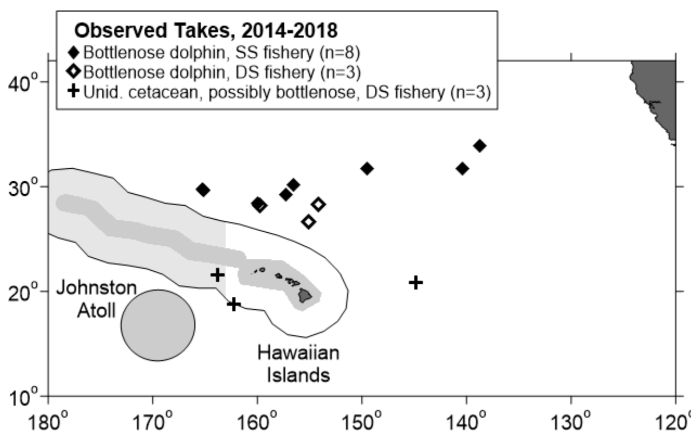

Figure 3. Locations of observed Pelagic Stock bottlenose dolphin takes within the shallow-set fishery (filled diamonds) and deep-set fishery (open diamonds), and unidentified cetaceans condiered to possibly or likely be bottlenose dolphins based on the observer's description (crosses) in the Hawaii-based longline fishery, ~~2011-2015~~2014-2018. Solid lines represent the U. S. EEZ. Gray shading notes areas closed to commercial fishing, with the PMNM Expansion area closed since August 2016. ~~longline fishing. Fishery descriptions are provided in Appendix 1~~.

~~been resighted. The responsible fishery is not known.~~ No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line or gillnet fisheries because these fisheries are not observed or monitored for protected species bycatch.

Bottlenose dolphins are one of the species commonly reported to steal bait and catch from several Hawaii sport and commercial fisheries (Nitta and Henderson 1993, Schlais 1984). Observations of bottlenose dolphins stealing bait or catch have been made in the day handline fishery (palu-ahi) for tuna, the night handline fishery for tuna (ika-shibi), the handline fishery for mackerel scad, the troll fishery for billfish and tuna, and the inshore set gillnet fishery (Nitta and Henderson 1993). Nitta and Henderson (1993) indicated that bottlenose dolphins remove bait and catch from handlines used to catch bottomfish off the island of Hawaii and Kaula Rock and formerly on several banks of the Northwestern Hawaiian Islands. Fishermen claim interactions with dolphins that steal bait and catch are increasing, including anecdotal reports of bottlenose dolphins getting “snagged” (Rizzuto 2007). Interaction rates between dolphins and the NWHI bottomfish fishery were estimated based on studies conducted in 1990-1993, indicating that an average of 2.67 dolphin interactions, defined as incidence of dolphins removing bait or catch from hooks, occurred for every 1000 fish brought on board (Kobayashi and Kawamoto 1995) These interactions generally involved bottlenose dolphins and it is not known whether these interactions result in serious injury or mortality of dolphins. This fishery was observed from 2003 through 2005 at 18-25% coverage, during which time, no incidental takes of cetaceans were reported. The bottomfish fishery is no longer permitted for the Northwestern Hawaiian Islands.

Table 1. Summary of available information on incidental mortality and serious injury of bottlenose dolphins (Hawaii Pelagic stock) in commercial longline fisheries, within and outside of the U.S. EEZs (McCracken 2019~~2017~~). Mean annual takes are based on 2014-2018~~2011-2015~~ data unless otherwise indicated. Information on all observed takes (T) and combined mortality events & serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome.

Fishery Name	Year	Data Type	Percent Observer Coverage	Observed total interactions (T) and mortality events, and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) of Hawaii Pelagic stock bottlenose dolphins			
				Outside U.S. EEZs		Hawaiian EEZ	
				Obs. T/MSI	Estimated M&SI (CV)	Obs. T/MSI	Estimated M&SI (CV)
Hawaii-based deep-set longline fishery	~~2011~~	Observer data	~~20%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
	~~2012~~		~~20%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
	~~2013~~		~~20%~~	~~2/2~~	~~11 (0.6)~~	~~0~~	~~0 (-)~~
	2014		21%	0	0 (-)	0	0 (-)
	2015		21%	0	0 (-)	0	0 (-)
	2016		20%	1/1	5 (0.9)	0	0 (-)
	2017		20%	1/1	7 (0.9)	0	0 (-)
	2018		18%	1/1	3 (0.9)	0	0 (-)
Mean Estimated Annual Take (CV)					**3.0 (0.6)**~~**2.2 (0.9)**~~	0	**0 (-)**
Hawaii-based shallow-set longline fishery	~~2011~~	Observer data	~~100%~~	~~2/1~~	~~1~~	~~0~~	~~0~~
	~~2012~~		~~100%~~	~~1/1~~	~~1~~	~~0~~	~~0~~
	~~2013~~		~~100%~~	~~2/2~~	~~2~~	~~0~~	~~0~~
	2014		100%	4/4	4	0	0
	2015		100%	2/2	2	0	0
	2016		100%	1/1	1	0	0
	2017		100%	0	0	0	0
	2018		100%	1/1	1	0	0
Mean Annual Takes (100% coverage)					**2**		**0**
Minimum total annual takes within U.S. EEZ							**0 (-)**

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2014~~2011~~ and 2018~~2015~~, eight~~11~~ bottlenose dolphins were observed hooked or entangled in the SSLL fishery (100% observer coverage), and three~~two~~ bottlenose dolphins were observed taken in the DSLL fishery (~~20~~18-22% observer coverage) (Bradford 2018a, 2018b, *in review*~~2017~~, Bradford and Forney 2017, McCracken 2019~~2017~~). Based on the locations, these takes are all considered to have been from the

Pelagic Stock of bottlenose dolphins. All ~~Ten of the~~ 11 dolphins were considered to have been seriously injured (Bradford ~~2017~~2018a, 2018b, *in review*, Bradford and Forney 2017), based on an evaluation of the observer's description of the interaction and following the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012). Average 5-yr estimates of annual mortality and serious injury for the Pelagic Stock during 2014-2018~~2011-2015~~ are 3.0~~4.2~~ (CV = 0.6~~0.9~~) bottlenose dolphins outside of U.S. EEZs, and 0 within the Hawaiian Islands EEZ (Table 1, McCracken 2019~~2017~~). Two~~Four~~ unidentified cetaceans, considered likely bottlenose dolphins based on the observer's description, were taken in the DSLL fishery, and three~~one~~ unidentified cetaceans was taken in the DSLL~~SSLL~~ fishery, some of which may have been bottlenose dolphins.

KAUAI/NIIHAU STOCK

POPULATION SIZE

A photo-identification study conducted from 2003 to 2005 identified 102 individual bottlenose dolphins around Kauai and Niihau (Baird *et al.* 2009). A Lincoln-Peterson mark-recapture analysis of the photo-identification data resulted in an abundance estimate of 147 (CV=0.11), or 184 animals when corrected for the proportion of marked individuals (Baird *et al.* 2009). The CV of this estimate is likely negatively-biased, as it does not account for variation in the proportion of marked animals within groups. There is no current abundance estimate for this stock.

Minimum Population Estimate

The minimum population estimate for the Kauai/Niihau stock of bottlenose dolphins is the number of distinctive individuals identified during 2012 to 2015 photo-identification studies, or 97 dolphins (Baird *et al.* 2017). The data used in the 2003-2005 mark-recapture estimate (Baird *et al.* 2009) are considered outdated, and therefore are not suitable for deriving a minimum abundance estimate.

Current Population Trend

Only one abundance estimate is available for this stock, such that there is insufficient information to assess population trends.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (97) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no reported fishery mortality or serious injury within the Kauai/Niihau stock range; Wade and Angliss 1997), resulting in a PBR of 1.0 bottlenose dolphins per year.

STATUS OF STOCK

The Kauai/Niihau Stock of bottlenose dolphins is not considered strategic under the 1994 amendments to the MMPA. The status of bottlenose dolphins in the Kauai/Niihau stock relative to OSP is unknown, and there are insufficient data to evaluate abundance trends. Bottlenose dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. There have been no reports of recent mortality or serious injuries; however, there is no systematic monitoring for interactions with protected species within near-shore fisheries that may take this species, thus mean annual takes are undetermined. Insufficient information is available to determine whether the total fishery mortality and serious injury for bottlenose dolphins is insignificant and approaching zero mortality and serious injury rate. One stranded bottlenose dolphin from the Kauaii/Niihau stock tested positive for *Morbillivirus* (Jacob *et al.* 2016). The presence of *morbillivirus* in 10 species of cetacean in Hawaiian waters (Jacob *et al.* 2016), raises concerns about the history and prevalence of this disease in Hawaii and the potential population impacts, including the cumulative impacts of disease with other stressors.

OAHU STOCK

POPULATION SIZE

A photo-identification study conducted in 2002, 2003 and 2006 identified 67 individual bottlenose dolphins around Oahu (Baird *et al.* 2009). A Lincoln-Peterson mark-recapture analysis of the photo-identification data resulted in an abundance estimate of 594 (CV=0.54), or 743 animals when corrected for the proportion of marked individuals (Baird *et al.* 2009). The estimate does not include individuals from the Northeastern (windward) side of the island. There is no current abundance estimate for this stock.

Minimum Population Estimate

There is no current minimum population estimate for the Oahu stock of bottlenose dolphins. The data used in the 2002-2006 mark-recapture estimate (Baird *et al.* 2009) are considered outdated, and therefore are not suitable for deriving a minimum abundance estimate, and the number of distinctive individuals identified during 2009 to 2012 photo-identification studies (Baird *et al.* 2017) is derived from insufficient survey effort to be considered a reasonable estimate of minimum population size.

Current Population Trend

Only one abundance estimate is available for this stock, such that there is insufficient information to assess population trends.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no reported fishery mortality in the stock range (Wade and Angliss 1997). Because there is no minimum population size estimate for this stock, the PBR is undetermined.

STATUS OF STOCK

The Oahu stock of bottlenose dolphins is not considered strategic under the 1994 amendments to the MMPA. The status of bottlenose dolphins in Oahu waters relative to OSP is unknown, and there are insufficient data to evaluate abundance trends. Bottlenose dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. There have been no reports of recent mortality or serious injuries; however, there is no systematic monitoring for interactions with protected species within near-shore fisheries that may take this species, thus mean annual takes are undetermined. Insufficient information is available to determine whether the total fishery mortality and serious injury for bottlenose dolphins is insignificant and approaching zero mortality and serious injury rate. *Morbilivirus* has been detected within other insular stocks of bottlenose dolphins in Hawaii (Jacob *et al.* 2016). The presence of *morbillivirus* in 10 species of cetacean in Hawaiian waters raises concerns about the history and prevalence of this disease in Hawaii and the potential population impacts, including the cumulative impacts of disease with other stressors.

4-ISLANDS STOCK
POPULATION SIZE

A photo-identification study conducted from 2000-2006 identified 98 individual bottlenose dolphins around Maui and Lanai (Baird *et al.* 2009). A Lincoln-Peterson mark-recapture analysis of the photo-identification data resulted in an abundance estimate of 153 (CV=0.24), or 191 animals when corrected for the proportion of marked individuals (Baird *et al.* 2009). This abundance estimate likely underestimates the total number of bottlenose dolphins in the 4-islands region because it does not include individuals from the Northeastern (windward) sides of Maui and Molokai. The CV of this estimate is likely negatively-biased, as it does not account for variation in the proportion of marked animals within groups. There is no current abundance estimate for this stock.

Minimum Population Estimate

There is no current minimum population estimate for the 4-Islands stock of bottlenose dolphins. The data used in the 2000-2006 mark-recapture estimate (Baird *et al.* 2009) are considered outdated, and therefore are not suitable for deriving a minimum abundance estimate, and the number of distinctive individuals identified during 2009 to 2012 photo-identification studies (Baird *et al.* 2017) is derived from insufficient survey effort to be considered a reasonable estimate of minimum population size.

Current Population Trend

Only one abundance estimate is available for this stock, such that there is insufficient information to assess population trends.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no reported fishery mortality in the 4-Islands stock area (Wade and Angliss 1997). Because there is no minimum population size estimate for this stock, the PBR is undetermined.

STATUS OF STOCK

The 4-Islands Region Stock of bottlenose dolphins is not considered strategic under the 1994 amendments to the MMPA. The status of bottlenose dolphins in 4-Islands waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Bottlenose dolphins are not listed as “threatened” or “endangered” under the Endangered Species Act (1973), nor as “depleted” under the MMPA. There have been no reports of recent mortality or serious injuries of this stock; however, there is no systematic monitoring for interactions with protected species within near-shore fisheries that may take this species, thus mean annual takes are undetermined. Insufficient information is available to determine whether the total fishery mortality and serious injury for bottlenose dolphins is insignificant and approaching zero mortality and serious injury rate. *Morbilivirus* has been detected within other insular stocks of bottlenose dolphins in Hawaii (Jacob *et al.* 2016). The presence of *morbillivirus* in 10 species of cetacean in Hawaiian waters raises concerns about the history and prevalence of this disease in Hawaii and the potential population impacts, including the cumulative impacts of disease with other stressors.

HAWAII ISLAND STOCK
POPULATION SIZE

A photo-identification study conducted from 2000-2006 identified 69 individual bottlenose dolphins around the island of Hawaii (Baird *et al.* 2009). A Lincoln-Peterson mark-recapture analysis of the photo-identification data resulted in an abundance estimate of 102 (CV=0.13), or 128 animals when corrected for the proportion of marked individuals (Baird *et al.* 2009). This abundance estimate likely underestimates the total number of bottlenose dolphins around the island of Hawaii because it does not include individuals from the Northeastern (windward) side of the island. The CV of this estimate is likely negatively-biased, as it does not account for variation in the proportion of marked animals within groups. There is no current abundance estimate for this stock.

Minimum Population Estimate

The minimum population estimate for the Hawaii Island bottlenose dolphins is the number of distinctive individuals identified during 2010 to 2013 photo-identification studies, or 91 dolphins (Baird *et al.* 2017). The data used in the 2000-2006 mark-recapture estimates (Baird *et al.* 2009) are considered outdated, and therefore are not suitable for deriving a minimum abundance estimate.

Current Population Trend

Only one abundance estimate is available for this stock, such that there is insufficient information to assess population trends.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size (91) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no reported fishery mortality in the Hawaii Islands stock area (Wade and Angliss 1997), resulting in a PBR of 0.9 bottlenose dolphins per year.

STATUS OF STOCK

The Hawaii Island Stock of bottlenose dolphins is not considered strategic under the 1994 amendments to the MMPA. The status of bottlenose dolphins in waters around Hawaii Island relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Hawaii Island bottlenose dolphins are regularly seen near aquaculture pens off the Kona coast, and aquaculture workers have been observed feeding bottlenose dolphins.

Bottlenose dolphins in this region are also known to interact with divers. Bottlenose dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. In the past 5 years, one animal was partially disentangled by a diver, but with hook and line remaining in its mouth was considered a serious injury. There is no systematic monitoring of takes in near-shore fisheries that may take this species, the single observed serious injury may be an underestimate of the total fishery mortality for this stock. Total fishery mortality and serious injury for Hawaii Island bottlenose dolphins is not approaching zero mortality and serious injury rate. *Morbilivirus* has been detected within other insular stocks of bottlenose dolphins in Hawaii (Jacob *et al.* 2016). The presence of *morbillivirus* in 10 species of cetacean in Hawaiian waters raises concerns about the history and prevalence of this disease in Hawaii and the potential population impacts, including the cumulative impacts of disease with other stressors.

HAWAII PELAGIC STOCK
POPULATION SIZE

Encounter data from ~~a 2010~~ shipboard line-transect surveys of the entire Hawaiian Islands EEZ were recently reevaluated for each survey year, resulting in the updated abundance estimates of bottlenose dolphins in the Hawaii EEZ (Bradford *et al. in review*) (Table 1).

Table 1. Line-transect abundance estimates for bottlenose dolphins derived from surveys of the entire Hawaii EEZ in 2002, 2010, and 2017 (Bradford *et al. in review*).

Year	Abundance	CV	95% Confidence Limits
2017	NA		
2010	25,188	0.58	8,791-72,168
2002	9,678	0.49	3,924-23,868

The updated design-based abundance estimates use sighting data from throughout the central Pacific to estimate the detection function and use Beaufort sea-state-specific trackline detection probabilities for bottlenose dolphins from Barlow *et al.* (2015). Although previous estimates from the Hawaii EEZ have been published using subsets of this data, Bradford *et al. (in review)* uses a consistent approach for estimating all abundance parameters and as such are considered the best available estimates for each survey year. There were no sightings of bottlenose dolphins during systematic survey effort in 2017 and therefore design-based estimates are not available for that survey year. Model-based abundance estimates are available for all survey years (Becker et al. *in review*), but are derived from sightings representing all bottlenose dolphins stocks within the Hawaiian islands, as removal of sightings of island-associated stock individuals would leave insufficient sample size to derive a robust model. Model covariates may not accurately reflect the habitat associations of pelagic bottlenose dolphins given the large number of insular sightings used in model development. Because the model is not stock-specific and pelagic stock abundance cannot be reliably extracted from model outputs, the design-based estimates are considered the best available for the pelagic stock. ~~using Beaufort sea-state-specific trackline detection probabilities for bottlenose dolphins, resulting in an abundance estimate of 21,815 (CV = 0.57) bottlenose dolphins (Bradford *et al.* 2017) in the Hawaii pelagic stock. A 2002 shipboard line-transect survey of the same region resulted in a density estimate of 1.31 individuals per 1000 km^2, such that when applied to the Pelagic Stock area (waters beyond the 1000 m isobath, (see Figures 1-2), the stock-specific abundance for 2002 was estimated as 3,178 (CV=0.59). Species abundances estimated from the 2002 HICEAS survey used pooled small dolphin, large dolphin, and large whale g(0) (the probability of sighting and recording an animal directly on the track line) estimates stratified by group size (Barlow 1995). Since then, Barlow (2015) developed a more robust method for estimating species-specific g(0) values that are adjusted for the Beaufort sea states that are encountered during a survey. This new method was used for analyzing the data from the 2010 survey, but has not yet been used to analyze the 2002 data.~~

Minimum Population Estimate

There is no current minimum population estimate for the Hawaii pelagic stock of bottlenose dolphins. The 2010 estimate is considered outdated, and therefore are not suitable for deriving a minimum abundance estimate. ~~The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) of the 2010 line-transect abundance estimate for the Hawaii Pelagic Stock, or 13,957 bottlenose dolphins.~~

Current Population Trend

The available abundance estimates for this stock have very broad and overlapping confidence intervals, precluding robust evaluation of population trend for this stock. ~~Abundance analyses of the 2002 and 2010 datasets used different g(0) values. The 2002 survey data have not been reanalyzed using this method. This change precludes evaluation of population trends at this time. Assessment of population trend will likely require additional survey data and reanalysis of all datasets using comparable methods.~~

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size within the U.S EEZ of the Hawaiian Islands ~~(13,957)~~ times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.5 (for a stock of unknown status with a Hawaiian Islands EEZ fishery mortality and serious injury rate CV of 0; Wade and Angliss 1997). ~~, resulting in a PBR of 140 bottlenose dolphin per year~~. Because there is no minimum population size estimate for this stock, the PBR is undetermined.

STATUS OF STOCK

The Hawaii Pelagic Stock of bottlenose dolphins is not considered strategic under the 1994 amendments to the MMPA. The status of bottlenose dolphins in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. It is not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Although the PBR for this stock is undetermined, ~~T~~the estimated rate of fisheries related mortality or serious injury within the Hawaiian Islands EEZ is zero. ~~(0 animals per year) is less than the PBR (140)~~. The total fishery mortality and serious injury for Hawaii pelagic bottlenose dolphins is insignificant and approaching zero mortality and serious injury rate. *Morbilivirus* has been detected within other insular stocks of bottlenose dolphins in Hawaii (Jacob *et al.* 2016). The presence of *morbillivirus* in 10 species of cetacean in Hawaiian waters raises concerns about the history and prevalence of this disease in Hawaii and the potential population impacts, including the cumulative impacts of disease with other stressors.

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PANTROPICAL SPOTTED DOLPHIN (*Stenella attenuata attenuata*): Hawaiian Islands Stock Complex – Oahu, 4-Islands, Hawaii Island, and Hawaii Pelagic Stocks

STOCK DEFINITION AND GEOGRAPHIC RANGE

Pantropical spotted dolphins are primarily found in tropical and subtropical waters worldwide (Perrin *et al.* 2009). Much of what is known about the species in the North Pacific has been learned from specimens obtained in the large directed fishery in Japan and in the eastern tropical Pacific (ETP) tuna purse-seine fishery (Perrin *et al*. 2009). Spotted dolphins are common and abundant throughout the Hawaiian archipelago, including nearshore where they are the second most frequently sighted species during nearshore surveys (Baird *et al*. 2013). Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands resulted in 14 sightings in 2002, ~~and~~ 49 sightings in 2010, and 25 sightings in 2017 (Barlow 2006, Bradford *et al*. 2017, Yano *et al.* 2018; Figure 1). Morphological differences and distribution patterns indicate that the spotted dolphins around the Hawaiian Islands belong to a stock that is distinct from those in the ETP (Perrin 1975; Dizon *et al.* 1994; Perrin *et al*. 1994b).

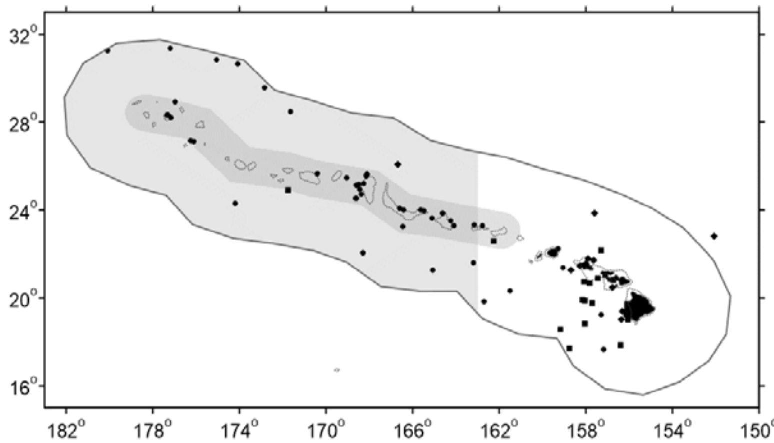

Figure 1. Pantropical spotted dolphin sighting locations during the 2002 (~~open~~ diamonds), ~~and~~ 2010 (~~black diamonds~~circle), and 2017 (square) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford *et al*. 2017, Yano et al 2018~~; see Appendix 2 for details on timing and location of survey effort~~). Outer line represents approximate boundary of survey area and U.S. EEZ. Dark g~~G~~ray shading indicates ~~area of~~ the original Papahanaumokuakea Marine National Monument, with the lighter gray shading denoting the full 2016 Expansion area. Dotted line represents the 1000 m isobath. Insular stock boundaries are shown in Figure 2.

Pantropical spotted dolphins have been observed in all months of the year around the main Hawaiian Islands, and in areas ranging from shallow near-shore water to depths of 5,000 m, although they peak in sighting rates in depths from 1,500 to 3,500 m (Baird *et al.* 2013). Although they represent from 22.9 to 26.5% of the odontocete sightings from Oahu, the 4-islands, and Hawaii Island, they are largely absent from the nearshore waters around Kauai and Niihau, representing only 3.9% of sightings in that area (Baird *et al.* 2013). Genetic analyses of 176 unique samples of pantropical spotted dolphins collected during near-shore surveys off each of the main Hawaiian Islands from 2002 to 2003, and near Hawaii Island from 2005 through 2008 suggest three island-associated stocks are evident (Courbis *et al*. 2014). The results of the Courbis *et al*. (2014) study indicate that pantropical spotted dolphins in Hawaii's nearshore waters have low haplotypic

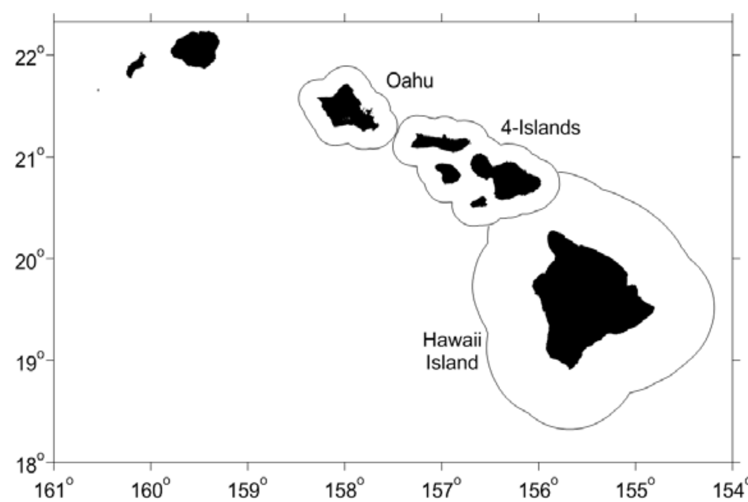

Figure 2. Main Hawaiian Islands insular spotted dolphin stock boundaries (gray lines). Oahu and 4-Islands stocks extend 20 km from shore. Hawaii Island stock extends to 65km from shore based on distance of furthest encounter.

diversity with haplotypes unique to each of the island areas. Courbis *et al*. (2014) conducted extensive tests on the relatedness of individuals among islands using the microsatellite dataset and found significant differences in haplotype frequencies between islands, suggesting genetic differentiation in spotted dolphins among islands. This suggestion is supported by the results of assignments tests, which indicate support for 3 island-associated populations: Hawaii Island, the 4-Islands region, and Oahu. Samples from Kauai and Niihau did not cluster together, but instead were spread among the Hawaii and Oahu clusters. Analysis of migration rate further support the separation of pantropical spotted dolphins into three island-associated stocks, with migration between regions on the order of a few individuals per generation. Based on an overview of all available information on pantropical spotted dolphins in Hawaiian waters, and NMFS guidelines for assessing marine mammal stocks (NMFS 2005), Oleson *et al.* (2013) proposed designation of three new island associated stocks in Hawaiian waters, as well as recognition of a fourth broadly distributed spotted dolphin stock given the frequency of sightings in pelagic waters. Fishery interactions with pantropical spotted dolphins and sightings near Palmyra and Johnston Atolls (NMFS PIR unpublished data) demonstrate that this species also occurs in U.S. EEZ waters there, but it is not known whether these animals are part of the Hawaiian population or are a separate stock or stocks of pantropical spotted dolphins.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there are four Pacific management stocks within the Hawaiian Islands EEZ (Oleson *et al.* 2013): 1) the Oahu stock, which includes spotted dolphins within 20km of Oahu, 2) the 4-Island stock, which includes spotted dolphins within 20 km of Maui, Molokai, Lanai, and Kahoolawe collectively, 3) the Hawaii Island stock, which includes spotted dolphins found within 65km from Hawaii Island, and 4) the Hawaii pelagic stock, which includes spotted dolphins inhabiting the waters throughout the Hawaiian Islands EEZ, outside of the insular stock areas, but including adjacent high seas waters. Because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of the Hawaii pelagic stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005). Spotted dolphins involved in eastern tropical Pacific tuna purse-seine fisheries are managed separately under the MMPA.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Entanglement in gillnets and hooking or entanglement in various hook and line fisheries have been reported for small cetaceans in Hawaii (Nitta and Henderson 1993). No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line or gillnet fisheries because these fisheries are not observed or monitored for protected species bycatch. Commercial and recreational troll fisherman have been observed "fishing" dolphins off the islands of Hawaii, Lanai, and Oahu, including spotted dolphins, in order to catch tuna associated with the animals (Courbis *et al*. 2009, Rizzuto 2007, Shallenberger 1981). Anecdotal reports from fisherman indicate that spotted dolphins are sometimes hooked (Rizzuto 1997) and photographs of dolphins suggest animals may be injured by both lines and propeller strikes (Baird unpublished data). ~~In 2010 a spotted dolphin (4-Islands stock) was observed entangled in fishing line off Lanai, with several wraps of line around the body and peduncle and a constricting wrap around the dorsal fin (Bradford and Lyman 2015).~~ In 2014, a spotted dolphin (Hawaii Island stock) was observed hooked above the jaw and trailing 8-10 feet of fishing line (Bradford and Lyman 2018~~*in review*~~). In 2017, a spotted dolphin (4 Islands stock) was spotted near Lanai with a band of debris around it rostrum preventing it from opening its mouth (Bradford and Lyman 2019). Based on the information provided, both of these injuries are considered serious injuries. The responsible fishery is not known for either case.

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2014~~2011~~ and 2018~~2015~~, no pantropical spotted dolphins were observed hooked or entangled in the SSLL fishery (100% observer coverage) or in the DSLL fishery (18~~20~~-21% observer coverage) (Bradford 2018a, 2018b, *in review*~~2017~~, Bradford and Forney 2017~~, McCracken 2017~~). Three~~Four~~ additional unidentified delphinids ~~cetaceans~~ were taken in the DSLL fishery~~, and one unidentified cetacean was taken in the SSLL fishery~~, some of which may have been spotted dolphins.

OAHU STOCK

POPULATION SIZE

The population size of the Oahu stock of spotted dolphins has not been estimated.

Minimum Population Estimate

There is no information on which to base a minimum population estimate of the Oahu stock of spotted dolphins.

Current Population Trend

No data are available on current population trend.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Oahu stock is calculated as the minimum population estimate 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 estimated fishery mortality or serious injury within the Oahu stock area; Wade and Angliss 1997). Because there is no minimum population estimate available the PBR for Oahu stock of spotted dolphins is undetermined.

STATUS OF STOCK

The Oahu stock of spotted dolphins is not considered a strategic stock under the MMPA. The status of Oahu spotted dolphins relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance for this stock. Spotted dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. There is no information with which to determine whether the total fishery mortality and serious injury for this stock is insignificant and approaching zero mortality and serious injury rate. *Morbilivirus* has been detected within other insular stocks of pantropical spotted dolphins in Hawaii (Jacob *et al*. 2016). The presence of *morbillivirus* in 10 species of cetacean in Hawaiian waters raises concerns about the history and prevalence of this disease in Hawaii and the potential population impacts, including the cumulative impacts of disease with other stressors.

4-ISLANDS STOCK

POPULATION SIZE

The population size of 4-Islands stock of spotted dolphins has not been estimated.

Minimum Population Estimate

There is no information on which to base a minimum population estimate of the 4-Islands stock of spotted dolphins.

Current Population Trend

No data are available on current population trend.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the 4-Islands stock is calculated as the minimum population estimate 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 estimated fishery mortality or serious injury within the 4-Islands stock area;

Wade and Angliss 1997). Because there is no minimum population estimate available for this stock the PBR for 4-Islands stock of spotted dolphins is undetermined.

STATUS OF STOCK

The 4-Islands stock of spotted dolphins is not considered a strategic stock under the MMPA. The status of 4-Islands spotted dolphins relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance for this stock. Spotted dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. There are insufficient data are available to determine whether the total fishery mortality and serious injury for this stock is insignificant and approaching zero mortality and serious injury rate. *Morbilivirus* has been detected within other insular stocks of pantropical spotted dolphins in Hawaii (Jacob *et al.* 2016). The presence of *morbillivirus* in 10 species of cetacean in Hawaiian waters raises concerns about the history and prevalence of this disease in Hawaii and the potential population impacts, including the cumulative impacts of disease with other stressors.

HAWAII ISLAND STOCK

POPULATION SIZE

The population size of the Hawaii Island stock of spotted dolphins has not been estimated. An extensive collection of identification photos from this population are available; however, a photo-identification catalog has not been developed. Such a catalog could serve as the basis for developing mark-recapture estimates, but no such analyses have yet been conducted.

Minimum Population Estimate

There is no information on which to base a minimum population estimate of the Hawaii Island stock of spotted dolphins.

Current Population Trend

No data are available on current population trend.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii Island stock is calculated as the minimum population estimate 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 estimated fishery mortality or serious injury within the Hawaii Island stock area; Wade and Angliss 1997). Because there is no minimum population estimate available for this stock the PBR for Hawaii Island stock of spotted dolphins is undetermined.

STATUS OF STOCK

The Hawaii Island stock of spotted dolphins is not considered a strategic stock under the MMPA. The status of Hawaii Island spotted dolphins relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance for this stock. Spotted dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Although one dolphin has been considered serious injured due to an interaction with fishing gear, there are insufficient data to determine whether the total fishery mortality and serious injury for this stock is insignificant and approaching zero mortality and serious injury rate. One spotted dolphin found stranded on Hawaii Island has tested positive for *Morbillivirus* (Jacob *et al.* 2016). The presence of *morbillivirus* in 10 species of cetacean in Hawaiian waters (Jacob 2012) raises concerns about the history and prevalence of this disease in Hawaii and the potential population impacts, including the cumulative impacts of disease with other stressors.

HAWAII PELAGIC STOCK

POPULATION SIZE

Encounter data from ~~a 2010~~ shipboard line-transect surveys of the entire Hawaiian Islands EEZ were recently reevaluated for each survey year, resulting in the following abundance estimates of spotted dolphins in the Hawaii EEZ (Bradford *et al. in review*) (Table 1).

Table 1. Line-transect abundance estimates for spotted dolphins derived from surveys of the entire Hawaii EEZ in 2002, 2010, and 2017 (Bradford *et al. in review*).

Year	Abundance	CV	95% Confidence Limits
2017	39,798	0.51	15,432-102,637
2010	49,488	0.39	23,551-103,992
2002	16,931	0.65	23,551-103,992

The updated design-based abundance estimates use sighting data from throughout the central Pacific to estimate the detection function and use Beaufort sea-state-specific trackline detection probabilities for spotted dolphins from Barlow *et al.* (2015). Although previous estimates from the Hawaii EEZ have been published using subsets of this data, Bradford *et al.* (*in review*), uses a consistent approach for estimating all abundance parameters and resulting estimates are considered the best available. Model-based abundance estimates are available for all survey years (Becker et al. *in review*), but are derived from sightings representing all spotted dolphin stocks within the Hawaiian islands, as removal of sightings of island-associated stock individuals would leave insufficient sample size to derive a robust model. Model covariates may not accurately reflect the habitat associations of pelagic spotted dolphins given the large number of insular sightings used in model development. Because the model is not stock-specific and pelagic stock abundance cannot be reliably extracted from model outputs, the design-based estimates are considered the best available for the pelagic stock. The best estimate of abundance for this stock is from the 2017 survey, or 39,798 (CV=0.51). ~~Encounter data from a 2010 shipboard line-transect survey of the entire Hawaiian Islands EEZ was recently evaluated using Beaufort sea-state-specific trackline detection probabilities for spotted dolphins, resulting in an abundance estimate of 55,795 (CV = 0.40) spotted dolphins (Bradford *et al.* 2017) in the Hawaii pelagic stock. A 2002 shipboard line-transect survey of the same area resulted in an abundance estimate of 8,978 (CV=0.48) pantropical spotted dolphins (Barlow 2006). Species abundances estimated from the 2002 HICEAS survey used pooled small dolphin, large dolphin, and large whale g(0) (the probability of sighting and recording an animal directly on the track line) estimates stratified by group size (Barlow 1995). Since then, Barlow (2015) developed a more robust method for estimating species-specific g(0) values that are adjusted for the Beaufort sea states that are encountered during a survey. This new method was used for analyzing the data from the 2010 survey, but has not yet been used to analyze the 2002 data.~~ Population estimates are available for Japanese waters (Miyashita 1993), but it is not known whether any of these animals are part of the same population that occurs around the Hawaiian Islands.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) of the 2017~~2010~~ abundance estimate for the pelagic stock area or 26,548 ~~40,338~~ pantropical spotted dolphins.

Current Population Trend

The three available abundance estimates for this stock have very broad and overlapping confidence intervals, precluding robust evaluation of population trend for this stock.~~Abundance analyses of the 2002 and 2010 datasets used different g(0) values. The 2002 survey data have not been reanalyzed using this method. This change precludes evaluation of population trends at this time. Assessment of population trend will likely require additional survey data and reanalysis of all datasets using comparable methods.~~

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii pelagic pantropical spotted dolphin stock is calculated as the minimum population estimate within the U.S. EEZ of the Hawaiian Islands (26,548~~40,338~~) 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 within the U.S. EEZ of the Hawaiian Islands; Wade and Angliss 1997), resulting in a PBR of 265 ~~403~~ pantropical spotted dolphins per year.

STATUS OF STOCK

The Hawaii pelagic stock of spotted dolphins is not considered strategic under the 1994 amendments to the MMPA. The status of Hawaii pelagic pantropical spotted dolphins relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Pantropical spotted dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Given the absence of recent recorded fishery-related mortality or serious injuries within U.S. EEZs, the total fishery mortality and serious injury can be considered to be insignificant and approaching zero. *Morbilivirus* has been detected within other insular stocks of bottlenose dolphins in Hawaii (Jacob *et al.* 2016). The presence of *morbillivirus* in 10 species of cetacean in Hawaiian waters raises concerns about the history and prevalence of this disease in Hawaii and the potential population impacts, including the cumulative impacts of disease with other stressors.

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Revised ~~6/1/2018~~ 8/25/2020

STRIPED DOLPHIN (*Stenella coeruleoalba*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Striped dolphins are found in tropical to warm-temperate waters throughout the world (Perrin et al. 2009). Sightings have historically been infrequent in shallow~~nearshore~~ waters (Shallenberger 1981, Mobley et al. 2000), though they are common, even nearshore in waters greater than 3500m (Baird 2016)~~, Baird et al 2013~~). Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands, resulted in 15 sightings of striped dolphins in 2002, ~~and~~ 29 in 2010, and 27 in 2017 (Figure 1; Barlow 2006, Bradford *et al*. 2017, Yano *et al*. 2018).

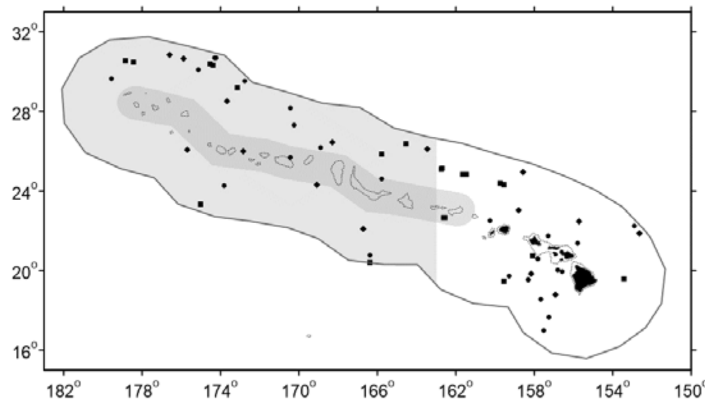

Figure 1. Striped dolphin sighting locations during the 2002 (~~open~~ diamonds), ~~and~~ 2010 (~~black diamonds~~circles), and 2017 (squares) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2017, Yano *et al*. 2018~~; see Appendix 2 for details on timing and location of survey effort~~). Outer line represents approximate boundary of survey area and U.S. EEZ. Dark~~l~~ g~~G~~ray shading indicates the original ~~area of~~ Papahanaumokuakea Marine National Monument, with the lighter gray shading denoting the full 2016 Expansion area. Dotted line represents the 1000 m isobath.

Striped dolphins have been intensively exploited in the western North Pacific, where three migratory stocks are provisionally recognized (Kishiro and Kasuya 1993). In the eastern tropical Pacific all striped dolphins are provisionally considered to belong to a single stock (Dizon *et al*. 1994). There is insufficient data to examine finer stock structure within Hawaiian waters, though data available to date do not suggest island-associated populations for this species (Baird 2016).

For the Marine Mammal Protection Act (MMPA) stock assessment reports, striped dolphins within the Pacific U.S. EEZ are divided into two discrete, non-contiguous areas: 1) waters off California, Oregon and Washington, and 2) waters around Hawaii (this report), including animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters. Because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of the Hawaii stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005). Striped dolphins involved in eastern tropical Pacific tuna purse-seine fisheries are managed separately under the MMPA.

POPULATION SIZE

Encounter data from ~~a 2010~~ shipboard line-transect surveys of the entire Hawaiian Islands EEZ was recently reevaluated, resulting in model-based abundance estimates of striped dolphins in the Hawaii EEZ (Becker *et al*. in review) (Table 1).

Table 1. Line-transect abundance estimates for striped dolphins derived from surveys of the entire Hawaii EEZ in 2002, 2010, and 2017 (Becker *et al*. in review).

Year	Model-based abundance	CV	95% Confidence Limits
2017	35,179	0.23	22,416-55,209
2010	36,886	0.22	24,004-56,681
2002	35,817	0.22	23,384-54,861

Sighting data from 2002 to 2017 within the Hawaii EEZ were used to derive habitat-based models of animal density for the overall period. The models were then used to predict density and abundance for each survey year based on the environmental conditions within that year (see Forney et al. 2015, Becker et al. 2016). The modeling framework incorporated Beaufort-specific trackline detection probabilities for striped dolphins from Barlow et al. (2015). Bradford et al. (*in review*) produced design-based abundance estimates for striped dolphins for each survey year that can be used as a point of comparison to the model-based estimates. While on average, the estimates are broadly similar between the two approaches, the annual design-based estimates show much greater variability between years than do the model-based estimates (Figure 2). The model-based approach reduces variability through explicit examination of habitat relationships across the full dataset, while the design-based approach evaluates encounter data for each year separately and thus is more susceptible to the effects of encounter rate variation. Model based-estimates are based on the implicit assumption that changes in abundance are attributed to environmental variability alone due to a lack of data to test for other effects. Despite not fully accounting for inter-annual variation in total abundance, the model-based estimates are considered the best available estimate for each survey year. Previously published design-based estimates for the Hawaii EEZ from 2002 and 2010 surveys (e.g. Barlow 2006, Bradford et al. 2017) used a subset of the dataset used by Becker et al. (*in review*) and Bradford et al. (*in review*) to derive line-transect parameters, such that these estimates have been superseded by the estimates presented here. The best estimate of abundance is based on the 2017 survey, or 35,179 (CV=0.23). ~~using Beaufort sea-state-specific trackline detection probabilities for striped dolphins, resulting in an abundance estimate of 61,021 (CV = 0.38) striped dolphins (Bradford et al. 2017) in the Hawaii stock. A 2002 shipboard line-transect survey of the same area resulted in an abundance estimate of 13,143 (CV=0.46) striped dolphins (Barlow 2006). Abundance analyses of the 2002 and 2010 datasets used different g(0) values. Species abundances estimated from the 2002 HICEAS survey used pooled small dolphin, large dolphin, and large whale g(0) (the probability of sighting and recording an animal directly on the track line) estimates stratified by group size (Barlow 1995). Since then, Barlow (2015) developed a more robust method for estimating species-specific g(0) values that are adjusted for the Beaufort sea states that are encountered during a survey. This new method was used for analyzing the data from the 2010 survey, but has not yet been used to analyze the 2002 data.~~

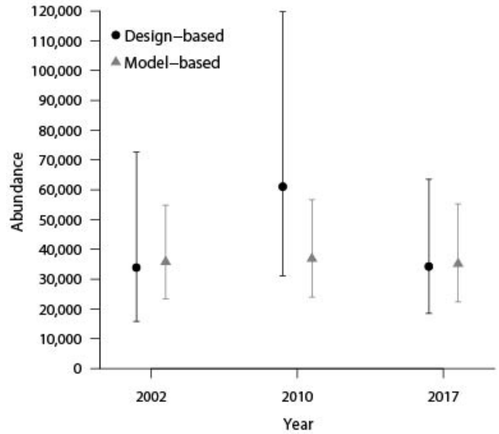

Figure 2. Comparison of design-based (circles, Bradford et al. *in review*) and model-based (triangles, Becker et al.*in* review) estimates of abundance for striped dolphins for each survey year (2002, 2010, 2017).

Population estimates are available for Japanese waters (Miyashita 1993) and the eastern tropical Pacific (Wade and Gerrodette 1993), but it is not known whether any of these animals are part of the same population that occurs around the Hawaiian Islands.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al. 1995) of the 2017~~2010~~ abundance estimate, or 29,058~~44,922~~ striped dolphins.

Current Population Trend

The model-based abundance estimates for striped dolphins provided by Becker *et al.* (*in review*) do not explicitly allow for examination of population trend other than that driven by environmental factors. Model-based examination of striped dolphin population trends including sighting data beyond the Hawaii EEZ will be required to more fully examine trend for this stock. ~~Abundance analyses of the 2002 and 2010 datasets used different g(0) values. The 2002 survey data have not been reanalyzed using this method. This change precludes evaluation of population trends at this time. Assessment of population trend will likely require additional survey data and reanalysis of all datasets using comparable methods.~~

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii stock of striped dolphins is calculated as the minimum population size within the U.S. EEZ of the Hawaiian Islands (29,058~~44,922~~) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.5 (for a stock of unknown status with no known fishery mortality and serious injury within the Hawaiian Islands EEZ; Wade and Angliss 1997), resulting in a PBR of 291~~449~~ striped dolphins per year.

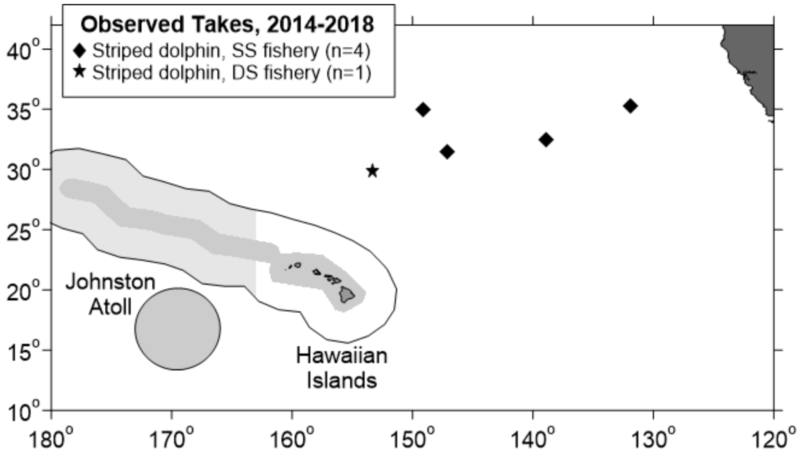

Figure 3~~2~~. Locations of striped dolphin takes ~~(filled diamonds)~~ in Hawaii-based longline fisheries, 2014-2018~~2011-2015~~. Solid lines represent the U.S. EEZs. Gray shading notes areas closed to longline fishing. ~~Fishery descriptions are provided in Appendix 1.~~

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Information on fishery-related mortality and serious injury of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Entanglement in gillnets and hooking or entanglement in various hook and line fisheries have been reported for small cetaceans in Hawaii (Nitta & Henderson, 1993). ~~One striped dolphin stranded entangled in fishing gear in 2005, but the responsible fishery cannot be determined, as the entangled gear was not described (NMFS PIR MMRN).~~ No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line or gillnet fisheries because these fisheries are not observed or monitored for protected species bycatch. There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2014~~2011~~ and 2018~~2015~~, two~~one~~ striped dolphins were~~was~~ seriously injured, one not seriously injured, and one could not be determined based on the information provided by the observer in the SSLL fishery (100% observer coverage), and one striped dolphin was ~~killed and one not~~ seriously injured in the DSLL fishery (~~20~~18-21% observer coverage) (Figure 3~~2~~, ~~Bradford 2017~~ Bradford 2018a, 2018b, *in review*, Bradford and Forney 2017, McCracken 2019~~2017~~). All striped dolphin interactions occurred outside of the U.S. EEZs. Average 5-yr estimates of annual mortality and serious injury for 2014-2018~~2011-2015~~ are ~~1.7~~0.4 (CV = 1.0) dolphins outside of U.S. EEZs, and zero within the Hawaiian Islands EEZ (Table ~~1~~2). Three~~Four~~ additional unidentified cetaceans were taken in the DSLL fishery~~, and one unidentified cetacean was taken in the SSLL fishery~~, some of which may have been striped dolphins.

Table ~~1~~2. Summary of available information on incidental mortality and serious injury of striped dolphin (Hawaii stock) in commercial longline fisheries, within and outside of U.S. EEZs (McCracken 2019~~2017~~). Mean annual takes are based on 2014-2018~~2011-2015~~ data unless otherwise indicated. Information on all observed takes (T) and combined mortality events & serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome.

Fishery Name	Year	Data Type	Percent Observer Coverage	Observed total interactions (T) and mortality events, and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) of striped dolphins			
				Outside U.S. EEZs		Hawaiian EEZ	
				Obs. T/MSI	Estimated M&SI (CV)	Obs. T/MSI	Estimated M&SI (CV)
Hawaii-based deep-set longline fishery	~~2011~~	Observer data	~~20%~~	~~1/1~~	~~3 (0.8)~~	~~0~~	~~0 (-)~~
	~~2012~~		~~20%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
	~~2013~~		~~20%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
	2014		21%	0	0 (-)	0	0 (-)

	2015		21%	1/0	3 (1.1)	0	0 (-)
	2016		20%	0	0 (-)	0	0 (-)
	2017		20%	0	0 (-)	0	0 (-)
	2018		18%	0	0 (-)	0	0 (-)
Mean Estimated Annual Take (CV)					**~~1.1~~0.4 (1.0)**		**0 (-)**
Hawaii-based shallow-set longline fishery	~~2011~~	Observer data	~~100%~~	~~0~~	~~0~~	~~0~~	~~0~~
	~~2012~~		~~100%~~	~~1/0~~	~~0~~	~~0~~	~~0~~
	~~0213~~		~~100%~~	~~0~~	~~0~~	~~0~~	~~0~~
	2014		100%	2/2[†]	2	0	0
	2015		100%	0	0	0	0
	2016		100%	1/1	2	0	0
	2017		100%	1/0	1	0	0
	2018		100%	0	0	0	0
Mean Annual Takes (100% coverage)					**~~0.6~~0.5**		**0**
Minimum total annual takes within U.S. EEZ							**0 (-)**

[†] Injury status could not be determined based on information collected by the observer. Injury status is prorated (see text).

STATUS OF STOCK

The Hawaii stock of striped dolphins is not considered strategic under the 1994 amendments to the MMPA. The status of striped dolphins in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Striped dolphins are not listed as “threatened” or “endangered” under the Endangered Species Act (1973), nor designated as “depleted” under the MMPA. Given the absence of recent recorded fishery-related mortality or serious injuries in U.S. EEZ waters, total fishery mortality and serious injury for striped dolphins can be considered insignificant and approaching zero. One striped dolphin stranded in the main Hawaiian Islands tested positive for *Brucella* (Chernov 2010) and two for *Morbillivirus* (Jacob et al. 2016). *Brucella* is a bacterial infection that if common in the population may limit recruitment by compromising male and female reproductive systems, and can also cause neurological disorders that may result in death (Van Bressem et al. 2009). Although *morbillivus* is known to trigger lethal disease in cetaceans (Van Bressem et al. 2009), its impact on the health of the stranded animals is not known as it was found in only a one tested tissue within each animal (Jacob et al. 2016). The presence of *Morbillivirus* in 10 species (Jacob et al. 2016) and *Brucella* in 3 species (Cherbov 2010, West unpublished data) raises concerns about the history and prevalence of these diseases in Hawaii and the potential population impacts on Hawaiian cetaceans. It is not known if *Brucella* or *Morbillivirus* are common in the Hawaii stock.

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Revised ~~5/31/2018~~ 8/4/2020

FRASER'S DOLPHIN (*Lagenodelphis hosei*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Fraser's dolphins are distributed worldwide in tropical waters (Dolar 2009 in Perrin et al. 2009). The~~y~~ species was first ~~have only recently been~~ documented within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands~~,~~ during a 2002 cetacean survey (Barlow 2006) and have been occasionally observed during surveys of Hawaiian waters since that time (~~, and were seen 4 times during a similar 2010 survey~~ (Bradford et al. 2017, Yano et al. 2018 Figure 1). There have been only ~~2~~4 sightings of Fraser's dolphins during ~~13 years of~~ nearshore surveys in the leeward main Hawaii Islands since the early 2000s (Baird et al. 2013).

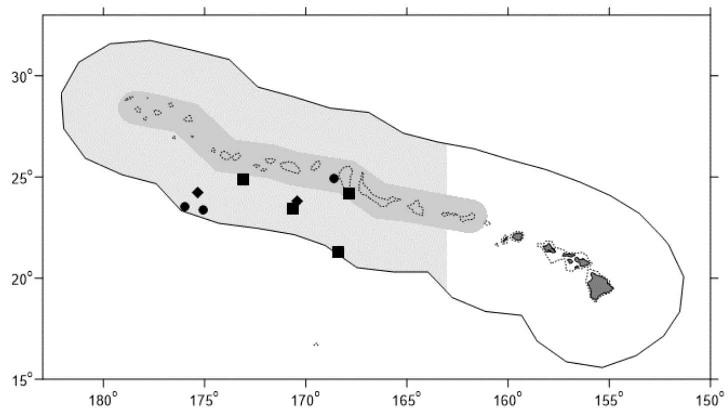

Figure 1. Fraser's dolphin sighting locations during the 2002 (~~open~~ diamond~~s~~), ~~and~~ 2010 (~~black diamonds~~circle), and 2017 (square) shipboard cetacean surveys of U.S. waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2017, Yano et al. 2018~~; see Appendix 2 for details on timing and location of survey effort~~). Outer line indicates approximate boundary of survey area and U.S. EEZ.~~a~~ Dark ~~G~~gray shading indicates original ~~area of~~ Papahanaumokuakea Marine National Monument, with the lighter gray shading denoting the full 2016 Expansion area. Dotted line represents the 1000 m isobath.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there is a single Pacific management stock including animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters. Because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

Encounter data from ~~a 2010~~ shipboard line-transect surveys of the entire Hawaiian Islands EEZ was recently reevaluated for each survey year, resulting in the following abundance estimates of Fraser's dolphins in the Hawaii EEZ (Bradford et al. *in review*) (Table 1).

Table 1. Line-transect abundance estimates for Fraser's dolphins derived from surveys of the entire Hawaii EEZ in 2002, 2010, and 2017 (Bradford et al. *in review*).

Year	Abundance	CV	95% Confidence Limits
2017	40,960	0.70	11,887-141,143
2010	56,688	0.70	16,391-196,056
2002	28,980	1.02	5,518-152,195

The updated design-based abundance estimates use sighting data from throughout the central Pacific to estimate the detection function and use Beaufort sea-state-specific trackline detection probabilities for Fraser's dolphins from Barlow et al. (2015). Although previous estimates from the Hawaii EEZ have been published using subsets of this data, Bradford et al. (*in review*), uses a consistent approach for estimating all abundance parameters and resulting estimates are considered the best available. The best estimate of abundance is based on a 2017 survey, or 40,960 (CV=0.70). ~~using Beaufort sea-state-specific trackline detection probabilities for bottlenose dolphins, resulting in an abundance estimate of 51,491 (CV = 0.66) Fraser's dolphins (Bradford et al. 2017) in the Hawaii stock. A 2002 shipboard line-transect survey of the same area resulted in an abundance estimate of 10,226 (CV=1.16) Fraser's~~

~~dolphins (Barlow 2006). Species abundances estimated from the 2002 HICEAS survey used pooled small dolphin, large dolphin, and large whale g(0) (the probability of sighting and recording an animal directly on the track line) estimates stratified by group size (Barlow 1995). Since then, Barlow (2015) developed a more robust method for estimating species-specific g(0) values that are adjusted for the Beaufort sea states that are encountered during a survey. This new method was used for analyzing the data from the 2010 survey, but has not yet been used to analyze the 2002 data.~~ Population estimates for Fraser's dolphins have been made in the eastern tropical Pacific (Wade and Gerrodette 1993), but it is not known whether these animals are part of the same population that occurs around the Hawaiian Islands and in the central North Pacific.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al. 1995) of the 2017 ~~2010~~ abundance estimate or 24,068 ~~31,034~~ Fraser's dolphins.

Current Population Trend

The three available abundance estimates for this stock have very broad and overlapping confidence intervals, precluding robust evaluation of population trend for this stock. ~~Abundance analyses of the 2002 and 2010 datasets used different g(0) values. The 2002 survey data have not been reanalyzed using this method. This change precludes evaluation of population trends at this time. Assessment of population trend will likely require additional survey data and reanalysis of all datasets using comparable methods.~~

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for Fraser's dolphins.~~Abundance analyses of the 2002 and 2010 datasets used different g(0) values. The 2002 survey data have not been reanalyzed using this method. This change precludes evaluation of population trends at this time. Assessment of population trend will likely require additional survey data and reanalysis of all datasets using comparable methods.~~

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii stock of Fraser's dolphin is calculated as the minimum population size within the U.S. EEZ of the Hawaiian Islands (24,068 ~~31,034~~) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no known fishery mortality or serious injury within the Hawaiian Islands EEZ; Wade and Angliss 1997), resulting in a PBR of 241 ~~310~~ Fraser's dolphins per year.

HUMAN CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Information on fishery-related mortality and serious injury of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. No interactions between nearshore fisheries and Fraser's dolphins have been reported in Hawaiian waters. There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2014 ~~2011~~ and 2018 ~~2015~~, no Fraser's dolphins were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-21% observer coverage) (Bradford ~~2017,~~ 2018a, 2018b, *in review*, Bradford and Forney 2017, McCracken 2019 ~~2017~~). There were ~~However,~~ two ~~four~~ other unidentified cetaceans ~~were~~ taken in the DSLL fishery during this period, ~~and one unidentified cetacean was taken in the SSLL fishery, some of~~ which may have been Fraser's dolphins.

STATUS OF STOCK

The Hawaii stock of Fraser's dolphins is not considered strategic under the 1994 amendments to the MMPA. The status of Fraser's dolphins in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this stock. Fraser's dolphins are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Given the absence of recent recorded fishery-related mortality or serious injuries the total fishery mortality and serious injury can be considered to be insignificant and approaching zero.

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Revised ~~5/31/2018~~ 8/25/2020

MELON-HEADED WHALE (*Peponocephala electra*): Hawaiian Islands Stock Complex: Hawaiian Islands & Kohala Resident Stocks

STOCK DEFINITION AND GEOGRAPHIC RANGE

Melon-headed whales are found in tropical and warm-temperate waters throughout the world. Although largely considered oceanic, photo-identification studies and other lies of evidence indicate the presence of island-associated population in several locations (Brownell 2009). ~~The distribution of reported sightings suggests that the oceanic habitat of this species is primarily equatorial waters (Perryman *et al.* 1994).~~ Small numbers have been taken in the tuna purse-seine fishery in the eastern tropical Pacific, and they are occasionally killed in direct fisheries in Japan and elsewhere in the western Pacific. Melon-headed whales in Hawaiian waters appear to prey primarily upon a large diversity of cephalopods, ad fish species (West et al. 2018). Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands resulted in one sighting in~~during~~ 2002, one in ~~and~~ 2010, and seven in 2017 ~~resulted in only one sighting each year~~ (Figure 1; Barlow 2006, Bradford *et al.* 2017, Yano *et al.* 2018). ~~Little is known about this species elsewhere in its range, and most knowledge about its biology comes from mass strandings (Perryman *et al.* 1994).~~

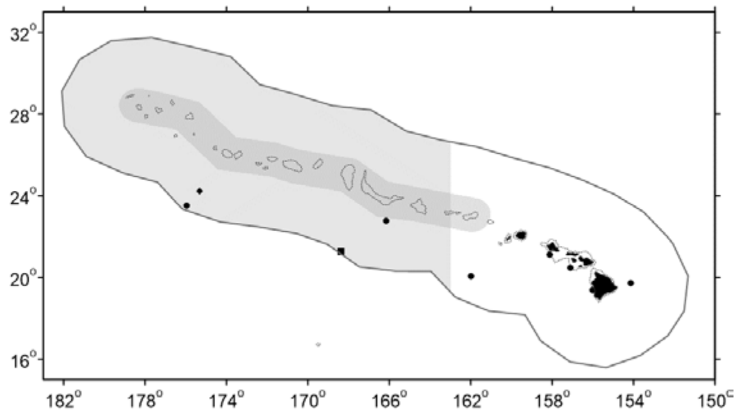

Figure 1. Melon-headed whale sighting location during the 2002 (~~open~~ diamond), ~~and~~ 2010 (~~black diamond~~circle), and 2017 (square) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford *et al.* 2017, Yano *et al.* 2018~~; see Appendix 2 for details on timing and location of survey effort~~). Outer line represents approximate boundary of survey area and U.S. EEZ. Dark g~~G~~ray shading indicates the original ~~area of~~ Papahanaumokuakea Marine National Monument, with the lighter gray shading denoting the full 2016 Expansion area. Dotted line represents the 1000 m isobath.

Photo-identification and telemetry studies suggest there are two demographically-independent populations of melon-headed whales in Hawaiian waters, the Hawaiian Islands stock and the Kohala resident stock. Resighting data and social network analyses of photographed individuals indicate very low rates of interchange between these populations (0.0009/yr) (Aschettino *et al.* 2012). This finding is supported by ~~preliminary~~ genetic analyses that indicate significant differentiation between ~~suggest restricted gene flow between~~ the Kohala residents and other melon-headed whales sampled in Hawaiian waters, despite overall high levels of interchange among most populations sampled (Martien et al. 2017~~Oleson *et al.* 2013~~), suggesting differences in social organization and foraging behavior may drive the observed structure. Some individuals in each population have been seen repeatedly for more than a decade, implying high site-fidelity for both populations. Individuals in the larger Hawaiian Islands stock have been resighted throughout the main Hawaiian Islands. Satellite telemetry data revealed distant offshore movements, nearly to the edge of the U.S. EEZ around the Hawaiian Islands (Figure 2), with apparent foraging near cold and warm-core eddies (Woodworth *et al.* 2012). Individuals in the smaller Kohala resident stock have a range restricted to shallower waters of the Kohala shelf and west side of Hawaii Island (Aschettino *et al.* 2012, Oleson *et al.* 2013 ~~Schorr *et al.* unpublished data~~). Satellite telemetry data indicate they occur in waters less than 2500m depth around the northwest and west shores of Hawaii Island, west of 156^0 45’ W and north of 19^0 15’N (Oleson *et al.* 2013). The northern boundary between the two stocks provisionally runs through the Alenuihaha Channel between Hawaii Island and Maui, bisecting the distance between the 1000 m depth contours (Oleson *et al.* 2013). Genetic analysis showed the strongest differentiation between animals sampled at Palmyra Atoll and other locations (Martien et al. 2017)

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there are two Pacific management stocks within the Hawaiian Islands EEZ (Oleson *et al.* 2013): 1) the Kohala resident stock, which includes melon-headed whales off the Kohala Peninsula and west coast of Hawaii Island and in less than 2500m of water, and 2) the

Hawaiian Islands stock, which includes melon-headed whales inhabiting waters throughout the U.S. EEZ of the Hawaiian Islands, including the area of the Kohala resident stock, and adjacent high seas waters. At this time, assignment of individual melon-headed whales within the overlap area to either stock requires photographic-identification of the animal. Because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of the Hawaiian Islands stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

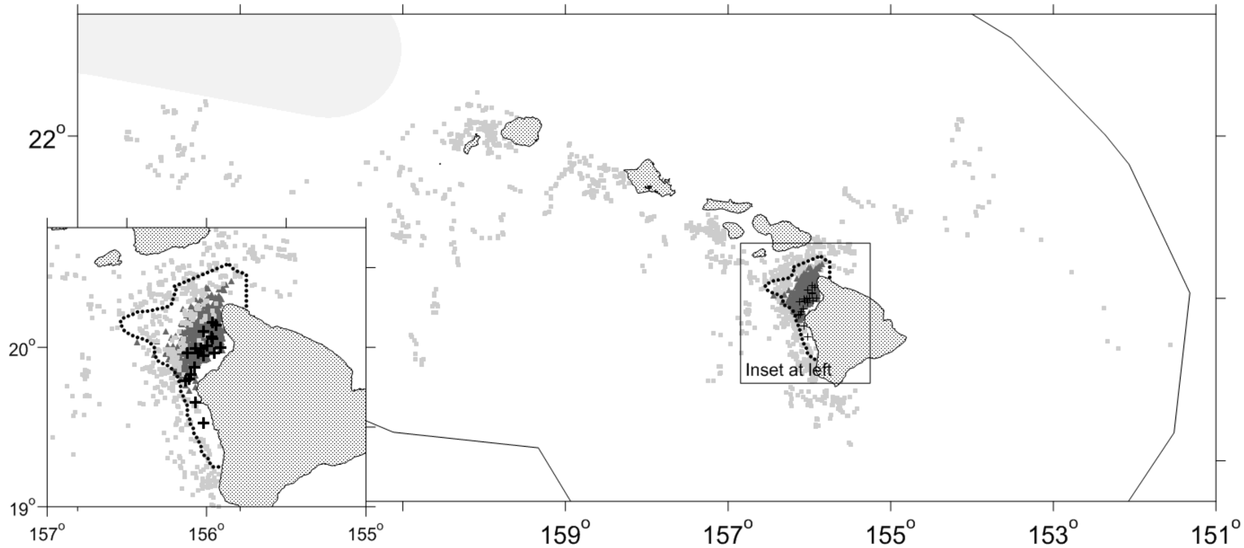

Figure 2. Sighting locations of melon-headed whales identified as being part of the Kohala resident stock (crosses) and telemetry records of Kohala resident (dark gray triangles) and Hawaiian Islands (light gray squares) melon-headed whale stocks (~~Schorr *et al.*, unpublished data~~ Oleson *et al.* 2013). The dotted line around waters adjacent to the northwest and west shores of Hawaii Island represents the provisional stock boundary for the Kohala resident stock (Oleson *et al.* 2013). The Kohala resident stock and the Hawaiian Islands stocks overlap throughout the range of the Kohala resident stock**.** Outer line represents U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Information on fishery-related mortality and serious injury of cetaceans in U.S. EEZ of the Hawaiian Islands waters is limited, but the gear types used in Hawaii fisheries are responsible for marine mammal mortality and serious injury in other U.S. fisheries~~ throughout U.S. waters~~. Entanglement in gillnets and hooking or entanglement in various hook and line fisheries have been reported for small cetaceans in Hawaii (Nitta and Henderson, 1993). No interactions between nearshore fisheries and melon-headed whales have been reported in Hawaiian waters. No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line or gillnet fisheries because these fisheries are not observed or monitored for protected species bycatch. Long-term photo-identification studies have noted individuals from both the Kohala Resident and Hawaiian Islands stocks with bullet holes in their dorsal fin or with linear scars on their fins or bodies (Aschettino 2010) which may be consistent fisheries interactions.

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2014~~2011~~ and 2018~~2015~~, no melon-headed whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (18-22~~20-21~~% observer coverage) (Bradford 2018a, 2018b, *in review*~~2017~~, Bradford and Forney 2017,~~ McCracken 2017~~). However, three unidentified delphinids ~~four unidentified cetaceans~~ were taken in the DSLL fishery~~, and one unidentified cetacean was taken in the SSLL fishery~~, some of which may have been melon-headed whales.

Other Mortality

In recent years, there has been increasing concern that loud underwater sounds, such as active sonar and seismic operations, may be harmful to beaked whales (Cox *et al.* 2006) and other cetaceans, including melon-headed whales (Southall *et al.* 2006, 2013) and pygmy killer whales (*Feresa attenuata*) (Wang and Yang 2006). The use of active sonar from military vessels has been implicated in mass strandings of beaked whales and recent mass-stranding reports suggest some delphinids may be impacted as well. A 2004 mass-stranding of 150-200 melon-headed whales in Hanalei Bay, Kauai occurred during a multi-national sonar training event around Hawaii (Southall *et al.* 2006). Although data limitations regarding the position of the whales prior to their arrival in the Bay, the magnitude of sonar exposure, behavioral responses of melon-headed whales to acoustic stimuli, and other possible relevant factors preclude a conclusive finding regarding the role of Navy sonar in triggering this event, sonar transmissions were considered a plausible cause of the mass stranding based on the spatiotemporal link between the sonar exercises and the stranding, the direction of movement of the transmitting vessels near Hanalei Bay, and propagation modeling suggesting the sonar transmissions would have been audible at the mouth of Hanalei Bay (Southall *et al.* 2006; Brownell *et al.* 2009). In 2008 approximately 100 melon-headed whales stranded within a lagoon off Madagascar during high-frequency multi-beam sonar use by oil and gas companies surveying offshore. Although the multi-beam sonar cannot be conclusively deemed the cause of the stranding event, the very close temporal and spatial association and directed movement of the sonar use with the stranding event, the unusual nature of the stranding event, and that all other potential causal factors were considered unlikely to have contributed, an Independent Scientific Review panel found that multi-beam sonar transmissions were a "plausible, if not likely" contributing factor (Southall *et al*. 2013) in this mass stranding event. This examination together with that of Brownell *et al.* (2009) suggests melon-headed whale may be particularly sensitive to impacts from anthropogenic sounds. No estimates of potential mortality or serious injury are available for U.S. waters.

KOHALA RESIDENT STOCK

POPULATION SIZE

Using the photo-ID catalog of individuals encountered between 2002 and 2009, Achettino (2010) used a POPAN open-population model to produce a mark-recapture abundance estimate of 447 (CV=0.12) individuals. The dataset used in this analysis ~~A portion of the data used in that analysis~~ is more than 8 years old, and there is no current estimate of abundance for this stock.~~; however, full sighting histories were required to produce a valid model for mark-recapture analyses, such that an estimate restricted to only the later years of the period is not available. Although this estimate includes individuals that have died since 2002 it is currently the best available abundance estimate for the resident stock~~.

Minimum Population Estimate

There is no current minimum population estimate for the Kohala resident stock of melon-headed whales. The data used in the 2002-2009 mark-recapture estimate (Aschettino 2010) are considered outdated, and therefore are not suitable for deriving a minimum abundance estimate. ~~The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) around the 2002-2009 mark-recapture abundance estimate (Aschettino 2010), or 404 melon-headed whales in the Kohala resident stock.~~

Current Population Trend

Only one abundance estimate is available for this stock, such that there is insufficient information to assess population trends.~~Photographic mark-recapture data will be evaluated in the future to assess whether sufficient data exists to assess trends.~~

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population estimate ~~(404)~~ 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 4.0 Kohala resident melon-headed whales per year.~~ Because there is no minimum population size estimate for this stock, the PBR is undetermined.

STATUS OF STOCK

The Kohala resident stock of melon-headed whales is not considered strategic under the MMPA. The status of this stock relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Melon-headed whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. There have been no reports of recent mortality or serious injuries; however, there is no systematic monitoring of takes in near-shore fisheries that may take this species. Given noted bullet holes and potential line injuries on individuals from this stock, insufficient information is available to determine whether the total fishery mortality and serious injury for Kohala Resident melon-headed whales is insignificant and approaching zero mortality and serious injury rate. The very restricted range and small population size of Hawaii Island resident melon-headed whales suggests this population may be at risk due to its proximity to U.S. Navy training, including sonar transmissions, in the Alenuihaha Channel between Hawaii Island and Maui (~~Anonymous 2006~~Forney *et al.* 2017). Although a 2004 mass-stranding in Hanalei Bay, Kauai could not be conclusively linked to Naval training events in the region (Southall *et al.* 2006), the spatiotemporal link between sonar exercises and the stranding does raise concern on the potential impact on the Kohala Resident population due to of sonar training nearby.

HAWAIIAN ISLANDS STOCK

POPULATION SIZE

Encounter data from ~~a 2010~~ shipboard line-transect survey of the entire Hawaiian Islands EEZ were recently reevaluated for each survey year, resulting in the following abundance estimates of melon-headed whales in the Hawaii EEZ (Bradford *et al. in review*) (Table 1).

Table 1. Line-transect abundance estimates for melon-headed whales derived from surveys of the entire Hawaii EEZ in 2002, 2010, and 2017 (Bradford *et al. in review*).

Year	Abundance	CV	95% Confidence Limits
2017	40,647	0.74	11,097-148,890
2010	8,743	1.01	1,685-45,375
2002	9,024	1.08	1,602-50,821

The updated design-based abundance estimates use sighting data from throughout the central Pacific to estimate the detection function and use Beaufort sea-state-specific trackline detection probabilities for bottlenose dolphins from Barlow *et al.* (2015), as there is insufficient sample size to estimate *g*(0) values for melon-headed whales. Although previous estimates from the Hawaii EEZ have been published using subsets of this data, Bradford *et al.* (*in review*), uses a consistent approach for estimating all abundance parameters and resulting estimates are considered the best available estimates for each survey year. The best estimate of abundance for this stock is from the 2017 survey, or 40,647 (CV=0.74) whales. ~~using Beaufort sea-state-specific trackline detection probabilities for bottlenose dolphins, resulting in an abundance estimate of 8,666 (CV = 1.00) melon headed whales (Bradford *et al.* 2017) in the Hawaiian Islands stock. Using the photo-ID catalog of individuals encountered between 2002 and 2009 near the main Hawaiian Islands, Achettino (2010) used a POPAN open-population model to produce a mark-recapture abundance estimate of 5,794 (CV=0.20) individuals. A 2002 shipboard line-transect survey of the Hawaiian EEZ resulted in an abundance estimate of 2,950 (CV=1.17) melon-headed whales (Barlow 2006). Species abundances estimated from the 2002 HICEAS survey used pooled small dolphin, large dolphin, and large whale g(0) (the probability of sighting and recording an animal directly on the track line) estimates stratified by group size (Barlow 1995). Since then, Barlow (2015) developed a more robust method for estimating species-specific g(0) values that are adjusted for the Beaufort sea states that are encountered during a survey. This new method was used for analyzing the data from the 2010 survey, but has not yet been used to analyze the 2002 data.~~ An abundance estimate of melon-headed whales is available for the eastern tropical Pacific (Wade and Gerrodette 1993), but it is not known whether any of these animals are part of the same population that occurs around the Hawaiian Islands.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) of the 2017 ~~2010~~ line-transect abundance estimate (Bradford *et al.* *in review* ~~2017~~) or 23,301 ~~4,299~~ melon-headed whales. ~~This log-normal 20th percentile minimum population size is similar to the log-normal 20th percentile mark-recapture estimate (4,904) from Aschettino (2010).~~

Current Population Trend

The three available abundance estimates for this stock have very broad and overlapping confidence intervals, precluding robust evaluation of population trend for this stock. Because of the relatively large group sizes observed for melon-headed whales (average 150-200 animals), a substantial increase in abundance can be realized with very few additional sightings (one each in 2002 and 2010 versus three in 2017). Alternative approaches will be required to examine population trend in melon-headed whales. ~~Abundance analyses of the 2002 and 2010 datasets used different g(0) values. The 2002 survey data have not been reanalyzed using this method. This change precludes evaluation of population trends at this time. Assessment of population trend will likely require additional survey data and reanalysis of all datasets using comparable methods~~.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population estimate for the U.S. EEZ of the Hawaiian Islands (23,301 ~~4,299~~) 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 233 ~~43~~ melon-headed whales per year.

STATUS OF STOCK

The Hawaiian Islands stock of melon-headed whales is not considered strategic under the 1994 amendments to the MMPA. The status of this stock relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Melon-headed whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. There have been no reports of recent mortality or serious injuries; however, there is no systematic monitoring of takes in near-shore fisheries that may take this species. Given noted bullet holes and potential line injuries on individuals from this stock, insufficient information is available to determine whether the total fishery mortality and serious injury for Hawaiian Islands melon-headed whales is insignificant and approaching zero mortality and serious injury rate. A 2004 mass-stranding of melon-headed whales in Hanalei Bay, Kauai occurred during a multi-national sonar training event around Hawaii (Southall *et al.* 2006). Although the event could not be conclusively linked to Naval training events in the region (Southall *et al.* 2006), the spatiotemporal link between sonar exercises and the stranding does raise concern on the potential impact on the Hawaiian Islands population due to its frequent use of nearshore areas within the main Hawaiian Islands.

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PYGMY KILLER WHALE (*Feresa attenuata*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Pygmy killer whales are found in tropical and subtropical waters throughout the world (Ross and Leatherwood 1994). They are poorly known in most parts of their range. Small numbers have been taken directly and incidentally in both the western and eastern Pacific. ~~Most knowledge of this species is from stranded or live-captured specimens.~~ Pryor et al. (1965) noted ~~stated~~ that pygmy killer whales appeared to be resident off Oahu~~have been observed several times off the lee shore of Oahu, and that "they seem to be regular residents of the Hawaiian area."~~ Extensive resightings of several individuals over several decades reveal a small residents groups off Kona and leeward Oahu (McSweeney et al. 2009, Baird 2016) ~~More recently, pygmy killer whales have also been seen off the islands of Niihau and Lanai (McSweeney et al. 2009).~~ Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands, resulted in three sightings of pygmy killer whales in 2002, ~~and~~ five in 2010, and three in 2017 (Figure 1; Barlow 2006, Bradford et al 2017, Yano et al. 2018).

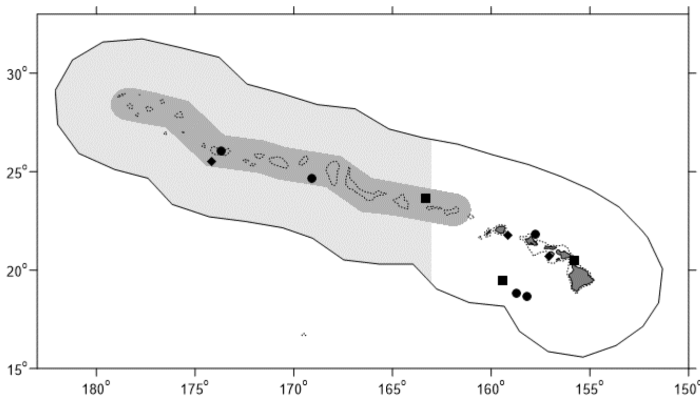

Figure 1. Pygmy killer whale sighting locations during the 2002 (~~open~~ diamonds), ~~and~~ 2010 (~~black diamonds~~circle), and 2017 (square) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2017, Yano et al. 2018~~; see Appendix 2 for details on timing and location of survey effort~~). Outer line represents approximate boundary of survey area and U.S. EEZ. Dark ~~G~~gray shading indicates the original ~~area of~~ Papahanaumokuakea Marine National Monument, with the lighter gray shading denoting the full 2016 Expansion area. Dotted line represents the 1000 m isobath.

Pygmy killer whales in Hawaiian waters may comprise more than one demographically-independent population.. A 22-year study off the Hawaii Island indicates that pygmy killer whales occur there year-round and in stable social groups. Over 80% of pygmy killer whales seen off Hawaii Island have been resighted and 92% have been linked into a single social network (McSweeney et al. 2009). Movements have also been documented between Hawaii Island and Oahu and between Oahu and Lanai (Baird et al. 2011a). Satellite telemetry data from four tagged pygmy killer whales suggest this resident group remains within 20km of shore (Baird et al 2011a, 2011b). Encounter rates for pygmy killer whales during near shore surveys are rare, representing less only 1.7% of all cetacean encounters to since 2000 (Baird et al. 2013). Division of this population into a separate island-associated stock may be warranted in the future.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there is a single Pacific management stock including animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters. Because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

Encounter data from ~~a 2010~~ shipboard line-transect surveys of the entire Hawaiian Islands EEZ were recently reevaluated for each survey year, resulting in the following abundance estimates of pygmy killer whales in the Hawaii EEZ (Bradford et al. *in review*) (Table 1).

Table 1. Line-transect abundance estimates for pygmy killer whales derived from surveys of the entire Hawaii EEZ in 2002, 2010, and 2017 (Bradford *et al. in review*).

Year	Abundance	CV	95% Confidence Limits
2017	10,328	0.75	2,771-38,491
2010	27,833	0.50	10,950-70,747
2002	3,854	0.77	1,015-14,640

The updated design-based abundance estimates use sighting data from throughout the central Pacific to estimate the detection function and use Beaufort sea-state-specific trackline detection probabilities derived for pygmy killer whales following the methods of Barlow et al. (2015). Although previous estimates from the Hawaii EEZ have been published using subsets of this data, Bradford et al. (*in review*), uses a consistent approach for estimating all abundance parameters and are considered the best available estimates for each survey year. The best estimate of abundance for this stock is based on the 2017 survey, or 10,328 (CV=0.75). ~~using Beaufort sea-state-specific trackline detection probabilities for pygmy killer whales, resulting in an abundance estimate of 10,640 (CV = 0.53) pygmy killer whales (Bradford et al. 2017) in the Hawaii stock. A 2002 shipboard line-transect survey of the same area resulted in an abundance estimate of 956 (CV=0.83) pygmy killer whales (Barlow 2006). Species abundances estimated from the 2002 HICEAS survey used pooled small dolphin, large dolphin, and large whale g(0) (the probability of sighting and recording an animal directly on the track line) estimates stratified by group size (Barlow 1995). Since then, Barlow (2015) developed a more robust method for estimating species-specific g(0) values that are adjusted for the Beaufort sea states that are encountered during a survey. This new method was used for analyzing the data from the 2010 survey, but has not yet been used to analyze the 2002 data~~. A population estimate has been made for this species in the eastern tropical Pacific (Wade and Gerrodette 1993), but it is not known whether any of these animals are part of the same population that occurs around the Hawaiian Islands.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al 1995) of the 2017 ~~2010~~ abundance estimate or 5,885 ~~6,998~~ pygmy killer whales within the Hawaiian EEZ.

Current Population Trend

The three available abundance estimates for this stock have very broad and overlapping confidence intervals, precluding robust evaluation of population trend for this stock.~~Abundance analyses of the 2002 and 2010 datasets used different g(0) values. The 2002 survey data have not been reanalyzed using this method. This change precludes evaluation of population trends at this time. Assessment of population trend will likely require additional survey data and reanalysis of all datasets using comparable methods~~.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for pygmy killer whales.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for pygmy killer whales stock is calculated as the minimum population estimate for the U.S. EEZ of the Hawaiian Islands (5,885~~6,998~~) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.5 ~~0.4~~ (for a stock of unknown status with no known fishery mortality or serious injury within the Hawaiian Islands EEZ ~~fishery mortality and serious injury rate CV greater than 0.80~~; Wade and Angliss 1997), resulting in a PBR of 59 ~~56~~ pygmy killer whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Information on fishery-related mortality and serious injury of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaii fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Entanglement in gillnets and hooking or entanglement in various hook and line fisheries have been reported for small cetaceans in Hawaii (Nitta & Henderson, 1993). A stranded pygmy killer whale from Oahu showed signs of hooking injury (Schofield 2007) and mouthline injuries have also been noted in some individuals (Baird unpublished data), though it is not known if these interactions result in serious injury or mortality. No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line or gillnet fisheries because these fisheries are not observed or monitored for protected species bycatch.

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2014~~2011~~ and 2018~~2015~~, no pygmy killer whales were observed hooked or entangled in the SSLL fishery (100% observer coverage), ~~and one pygmy killer whale was observed dead inside of the Hawaiian EEZ~~or in the DSLL fishery (20-21% observer coverage) (~~Bradford 2017~~ Bradford 2018a, 2018b, *in review*, Bradford and Forney 2017, McCracken 2019~~2017~~). ~~Average 5-yr estimates of annual mortality and serious injury for pygmy killer whales during 2011-2015 are 1.1 (CV = 1.1) pygmy killer whales within the Hawaiian Islands EEZ and 0 outside of U.S. EEZs (Table 1, McCracken 2017).~~ There were four additional ~~In addition, four~~ unidentified cetaceans~~ were~~ taken in the DSLL fishery during this period~~, and one unidentified cetacean was taken in the SSLL fishery~~, some of which may have been pygmy killer whales.

~~**Table 1.** Summary of available information on incidental mortality and serious injury of pygmy killer whales in commercial longline fisheries, within and outside of the U.S. EEZs (McCracken 2017). Mean annual takes are based on 2011-2015 data unless otherwise indicated. Information on all observed takes (T) and combined mortality events & serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome.~~

~~Fishery Name~~	~~Year~~	~~Data Type~~	~~Percent Observer Coverage~~	~~Observed total interactions (T) and mortality events, and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) of pygmy killer whales~~			
				~~Outside U.S. EEZs~~		~~Hawaiian EEZ~~	
				~~Obs. T/MSI~~	~~Estimated M&SI (CV)~~	~~Obs. T/MSI~~	~~Estimated M&SI (CV)~~
~~Hawaii-based deep-set longline fishery~~	~~2011~~	~~Observer data~~	~~20%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
	~~2012~~		~~20%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
	~~2013~~		~~20%~~	~~0~~	~~0 (-)~~	~~1/1~~	~~5 (0.9)~~
	~~2014~~		~~21%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
	~~2015~~		~~21%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
~~**Mean Estimated Annual Take (CV)**~~					~~**0 (-)**~~	-	~~**1.1 (1.1)**~~
~~Hawaii-based shallow-set longline fishery~~	~~2011~~	~~Observer data~~	~~100%~~	~~3/3~~	~~0~~	~~0~~	~~0~~
	~~2012~~		~~100%~~	~~4/4~~	~~0~~	~~0~~	~~0~~
	~~2013~~		~~100%~~	~~3/2~~	~~0~~	~~0~~	~~0~~
	~~2014~~		~~100%~~	~~7/6~~	~~0~~	~~0~~	~~0~~
	~~2015~~		~~100%~~	~~4/3~~	~~0~~	~~0~~	~~0~~
~~**Mean Annual Takes (100% coverage)**~~					~~**0**~~	-	~~**0**~~
~~**Minimum total annual takes within U.S. EEZ**~~				-	-	-	~~**1.1 (1.1)**~~

Other Mortality

~~In recent years, there has been increasing concern that loud~~ Loud underwater sounds, such as active sonar and seismic operations, may be harmful to beaked whales (Cox *et al*. 2006) and other cetaceans, including melon-headed whales (Southall *et al*. 2006, 2013, Brownell *et al*. 2009) and pygmy killer whales (Wang and Yang 2006). The use of active sonar from military vessels has been implicated in mass strandings of beaked whales, and recent mass-stranding reports suggest some delphinids may be impacted as well. Two mass-strandings of pygmy killer whales occurred in the coastal areas of southwest Taiwan in February 2005, possibly associated with offshore naval training exercises (Wang and Yang 2006). A necropsy of one of the pygmy killer whales revealed hemorrhaging in the cranial tissues of the animal. Additional research on the behavioral response of delphinids in the presence of sonar transmissions is needed in order to understand the level of impact. No estimates of potential mortality or serious injury are available for U.S. waters.

STATUS OF STOCK

The Hawaii stock of pygmy killer whales is not considered strategic under the 1994 amendments to the MMPA. The status of pygmy killer whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Pygmy killer whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. ~~The estimated rate of fisheries related mortality or serious injury within the Hawaiian Islands EEZ (1.1animals per year) is less than the PBR (56).The total fishery mortality and serious injury can be considered to be insignificant and approaching zero because mortality and serious injury is less than 10% of PBR.~~ Given the absence of recent recorded fishery-related mortality or serious injuries, the total fishery mortality and serious injury can be considered to be insignificant and approaching zero. One pygmy killer whale stranded in the MHI has tested positive for *Morbillivirus* (Jacob et al. 2016). The presence of *morbillivirus* in 10 species of cetacean in Hawaiian waters, all identified as a unique strain of *morbillivirus*, (Jacob et al. 2016), raises concerns about the history and prevalence of this disease in Hawaii and the potential population impacts, including cumulative impacts of disease with other stressors.

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FALSE KILLER WHALE (*Pseudorca crassidens*): Hawaiian Islands Stock Complex – Main Hawaiian Islands Insular, Northwestern Hawaiian Islands, and Hawaii Pelagic Stocks

STOCK DEFINITION AND GEOGRAPHIC RANGE

False killer whales are found worldwide in tropical and warm-temperate waters (Stacey *et al.* 1994). In the North Pacific, this species is well known from southern Japan, Hawaii, and the eastern tropical Pacific. False killer whales were encountered during ~~two~~ three shipboard line-transect surveys of the U.S. Exclusive Economic Zone (EEZ) around the Hawaiian Islands in 2002, ~~and~~ 2010, and 2017 (Figure 1; Barlow 2006, Bradford *et al.* 2014, Yano *et al.* 2018) and focused studies near the main and Northwestern Hawaiian Islands indicate that false killer whales occur in near shore waters throughout the Hawaiian archipelago (Baird *et al.* 2008, 2013). This species also occurs in U.S. EEZ waters around Palmyra and Johnston Atolls (e.g., Barlow *et al.* 2008) and American Samoa (Johnston *et al.* 2008, Oleson 2009).

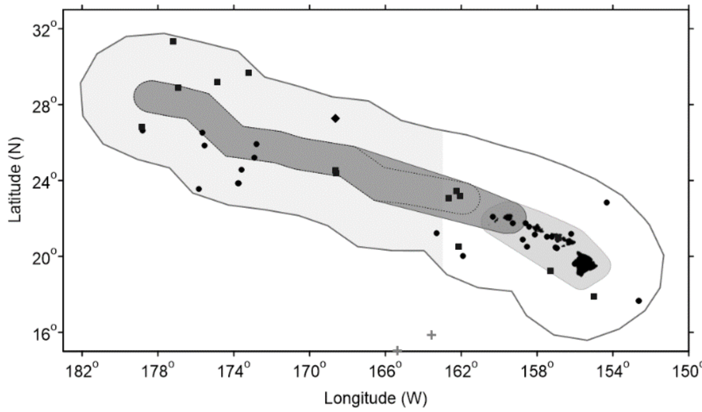

Figure 1. False killer whale sighting locations during the 2002 (diamond), 2010 (circle), and 2017 (square) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford *et al.* 2014, Yano *et al.* 2018).~~False killer whale on-effort sighting locations during standardized shipboard surveys of the Hawaiian Islands U.S. EEZ (2002, gray diamond, Barlow 2006; 2010, black triangles, Bradford *et al.* 2014, pelagic waters of the central Pacific south of the Hawaiian Islands (2005, gray crosses, Barlow and Rankin 2007) and the Johnston Atoll EEZ. Outer dashed lines represent approximate boundary of U.S. EEZs~~. ~~;~~ ~~light~~Medium ~~shaded~~ gray shaded area is the main Hawaiian Islands insular false killer whale stock area., including overlap zone between MHI insular and pelagic false killer whale stocks; D~~d~~ark shaded gray area is the Northwestern Hawaiian Islands stock area, which overlaps the pelagic false killer whale stock area and part of the MHI insular false killer whale stock area. Outer line represents approximate boundary of survey area and U.S. EEZ. Dotted line represents the original boundary of the Papahanaumokuakea Marine National Monument and the light gray shaded area is the 2016 Expansion area. Detail of stock boundaries shown in Figure 2.

Genetic, photo-identification, and telemetry studies indicate there are three demographically-independent populations of false killer whales in Hawaiian waters. Genetic analyses indicate restricted gene flow between false killer whales sampled near the main Hawaiian Islands (MHI), the Northwestern Hawaiian Islands (NWHI), and in pelagic waters of the Eastern (ENP) and Central North Pacific (CNP) (Chivers *et al.* 2010; Martien ~~*et al.* 2011,~~ 2014). Martien *et al.* (2014) analyzed mitochondrial DNA (mtDNA) control region sequences and genotypes from 16 nuclear DNA (nuDNA) microsatellite loci from 206 individuals from the MHI, NWHI, and offshore waters of the CNP and ENP and showed highly significant differentiation between populations confirming limited gene flow in both sexes. Their ~~analysis using~~ mtDNA analysis reveals strong phylogeographic patterns consistent with local evolution of haplotypes unique to false killer whales occurring nearshore within the Hawaiian Archipelago, while ~~and their assessment of~~the nuDNA analysis suggests ~~that~~ NWHI false killer whales are at least as differentiated from MHI animals as they are from offshore animals. Photo-ID~~graphic identification~~ and social network analyses of individuals seen near the MHI indicate a tight social network with no connections to false killer whales seen near the NWHI or ~~in~~ offshore waters, and ~~assessment of~~ satellite telemetry collected from 27 tagged MHI false killer whales shows movements restricted to the MHI (Baird *et al.* 2010, 2012). Further ~~evaluation~~ analysis of photographic and genetic data from individuals seen near the MHI suggests the occurrence of three separate social clusters (Baird *et al.* 2012, Martien *et al.* 2019~~2011~~). Parentage analysis of sampled individuals reveals natal group fidelity of males and females and mating within the natal group 36-64% of the time (Martien *et al.* 2019).~~, where mating occurs primarily, though not exclusively within clusters (Martien *et al.* 2011)~~. Additional ~~details on data and analyses~~scientific support for ~~supporting~~ the separation

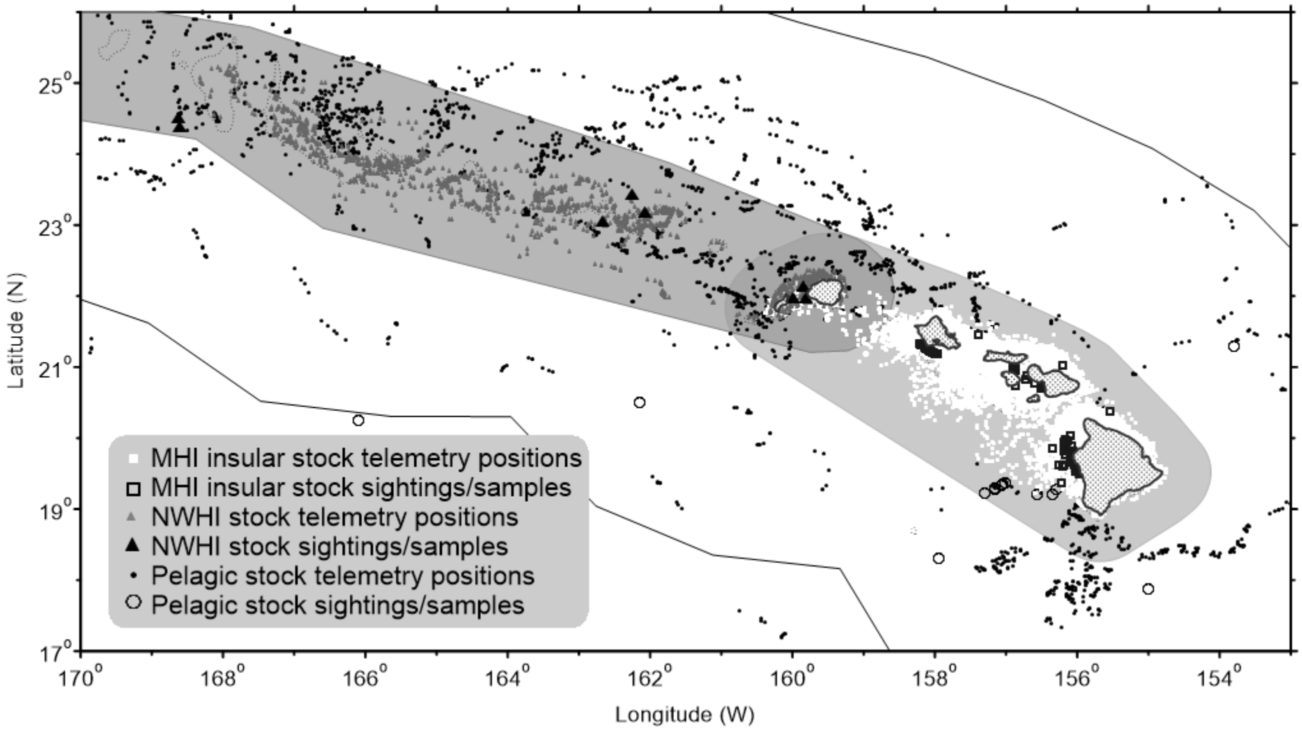

Figure 2. Sighting, biopsy sample, and telemetry record locations of false killer whale identified as being part of the MHI insular (square symbols), NWHI (triangle symbols), or pelagic (circle symbols) stocks. The MHI stock area is shown in light gray; the NWHI stock area is shown in dark gray; the pelagic stock area includes the entire EEZ ~~excluding the region delineated by the black line around each of the MHI~~ (reproduced from Bradford *et al.* 2015, with pelagic stock boundary revision described in Bradford et al. 2020). The MHI insular, pelagic, and NWHI stocks overlap around Kauai and Niihau.

of false killer whales in Hawaiian waters into three separate stocks ~~are~~ is summarized ~~within~~ by Oleson *et al.* (2010, 2012).

Fishery observers have collected tissue samples for genetic analysis from cetaceans incidentally caught in the Hawaii-based longline fishery since 2003. Between 2003 and 2010, eight false killer whale samples, four collected outside the Hawaiian EEZ and four collected within the EEZ, but more than 100 nautical miles (185km) from the main Hawaiian Islands were determined to have Pacific pelagic haplotypes (Chivers *et al.* 2010). At the broadest scale, significant differences in both mtDNA and nuDNA are evident between pelagic false killer whales in the ENP and CNP strata (Chivers *et al.* 2010). ~~, although the sample~~ Sample distribution ~~to the~~ east and west of Hawaiian waters is insufficient to determine whether the sampled strata represent one or more stocks, and where pelagic stock boundaries ~~would be drawn~~may occur.

The stock range and boundaries of the three Hawaiian stocks of false killer whales ~~were recently reevaluated, given significant new information on the occurrence and movements of each stock and~~ are reviewed in detail in Bradford *et al.* (2015), and further revised for the pelagic stock in Bradford et al (2020) ~~and shown in~~ (Figure 2). The stocks have partially overlapping ranges. MHI insular false killer whales have been satellite tracked as far as 115 km from the main Hawaiian Islands, while pelagic stock animals have been tracked to within 5.6 ~~11~~ km of the main Hawaiian Islands and throughout the NWHI. NWHI false killer whales have been seen ~~as far as~~ up to 93 km from the NWHI and near-shore around Kauai and Oahu (Baird *et al.* 2012, Bradford *et al.* 2015). Stock boundary descriptions are complex, but can be summarized as follows. The MHI insular stock boundary is derived from a Minimum Convex Polygon (MCP) bounded around a 72-km radius of the MHI, resulting in a boundary shape that reflects greater offshore use in the leeward portion of the MHI. The NWHI stock boundary is defined by a 93-km radius around the NWHI, with this radial boundary extended to the southeast to encompass Kauai and Niihau. The NWHI boundary is latitudinally expanded at the eastern end of the NWHI to encompass animal movements observed outside of the 93-km radius (see Figure 2). The pelagic stock has no inner or outer boundary within the EEZ. ~~Throughout the MHI the pelagic stock inner boundary is placed at 11 km from shore. There is no inner boundary within the NWHI.~~ The 2015 boundary revision placed an inner boundary at 11km from shore around each of the MHI, though this boundary was removed, given new telemetry data indicating use of waters within 5.6 km the MHI (Bradford *et al.* 2020) The construction of these stock boundaries results in ~~a number ofseveral~~ multiple stock overlap zones. The entirety of ~~waters outside of 11km from shore from Oahu to Hawaii Island out to~~ the MHI insular stock area is ~~boundary are~~ an overlap zone between the MHI insular and pelagic stocks. The entirety of the NWHI stock range~~, with the exception of the area within 11km around Kauai and Niihau~~ is an overlap zone between NWHI and pelagic false killer whales. All three stocks overlap ~~between 11 km from shore around Kauai and Niihau~~ out to the MHI insular stock boundary between Kauai and Nihoa and to the NWHI stock boundary between Kauai and Oahu (see Figure 2).

The pelagic stock includes animals found within the ~~Hawaiian Islands~~U.S EEZ around Hawaii and in adjacent international waters. New model-based abundance estimates for the central Pacific enable examination of the status of the broader population of false killer whales relative to ~~; however, because data on false killer whale abundance, distribution, and~~ human-caused impacts resulting from U.S. fisheries ~~are largely lacking for~~operating in international waters. ~~, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).~~ The Palmyra Atoll stock of false killer whales is still considered to be a separate stock because comparisons amongst false killer whales sampled at Palmyra Atoll and those sampled from the MHI insular stock and the pelagic ENP reveal restricted gene flow, although the sample size remains too low for robust comparisons (Chivers *et al.* 2010). ~~, t~~The status of Hawaii pelagic ~~this~~ stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005), and abundance estimates for the broader central Pacific (including Palmyra Atoll) are provided for comparison to U.S. fisheries impacts on the high-seas. .~~NMFS will obtain and analyze additional samples for genetic studies of Hawaii pelagic and Palmyra stock structure, and will evaluate new information on stock ranges as it becomes available.~~

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there are ~~currently~~ five Pacific Islands Region management stocks: 1) the Main Hawaiian Islands insular stock, which includes animals inhabiting waters within a modified 72 km radius around the main Hawaiian Islands, 2) the Northwestern Hawaiian Islands stock, which includes animals inhabiting waters within a 93 km radius around the NWHI and Kauai, with a ~~slight~~ latitudinal expansion of this area at the eastern end of the range, 3) the Hawaii pelagic stock, which includes false killer whales inhabiting waters of the U.S. EEZ around Hawaii ~~greater than 11 km from the main Hawaiian Islands, including~~ and adjacent high seas waters, 4) the Palmyra Atoll stock, which includes animals found within the U.S. EEZ of Palmyra Atoll, and 5) the American Samoa stock, which includes animals found within the U.S. EEZ of American Samoa. Estimates of abundance, potential biological removal, and status determinations for the first three stocks are presented below~~;~~. ~~the~~ Palmyra Atoll and American Samoa stocks ~~are covered~~ appear in separate reports.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Interactions with false killer whales, including depredation of pelagic fish catch ~~of a variety of pelagic fishes~~, have been identified in logbooks and NMFS observer records from Hawaii pelagic longline fishing trips (Nitta and Henderson 1993, Oleson *et al.* 2010, PIRO 2015). False killer whales have been observed feeding on a variety of large pelagic fish, including mahi mahi (*Coryphaena hippurus*), ~~and~~ yellowfin tuna (*Thunnus albacares*), big eye tuna (*T. obesus*), albacore (*T.alalunga*), wahoo (*Acanthocybium solandri*), skipjack (*Katsuwonus pelamis*), and broadbill swordfish (*Xiphias gladius*) (Baird 2016~~2009~~), and they ~~have been~~are reported to take large fish from ~~the~~ trolling lines of commercial and recreational fishermen (Shallenberger 1981). There are anecdotal reports of marine mammal interactions in the commercial Hawaii shortline fishery which sets gear at Cross Seamount and possibly around the main Hawaiian Islands. The commercial shortline fishery is licensed to sell ~~their~~ catch through the State of Hawaii Commercial Marine License program, and until recently, no reporting systems existed to document marine mammal interactions. Baird and Gorgone (2005) documented high rates of dorsal fin disfigurements consistent with injuries from unidentified fishing line for ~~false killer whales belonging to the~~ MHI insular stock false killer whales. ~~A recent report included evaluation~~ Evaluation of additional individuals with dorsal fin injuries and disfigurements ~~and suggested~~suggests that the ~~rate of~~ interaction rate between false killer whales and various forms of hook and line gear may vary by population and social cluster, with the highest rates in the MHI insular stock ~~showing the highest rate of dorsal fin disfigurements~~ (Baird *et al.* 2014). The commercial or recreational fishery or fisheries responsible for these injuries is unknown. ~~Examination of a~~ A stranded MHI insular false killer whale in October 2013 ~~revealed that this individual~~ had five fishing hooks and fishing line in its stomach ~~(NMFS PIR Marine Mammal Response Network~~) and another stranded animal in September 2016 had one fishing hook in its stomach (Bradford and Lyman *et al*. 2018). Although the fishing gear is not believed to have caused the death of either ~~the~~ whale, ~~the finding~~ examinations confirm~~s~~ that MHI insular false killer whales ~~are consuming~~ consume previously hooked fish or are interacting with MHI hook and line fisheries ~~in the MHI~~. Many of the hooks within the whale's stomach were not consistent with those currently allowed for use within the commercial longline fisheries and could have come from a variety of near-shore fisheries. No estimates of human-caused mortality or serious injury are currently available for near-shore hook and line or other fisheries because these fisheries are not ~~observed or~~ monitored for protected species bycatch.

Because of high rates of false killer whale mortality and serious injury in Hawaii-based longline fisheries, a Take Reduction Team was established in January 2010 (75 FR 2853, 19 January, 2010). The Team was charged with developing recommendations to reduce incidental mortality and serious injury of the Hawaii pelagic, MHI insular and Palmyra stocks of false killer whales in Hawaii-based longline fisheries. The Team submitted a draft Take Reduction Plan (TRP) to NMFS, and NMFS published a final TRP based on the Team's recommendations (77 FR 71260, 29 November, 2012). Take reduction measures include gear requirements, time-area closures (the Southern Exclusion Zone, or SEZ), and measures to improve captain and crew response to hooked and entangled false killer whales. The seasonal contraction of the Longline Exclusion Zone (LLEZ) around the MHI was also eliminated. The TRP became effective December 31, 2012, with gear requirements effective February 27, 2013. ~~These measures were not in effect during 2008-2012, a portion of the period for which bycatch was estimated in this report.~~ Adjustments to bycatch estimation methods were implemented for 2013 to account for changes in fishing gear and captain training intended to reduce the false killer whale serious injury rate (~~see below,~~ McCracken 2015).

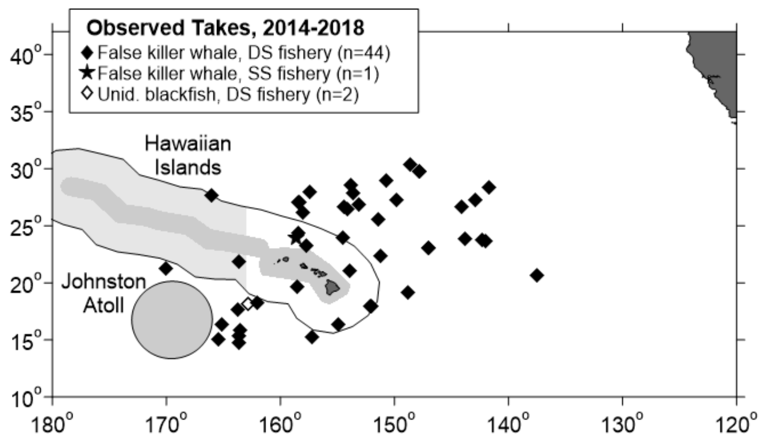

Figure 3. Locations of observed false killer whale takes (black symbols) and possible takes (blackfish) of this species (open symbols) in the Hawaii-based longline fisheries, 2014-2018~~2011-2015~~. ~~Takes occurring prior to the implementation of Take Reduction Plan (2010-2012) regulations are shown as diamonds, and those since the TRP regulations (2013-2015) are shown as stars.~~ Some take locations overlap. Stock boundaries for false killer whales are not shown and all observed takes during this period occurred in the pelagic stock area. Solid lines represent the U. S. EEZ. Gray shading notes areas closed to commercial fishing, with the PMNM Expansion area closed since August 2016. Takes within the PMNM closed area occurred prior to the closure in 2016. ~~Solid gray lines represent the U.S. EEZ; the dotted line is the MHI insular stock area; the dashed line is the NWHI stock area; both MHI and NWHI stocks overlap with the pelagic stock. The gray shaded area represents the longline exclusion zone, implemented year-round since December 31, 2012, and original boundary of the Papahānaumokuākea Marine National Monument. Both areas were closed to longline fishing during the 2011-2015 period.~~

There are two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas, but are prohibited from operating within the Papahānaumokuākea Marine National Monument (PMNM) and within the LLEZ around the main Hawaiian Islands and the Pacific Remote Islands and Atolls (PRIA) MNM around Johnston Atoll. The PMNM originally included the waters within a 50 nmi radius around the NWHI. As of August, 2016, the PMNM area was expanded to extend to the 200 nmi EEZ boundary west of 163º W. ~~Stock Assessment Reports generally describe fishery interaction details for the most recent five years, and as such, only years 2011 through 2015 are described here.~~ Between 2014~~2011~~ and 2018~~2015~~, one~~three~~ false killer whale~~s~~ were observed hooked or entangled in the SSLL fishery (100% observer coverage) within the U.S. EEZ of the Hawaiian Islands, and 44~~26~~ false killer whales were observed taken in the DSLL fishery (18~~20~~-21% observer coverage) within Hawaiian waters or adjacent high-seas waters ~~(excluding Palmyra Atoll EEZ waters)~~ (Bradford 2018a, 2018b, *in review* ~~2017~~, Bradford and Forney 2017) (Figure 3). The severity of injuries resulting from interactions with longline gear is determined based on an evaluation of the observer's description of each interaction and following the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012). The one ~~Of the three~~ animal~~s~~ taken in the SSLL fishery was ~~, two were~~ considered not seriously injured ~~and one could not be determined based on the information provided by the observer~~. In the DSLL fishery, 9 false killer whales were taken within the Hawaiian EEZ, ~~Two of those takes occurred in 2012 within the pelagic-NWHI overlap zone north of Kauai before this area was closed to longline fishing. Of the remaining 7 interactions within the Hawaiian EEZ, all were~~ all within the range of the pelagic stock, with 7~~four~~ considered seriously injured, one non-seriously injured, and one~~three~~ could not be determined based on the information provided by the observer. Outside of the Hawaii EEZ three were~~one was~~ observed dead, ~~12~~24 were considered seriously injured, ~~and~~ six~~four~~ were considered not seriously injured, and two could not be determined based on the information provided by the observer. One~~Five~~ additional unidentified "blackfish" (unidentified cetaceans known to be either false killer whales or short-finned pilot whales) were also taken~~, one within the SSLL fishery and four~~ within in the DSLL fishery outside of the ~~. The single SSLL interaction occurred outside the Hawaiian EEZ and the animal was considered seriously injured. Of the four DSLL interactions, one occurred inside the~~ Hawaii EEZ and was considered seriously injured~~, and three occurred outside the Hawaii EEZ, with one considered seriously injured, one considered not seriously injured, and one whose injury status could not be determined based on the information provided by the observer~~. The SEZ, a large triggered closure area south of the MHI implemented under the TRP, was closed following 2 serious injuries within the Hawaii EEZ in November 2018. This closure remained in effect through the remainder of calendar year 2018.

The ~~injury status of~~ total estimated number~~take~~ of dead or seriously injured whales is calculated based on ~~s is prorated to serious versus non-serious using~~ the ~~historic rate~~ratio of observed dead and seriously injury whales versus those judged to be not seriously injured~~within the observed takes~~. Prior to the implementation of the FKW TRP, f~~F~~or the period 2008 to 2012, the rate of dead and seriously injured~~y for~~ false killer whales was 93% (McCracken 2014). ~~Because t~~The implementation of weak hooks under the TRP was intended to reduce the serious injury rate in the deep-set fishery, and as such the ~~these historic averages were not used for 2013-2015. The allocation of estimated serious versus non-serious injuries in 2013-2015 take was based on the~~ proportion of dead and seriously injured whales versus non-serious injuries is calculated annually based on the injury status of observed takes ~~of observed takes~~ since the implementation of the TRP in 2013~~in those years~~ (McCracken 2019~~2017~~). ~~The proration of serious injury status will be updated as additional data become available to better estimate serious versus non-serious injury proportion under TRP measures.~~

~~Takes of false killer whales of unknown stock within the stock overlap zones must be prorated to MHI insular, pelagic, or NWHI stocks. No genetic samples are available to establish stock identity for the two takes inside the NWHI-pelagic overlap zone north of Kauai, but both stocks are considered at risk of interacting with longline gear.~~ The pelagic stock ~~is known to~~ interacts with longline fisheries ~~in waters offshore of the overlap zone,~~ based on two genetic samples obtained by fishery observers (Chivers *et al.* 2010). MHI insular and NWHI false killer whales have been documented via telemetry to move far enough offshore to reach longline fishing areas (Bradford *et al.* 2015), and ~~animals from the~~ MHI insular stock animals have ~~a~~ high rates of dorsal fin disfigurements consistent with injuries from unidentified fishing line (Baird and Gorgone 2005, Baird *et al.* 2014). Annual bycatch estimates are prorated to stock using the following process. Takes of unidentified blackfish are prorated to false killer whale and short-finned pilot whale based on distance from shore (McCracken 2010) given patterns of previous bycatch for each species. ~~The distance-from-shore model was chosen following consultation with the Pacific Scientific Review Group, based on the model's logic and performance relative to a number of other models with similar output (McCracken 2010).~~ Following proration of unidentified blackfish takes to species, Hawaii EEZ and high-seas estimates of false killer whale take are calculated by summing the annual false killer whale take and the annual blackfish take prorated as false killer whale within each region (McCracken 2019~~7~~). Takes within the ~~Because the s~~shallow-set longline fishery ~~is fully observed, takes~~ are assigned to the stock area~~zone~~ in which they were observed ~~and there is no further apportionment based on fishing effort.~~ Estimated takes in~~For~~ the deep-set fishery within the Hawaii EEZ ~~, annual takes~~ are apportioned to each stock area ~~overlap zone and the pelagic-only stock area based~~by first allocating take to each areas based on ~~on~~ relative annual fishing effort (by set) in that ~~each~~ area~~zone~~. If ~~For the deep-set fishery, if~~an observed take occurred ~~bycatch was observed~~ within the MHI-pelagic or NWHI-pelagic overlap zones~~a specific overlap zone~~, the ~~observed~~ take was~~s were~~ assigned to that zone and the remaining estimated bycatch was assigned to stock areas as previously described ~~among zones and stocks according to the described process.~~ ~~The total annual EEZ bycatch estimate is multiplied by the proportion of total fishing effort (by set) within each zone to estimate the bycatch within that zone.~~ ~~Because the shallow-set longline fishery is fully observed, takes are assigned to the zone in which they were observed and there is no further apportionment based on fishing effort.~~ For both the shallow-set and deep-set fisheries,~~each longline fishery, the zonal~~stock area bycatch estimates are then ~~then~~ multiplied by the relative density of each stock within the stock area~~in the respective zone~~ to estimate ~~prorate~~stock-specific bycatch for each year~~to stock~~. ~~For the deep-set fishery, if bycatch was observed within a specific overlap zone, the observed takes were assigned to that zone and the remaining estimated bycatch was assigned among zones and stocks according to the described process.~~ ~~Following proration by fishing effort and stock density within each zone, stock-specific bycatch estimates are summed across zones to yield the total stock-specific annual bycatch by fishery.~~ Uncertainty in stock-specific bycatch estimates combines variances of total annual false killer whale bycatch and the fractional variance of false killer whale density according to which stock is being estimated. Enumeration of fishing effort within stock overlap zones is assumed to be known without error.

Based on this approach, estimates of annual mortality and serious injury of false killer whales, by stock and EEZ area~~,~~ are shown in Table 1. Two~~Three~~ mortality and serious injury estimates are provided ~~(Table 1)~~: a 5-yr average for the period prior to TRP-implementation (2008-2012), ~~a 3-yr average for the period following TRP implementation (2013-2015),~~ and a 5-yr average for the most recent 5 years following the TRP~~assuming no significant change in mortality rate within the fishery~~ (2014-2018~~2011-2015~~). ~~The later estimate is not provided for the MHI insular stock as the fishery has been largely excluded from the stock range through expansion of the LLEZ, resulting in significant change in the conduct of the fishery with respect to this stock.~~ The bycatch rate (per 1000 sets) and the proportion of non-serious injuries prior to and following TRP implementation are~~were~~ examined for all stocks as part of the FKW TRT monitoring strategy.

Table 1. Summary of available information on incidental mortality and serious injury (MSI) of false killer whales and unidentified blackfish (false killer whale or short-finned pilot whale) in commercial longline fisheries, by stock and EEZ area, as applicable (McCracken 2019~~7~~). 5-yr mean annual takes are presented for 2008-2012~~, –~~ (prior to the implementation of the TRP~~, –~~) and for 2014-2018. ~~2013-2015 due to changes in fishing gear under the TRP intended to reduce serious injury rate, and for 2011-2015, ignoring any change in mortality rate.~~ Information on ~~all~~ observed takes (T) and combined mortality ~~&~~ and serious injury is included. Unidentified blackfish are pro-rated as either false killer whales or short-finned pilot whales ~~according to~~based on ~~their~~ distance from shore (McCracken 2010). CVs are estimated based on the combined variances of annual false killer whale and blackfish take estimates and the relative density estimates for each stock within the overlap zones. Values of '0' presented with no further precision are based on observation at 100% coverage and are not estimates.

Fishery Name	Year	Data Type	Percent Observer Coverage	Observed takes: FKW T/MSI UB T/MSI: Outside U.S EEZ	Observed takes: FKW T/MSI UB T/MSI: Within Hawaii EEZ	Estimated M&SI (CV): Pelagic Stock: Outside U.S EEZ	Estimated M&SI (CV): Pelagic Stock: Within Hawaii EEZ	Estimated M&SI (CV): MHI insular Stock	Estimated M&SI (CV): NWHI Stock
Hawaii-based deep-set longline fishery	~~2011~~	Observer data	~~20%~~	~~0~~ ~~1/0~~	~~3/3‡~~ ~~1/1~~	~~2.2 (3.6)~~	~~12.2 (0.4)~~	~~0.1 (0.6)~~	~~0.3 (1.2)~~
	~~2012~~		~~20%~~	~~0~~ ~~1/1~~	~~3/3*‡~~ ~~0~~	~~3.6 (2.3)~~	~~13.0 (0.4)~~	~~0.1 (3.9)~~	~~1.6 (1.3)~~
	~~2013~~		~~20%~~	~~3/1~~ ~~0~~	~~1/1~~ ~~0~~	~~6.6 (0.9)~~	~~4.1 (1.4)~~	~~0.0 (1.9)~~	~~0.0 (-)~~
	2014		21%	9/8 0	2/1† 0	35.8 (0.5)	8.4 (0.7)	0.0 (0.8)	0.0 (1.5)
	2015		21%	5/4 1/1†	0 0	22.3~~1~~ (0.4)	0 (-)	0 (-)	0 (-)
	2016		20%	9/8† 0	1/1 0	27.9 (0.3)	4.0 (0.8)	0 (0.8)	0 (2.1)
	2017		20%	4/4† 0	2/1 0	28.5 (0.4)	8.1 (0.6)	0.1 (0.6)	0 (2.0)
	2018		18%	8/5 0	4/4 0	29.7 (0.4)	11.9 (0.4)	0.1 (0.5)	0 (2.0)
Pre-TRP Mean Estimated Annual Take (CV) 2008-2012						**10.0 (0.4)**	**13.3 (0.2)**	**0.2 (0.4)**	**0.6 (0.8)**
~~**Estimated Annual Take (CV) under TRP 2013-2015**~~						~~**21.2 (0.5)**~~	~~**4.1 (1.0)**~~	~~**0.0 (0.7)**~~	~~**0.0 (1.3)**~~
Mean Estimated Annual Take (CV) 2014-2018~~2011-2015~~						**28.8 (0.2)** ~~**15.2 (0.3)**~~	**6.5 (0.3)** ~~**7.5 (0.3)**~~	**0.03 (0.3)** **(-)**	**0.01 (1.1)** ~~**0.4 (1.1)**~~
Hawaii-based shallow-set longline fishery	~~2011~~	Observer data	~~100%~~	~~0~~ ~~1/1~~	~~1/0~~ ~~0~~	~~0.7~~	~~0~~	~~0~~	~~0~~
	~~2012~~		~~100%~~	~~0~~ ~~0~~	~~1/1‡~~ ~~0~~	~~0~~	~~0.3~~	~~0~~	~~0~~
	~~2013~~		~~100%~~	~~0~~ ~~0~~	~~0~~ ~~0~~	~~0~~	~~0~~	~~0~~	~~0~~
	2014		100%	0 0	1/0 0	0.2~~0~~	0	0	0
	2015		100%	0 0	0 0	0	0	0	0

	2016		100%	0 0	0 0	0	0	0	0
	2017		100%	0 0	0 0	0	0	0	0
	2018		100%	0 0	0 0	0	0	0	0
Pre-TRT Mean Annual Takes (100% coverage) 2008-2012						**0.3**	**0.3**	**0**	**0**
~~**Mean Annual Take (CV) under TRP 2013-2015**~~						~~**0**~~	~~**0**~~	~~**0**~~	~~**0**~~
Mean Annual Takes (100% coverage) 2014-2018~~2011-2015~~						**0.2~~0.1~~**	**0~~0.1~~**	**0~~-~~**	**0**
Pre-TRP Minimum total annual takes within U.S. EEZ (2008-2012)							**13.6 (0.2)**	**0.2 (0.4)**	**0.6 (0.8)**
~~**Minimum total take under TRP within U.S. EEZ 2013-2015**~~							~~**4.1 (1.0)**~~	~~**0 (0.7)**~~	~~**0 (1.3)**~~
Minimum total annual takes within U.S EEZ (2014-2018~~2011-2015~~)							**~~7.6~~ 6.5 (0.3)**	**0.03 (0.3)**	**0.01 ~~0.4~~ (1.1)**

~~* Two observed takes occurred within the NWHI-pelagic overlap zone and are therefore allocated for proration between NWHI and pelagic stocks. Remaining estimated takes are prorated among stocks as described for each overlap zone.~~

† Injury status could not be determined based on information collected by the observer. Injury status is prorated (see text).

~~Significant regulatory change under the TRP largely excluded the longline fishery from the MHI insular stock range, such that the 5-year average take is not reported for this stock.~~

Proration of false killer whale and unidentified blackfish takes within ~~the~~ overlap zones ~~and of unidentified blackfish takes~~ introduces unquantified uncertainty into the bycatch estimates. ~~, but u~~ Until methods of determining stock identity and/or species (e.g. photos, tissue samples) for animals observed taken within the overlap zone are available, ~~and all animals taken can be identified to species (e.g., photos, tissue samples), these~~ proration approaches are needed ensure that potential impacts to all stocks are assessed in the overlap zones.

MAIN HAWAIIAN ISLANDS INSULAR STOCK

POPULATION SIZE

Bradford *et al.* 2018 used encounter data from dedicated and opportunistic surveys for MHI insular false killer whales from 2000 to 2015 to generate annual mark-recapture estimates of abundance ~~over the survey period~~. Due to spatiotemporal biases imposed by sampling constraints, annual estimates reflect the abundance of MHI insular false killer whales within the surveyed area in that year, and therefore should not be considered indicative of total population size every year. The abundance estimate for 2015 was 167 (CV = 0.14). Annual estimates over the 16 year survey period ranged from 144 to 187 animals and are similar to multi-year aggregated estimates published previously (~~e.g.~~ Oleson *et al.* 2010).

Minimum Population Estimate

The minimum population estimate for the MHI insular stock of false killer whales is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) of the 2015 abundance estimate (from Bradford *et al.* ~~in review~~2018), or 149 false killer whales.

Current Population Trend

Reeves *et al.* (2009) suggested that the MHI insular stock of false killer whales may have declined between 1989 and 2007 ~~during the last two decades~~, based on sightings data collected near Hawaii using various methods ~~between 1989 and 2007~~. Baird (2009) reviewed trends in sighting rates of false killer whales from aerial surveys conducted using consistent methodology around the main Hawaiian Islands between 1994 and 2003 (Mobley *et al.* 2000). Sighting rates during these surveys showed a statistically significant decline that could not be attributed to any weather or methodological changes. The Status Review of MHI insular false killer whales (Oleson *et al.* 2010) presented a quantitative analysis of extinction risk using a Population Viability Analysis (PVA). The modeling exercise was conducted to evaluate the probability of actual or near extinction, defined as a population reduced to fewer than 20 animals, given measured, estimated, or inferred information on population size and trends, and varying impacts of catastrophes, environmental stochasticity and Allee effects. All plausible models indicated the probability of decline to fewer than 20 animals within 75 years was greater than 20%. Though causation was not evaluated, all plausible models indicated the population ~~has~~ had declined since 1989, at an average rate of -9% per year (95% probability intervals -5% to -12.5%), though some two-stage models suggested a lower rate of decline ~~over the past decade~~ (Oleson *et al.* 2010). ~~The a~~ Annual abundance estimates ~~available~~ in Bradford *et al.* 2018 are not appropriate for evaluating population trends, as the study area varied by year, and each annual estimate represents only ~~the~~ animals present in the study area within ~~that~~ each year.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the MHI insular false killer whale stock is calculated as the minimum population estimate (149) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.1 (for a stock listed as Endangered under the ESA and with minimum population size less than 1500 individuals; Taylor *et al.* 2000) resulting in a PBR of 0.3 false killer whales per year, or approximately one animal every 3.3 years.

STATUS OF STOCK

The status of MHI insular stock false killer whales relative to OSP is unknown, although this stock appears to have declined during the past two decades (Oleson *et al.* 2010, Reeves *et al.* 2009; Baird 2009). MHI insular false killer whales are listed as "endangered" under the Endangered Species Act (1973) (77 FR 70915, 28 November, 2012). The Status Review report produced by the Biological Review Team (BRT) (Oleson *et al.* 2010, amended in Oleson *et al.* 2012) found that Hawaiian insular false killer whales are a Distinct Population Segment (DPS) of the global false killer whale taxon. Of the 29 identified threats to the population, the BRT considered the effects of small population size, including inbreeding depression and Allee effects, exposure to environmental contaminants (Ylitalo *et al.* 2009), competition for food with commercial fisheries (Boggs & Ito, 1993, Reeves *et al.* 2009), and hooking, entanglement, or intentional harm by fishermen to be the most substantial threats to the population. Because MHI insular false killer whales are formally listed as "endangered" under the ESA, they are automatically considered as a "depleted" and "strategic" stock under the MMPA. For the 5-yr period prior to the implementation of the TRP, the average estimated mortality and serious injury to MHI insular stock false killer whales (0.21 animals per year) exceeded the PBR (0.18 animals per year. Following implementation of the TRP a significant portion of the recognized stock range is inside of the expanded year-round LLEZ around the MHI, providing significant protection for this stock from longline fishing. Prior to that time, a seasonal contraction to the LLEZ potentially exposed a significant portion of the offshore range of the stock to longline fishing. ~~Because of the significant change in longline fishery activity relative to the MHI insular stock under the TRP, the status of the stock is assessed relative to the post-TRP period (2013-2015).~~ For the most recent 5-yr period, ~~this period~~ the estimate of mortality and serious injury (0.03~~1~~) is below the PBR (0.30). The total fishery mortality and serious injury for the MHI insular stock of false killer whales cannot be considered to be insignificant and approaching zero, as it is greater than 10% of PBR. Effects of other threats have yet to be assessed, e.g., nearshore hook and line fishing and environmental contamination. There is significant geographic overlap between various nearshore fisheries and evidence of interactions with hook-and-line gear (e.g. Baird *et al.* 2015), such that these fisheries may pose a threat to the stock. Five MHI insular false killer whales ~~have recently~~ stranded between 2010-2016, including four from cluster 3 (PIRO MMRN), a high rate for a single social cluster. Recent research has indicated that concentrations of polychlorinated biphenyls (PCBs) exceeded proposed threshold levels for health effects in 84% of sampled MHI insular false killer whales (Foltz *et al.* 2014).

HAWAII PELAGIC STOCK

POPULATION SIZE

Encounter data from shipboard line-transect surveys conducted throughout the central Pacific were used to estimate the abundance of false killer whales across the central Pacific, including within the Hawaii EEZ (Bradford et al. 2020) (Table 2).

Table 2. Model-based line-transect abundance estimates for false killer whales derived from NMFS surveys in the central Pacific since 1997 (Bradford et al. *in review*).

	Hawaii EEZ			Central Pacific		
Year	Model-based abundance	CV	95% Confidence Limits	Model-based abundance	CV	95% Confidence Limits
2017	2,086	0.35	1,079-4,031	34,536	0.35	17,782-54,363
2010	2,144	0.32	1,159-3,965	25,212	0.33	13,449-47,262
2002	2,122	0.33	1,136-3,964	25,723	0.30	14,397-45,958

The model-based abundance estimates use sighting data from 1997 to 2017 from across the central Pacific to derive habitat-based models of animal density for the overall period. The models were then used to predict the density and abundance for each Hawaii survey year (2002, 2010, and 2017) based on the environmental conditions within that year (see Forney et al. 2015, Becker et al. 2016). The modeling framework incorporates Beaufort-specific trackline detection probabilities for false killer whales derived following the methods of Barlow et al. (2015) and accounts for changes in false killer whale data collection through time (see Bradford et al. 2020 for details). Bradford et al. (2020) also produced design-based abundance estimates for false killer whales within the Hawaii EEZ for each Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS) year, and these can be used as a point of comparison to the model-based estimates. While on average, the estimates are broadly similar between the two approaches, the annual design-based estimates show much greater variability between years than do the model-based estimates (Figure 4). The model-based approach reduces variability through explicit examination of habitat relationships across the full dataset, while the design-based approach evaluates encounter data for each year separately and thus is more susceptible to the effects of encounter rate variation. Bradford et al. (2020) found through simulation that the low sighting rate in 2002 and high sighting rate in 2017 could be explained by encounter rate variation. Although a 'year' covariate was tested during model development, it was not selected as a significant variable. Despite not fully accounting for inter-annual variation in total abundance, the model-based estimates are considered the best available estimate for each survey year. Current model-based estimates for the central Pacific include animals that are considered part of the Palmyra Atoll stock, as well as animals that may be part of an eastern Pacific stock on the eastern edge of the modeled area, and therefore are likely an overestimate of the full Hawaii pelagic stock abundance. Previous abundance estimates from the Hawaii EEZ and central Pacific using subsets of the full dataset and different line-transect parameters have been published previously. The estimate of 2,086 (CV=0.35) from the 2017 survey is considered the best available current estimate for false killer whales in the Hawaii EEZ (Bradford et al. 2020). ~~Analysis of a 2010shipboard line-transect survey the Hawaiian Islands resulted in an abundance estimate of 1,540 (CV=0.66) false killer whales outside of 11 km of the main Hawaiian Islands (Bradford *et al.* 2014, 2015).~~

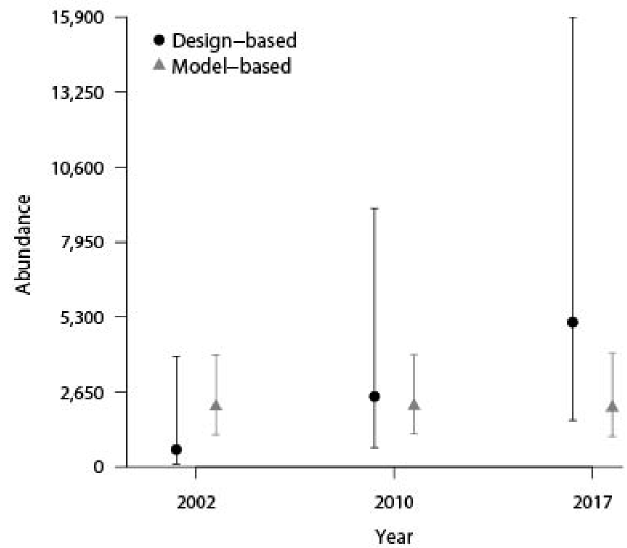

Figure 4. Comparison of design-based (circles, Bradford et al. *in review*) and model-based (triangles, Becker et al. *in* review) estimates of abundance for false killer whales for each HICEAS year (2002, 2010, 2017).

The reanalysis may still be subject to potential bias due to vessel attraction as described by Bradford *et al.* (2014). There the authors reported that most (64%) false killer whale groups seen during the 2010 HICEAS survey were seen moving toward the vessel when detected by the visual observers. Together with an increase in sightings close to the trackline, these behavioral data suggest vessel attraction is likely occurring and may be significant. Similar to the treatment of the detection function in ~~Although~~ Bradford *et al.* (2014, 2015), new model-based estimates use Beaufort-specific effective strip width estimates (following Barlow *et al.* 2015) derived from an analysis that ~~employed~~ used a half-normal model to minimize the effect of vessel attraction.~~, t~~The abundance estimate may still be positively biased ~~as a result of~~due to vessel attraction because groups originally outside of the survey strip, and therefore unavailable for observation by the visual survey team, may have moved within the survey strip and been sighted. ~~There is some suggestion of such attractive movement within the~~ The acoustic data and visual data suggests vessel attraction (Bradford *et al.* 2014), though the extent of any bias created by this movement is unknown. ~~EEZ-wide abundance was previously estimated to be 484 (CV = 0.93) from a 2002 survey (Barlow and Rankin 2007). A 2005 survey (Barlow and Rankin 2007) resulted in a separate abundance estimate of 906 (CV=0.68) false killer whales in international waters south of the Hawaiian Islands EEZ and within the EEZ of Johnston Atoll, but it is unknown how many of these animals might belong to the Hawaii pelagic stock.~~

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) of the 2017~~2010~~ abundance estimate for the Hawaiian Islands EEZ ~~outside of 11 km from the main Hawaiian Islands~~ (Bradford *et al.* ~~*2014, 2015*~~2020) or ~~928~~1,567 false killer whales. For the entire central Pacific study area, the minimum population size for 2017 is estimated to be 25,940 false killer whales.

Current Population Trend

Although a 'year' covariate was evaluated during model development and not included during the model selection process, the final model-based abundance estimates for false killer whales provided by Bradford *et al.* (2020) do not explicitly examine population trend other than that driven by environmental factors. In contrast, annual design-based estimates suggest an increase population size within the Hawaii EEZ, however, these changes can be largely explained by random variability in encounter rate common for species with low density and patchy distribution. Examination of population trend for false killer whales requires additional data inside and outside of the Hawaii EEZ. ~~No data are available on current population trend. It is incorrect to conclude that the increase in the abundance estimate from 2002 to 2010 represents an increase in population size, given changes to the survey design in 2010 and the analytical framework specifically intended to better enumerate and account for overall group size (Bradford *et al.* 2014), the low precision of each estimate, and a lack of understanding of the oceanographic processes that may drive the distribution of this stock over time. Further, estimation of the detection function for the 2002 and 2010 estimates relied on shared data, such that the resulting abundance estimates are not statistically independent and cannot be compared in standard statistical tests. Only a portion of the overall range of this population has been surveyed, precluding evaluation of abundance of the entire stock.~~

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii pelagic stock of false killer whales is calculated as the minimum population estimate for the U.S. EEZ of the Hawaiian Islands (1,567 ~~928~~) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with a Hawaiian Islands EEZ mortality and serious injury rate CV <= 0.30; Wade and Angliss 1997), resulting in a PBR of 16 ~~9.3~~ false killer whales per year. For the entire central Pacific, based on the minimum population size of 25,940 false killer whales, and using the same recovery factor and maximum net growth rate as for the Hawaii pelagic stock, would yield a PBR of 259 false killer whales per year.

STATUS OF STOCK

The status of the Hawaii pelagic stock of false killer whales relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Concentrations of polychlorinated biphenyls (PCBs) exceeded proposed threshold levels for health effects in 84% of sampled MHI insular false killer whales (Foltz *et al.* 2014), and elevated concentrations are also expected in pelagic false killer whales given the amplification of these contaminants through the food chain and likely similarity in false killer whale diet across the region. This stock is not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Following the NMFS Guidelines for Assessing Marine Mammal Stocks (NMFS 2005), the status of this transboundary stock of false killer whales is assessed based on the estimated abundance and ~~estimates of~~ mortality and serious injury within the U.S. EEZ of the Hawaiian Islands because estimates of human-caused mortality and serious injury from all U.S. and non-U.S. sources in high seas waters are not available. ~~, and because the geographic range of this stock beyond the Hawaiian Islands EEZ is poorly known. For the 5-yr period prior to the implementation of the TRP, the average rate of mortality and serious injury to pelagic stock false killer whales within the Hawaiian Islands EEZ (13.6 animals per year) exceeded the PBR (9.3 animals per year). In most cases, the NMFS Guidelines for Assessing Marine Mammal Stocks (NMFS 2005) suggest pooling estimates of mortality and serious injury across 5 years to reduce the effects of sampling variation. If there have been significant changes in fishery operation that are expected to affect take rates, such as the 2013 implementation of the TRP, the guidelines recommend using only the years since regulations were implemented. Using only bycatch information from 2013-2015, the estimated mortality and serious injury of false killer whales within the HI EEZ (4.1) is below the PBR (9.3). Of note, in 2014 the total number of false killer whales taken in the deep-set fishery (55) is the highest recorded since 2003 and the total estimated mortality and serious injury of false killer whales (44) is the second highest since 2003. The total estimated mortality and serious injury of false killer whales in 2015 is the 2nd highest in 5 years. The proportion of non-serious~~

~~injuries is lower in 2013-2015 than the aggregate of all prior years; however, similar 3-year average non-serious injury rates have been observed previously. Further, recent studies (Carretta and Moore 2014) have argued that estimates from a single year of data can be biased when take events are rare, as are takes of false killer whales in the Hawaii-based longline fisheries, and that several years of data may need to be pooled to reduce error. For these reasons, the strategic status for this stock has been evaluated relative to the most recent 5 years of estimated mortality and serious injury.~~ The estimated mortality and serious injury within the Hawaii EEZ in 2018 is the highest recorded since before the TRP was put into place. Although take estimates for 2019 are not reported here, 5 observed takes within the EEZ were reported in that year, resulting in closure of the SEZ in February 2019. Take rates of false killer whales by the deep-set longline fishery outside of the EEZ continue to remain significantly higher since the TRP. Model-based estimates of abundance and PBR for the central Pacific should be considered when evaluating stock status across the fishery area. ~~The total~~ Total 5-year mortality and serious injury for 2014-2018 ~~2011-2015~~ (6.5 ~~7.6~~) is less than PBR (16 ~~9.3~~), ~~such that~~therefore this stock is not considered a "strategic stock" under the MMPA. Additional monitoring of bycatch rates ~~for~~ of this stock ~~will be~~ are required before assessing whether TRP measures have reduced rangewide fishery takes below PBR. ~~The t~~ Total fishery mortality and serious injury for the Hawaii pelagic stock of false killer whales cannot be considered to be insignificant and approaching zero.

NORTHWESTERN HAWAIIAN ISLANDS STOCK

POPULATION SIZE

Encounter data from shipboard line-transect surveys of the entire Hawaiian Islands EEZ were reevaluated for each survey year, resulting in the following abundance estimates of Northwestern Hawaiian Islands false killer whales (Bradford *et al*. 2020) (Table 3).

Table 3. Line-transect abundance estimates for Northwestern Hawaiian Islands false killer whales derived from surveys of the entire Hawaii EEZ in 2002, 2010, and 2017 (Bradford et al. 2020).

Year	Abundance	CV	95% Confidence Limits
2017	477	1.71	48-4,712
2010	878	1.15	145-5,329
2002	N/A		

The updated design-based abundance estimates use sighting data from throughout the central Pacific to estimate the detection function and use Beaufort sea-state-specific trackline detection probabilities for false killer whales following the methods of Barlow et al. (2015). Although a previous 2010 estimate for this stock was published using a subset of this data, Bradford et al. (2020), uses a consistent approach for estimating all abundance parameters and resulting estimates are considered the best available. There were no sightings of false killer whales in the NWHI stock area in 2002. ~~A 2010 line transect survey that included the waters surrounding the Northwestern Hawaiian Islands produced an estimate of 617 (CV = 1.11) false killer whales attributed to the Northwestern Hawaiian Islands stock (Bradford *et al.* 2014, 2015). This is the best available abundance estimate for false killer whales within the Northwestern Hawaiian Islands.~~ The reanalysis may still be subject to potential bias due to vessel attraction as described by Bradford *et al.* (2014). Those authors reported that most (64%) false killer whale groups seen during the 2010 HICEAS survey were seen moving toward the vessel when detected by the visual observers. Together with an increase in sightings close to the trackline, these behavioral data suggest vessel attraction is likely occurring and may be significant. Bradford *et al.* (2014, 2015, 2020) ~~employed~~ used a half-normal model to minimize the effect of vessel attraction, because groups originally outside of the survey strip, and therefore unavailable for observation by the visual survey team, may have moved within the survey strip and been sighted. There is some suggestion of such attractive movement within the acoustic and visual data (Bradford *et al.* 2014) though the extent of any bias created by this movement is unknown. The best estimate of current abundance is 477 (CV=1.71) false killer whales from the 2017 survey (Bradford *et al.* 2020).

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) of the 2017~~2010~~ abundance estimate for the Northwestern Hawaiian Islands stock (Bradford *et al.* 2020 ~~2015~~) or 178 ~~290~~ false killer whales. This estimate has not been corrected for vessel attraction and may be positively- biased.

Current Population Trend

The two available abundance estimates for this stock have very broad and overlapping confidence intervals, precluding evaluation of population trend for this stock. ~~No data are available on current population trend because there is only one estimate of abundance from 2010.~~

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for this species in the waters surrounding the Northwestern Hawaiian Islands.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Northwestern Hawaiian Islands false killer whale stock is calculated as the minimum population estimate (178 ~~290~~) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.40 (for a stock of unknown status, with a Hawaiian Islands EEZ mortality and serious injury rate CV > 0.8; Wade and Angliss 1997), resulting in a PBR of 1.4 ~~2.3~~ false killer whales per year.

STATUS OF STOCK

The status of false killer whales in Northwestern Hawaiian Islands waters relative to OSP is unknown, and ~~there are~~ insufficient data exists to evaluate abundance trends ~~in abundance~~. Concentrations of polychlorinated biphenyls (PCBs) exceeded proposed threshold levels for health effects in 84% of sampled MHI insular false killer whales (Foltz *et al.* 2014), and elevated concentrations are ~~also~~ expected in NWHI false killer whales given ~~the~~ amplification of these contaminants through the food chain and likely similarity in false killer whale diet across the region. Biomass of some false killer whale prey species may have declined around the Northwestern Hawaiian Islands (Oleson *et al.* 2010, Boggs & Ito 1993, Reeves *et al.* 2009), though waters within the original Papahānaumokuākea Marine National Monument have been closed to commercial longlining since 1991 and to other fishing since 2006. This stock is not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor as "depleted" under the MMPA. The rate of mortality and serious injury to NWHI false killer whales (0.01)~~, (0.6 for 2008-2012, 0 for 2013-2015, 0.4 for 2011-2015)~~ is less than the PBR (1.4 ~~2.3~~ animals per year), ~~but is not~~ and can be considered to be insignificant and approaching zero. ~~mortality and serious injury rate because it exceeds 10% of PBR (NMFS 2004).~~ ~~Only a~~ A very small portion of the recognized stock range lies outside of the newly expanded PMNM and the expanded LLEZ, such that this stock is likely not exposed to high levels of fishing effort because commercial and recreational fishing is prohibited within Monument waters and longlines are excluded from the majority of the stock range. ~~Additional monitoring of bycatch rates for this stock will be required before assessing whether TRP measures have reduced fishery takes to below 10% of PBR.~~

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KILLER WHALE (*Orcinus orca*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Killer whales have been observed in all oceans and seas of the world (Leatherwood and Dahlheim 1978). Although reported from tropical and offshore waters (Heyning and Dahlheim 1988), killer whales prefer the colder waters of both hemispheres, with greatest abundances found within 800 km of major continents (Mitchell 1975). They are considered rare in Hawaiian waters. ~~No killer whales were seen during 1993-98 aerial surveys within about 25 nmi of the main Hawaiian Islands, but one sighting was reported during subsequent surveys (Mobley *et al.* 2000, 2001).~~ Baird *et al.* (2006) reported 21 sighting records in Hawaiian waters between 1994 and 2004. Summer/fall shipboard surveys of U.S. Exclusive Economic Zone (EEZ) Hawaiian waters resulted in two sightings in 2002, ~~and~~ one in 2010~~.~~, and one in 2017 (Figure 1; Barlow 2006; Bradford *et al.* 2017, Yano *et al.* 2018). ~~Three strandings have been reported since 1950 (Richards 1952, NMFS PIR Marine Mammal Reponses Network database), including one since 2007.~~ Eighteen additional sightings were reported around the main Hawaiian Islands, French Frigate Shoals, and offshore of the Hawaiian islands (Baird *et al.* 2006). Except in the northeastern Pacific where "resident", "transient", and "offshore" stocks have been described for coastal waters of Alaska, British Columbia, and Washington to California (Bigg 1982; Leatherwood *et al.* 1990, Bigg *et al.* 1990, Ford *et al.* 1994), little is known about stock structure of killer whales in the North Pacific. A global-scale analysis of killer whale phylogeographic structure clustered one animal sampled near Hawaii with eastern and western North Pacific transients. The other Hawaii sample within that analysis did not cluster with any known ecotype, but had divergence time between that of transient and offshore forms (Morin *et al.* 2010). Killer whales in Hawaii have been observed chasing and feeding on both marine mammals and large sharks, including observations of a killer whale attacking a spotted dolphin, chasing a rough-toothed dolphin, and consuming big-eye thresher and hammerhead sharks (Baird 2016).

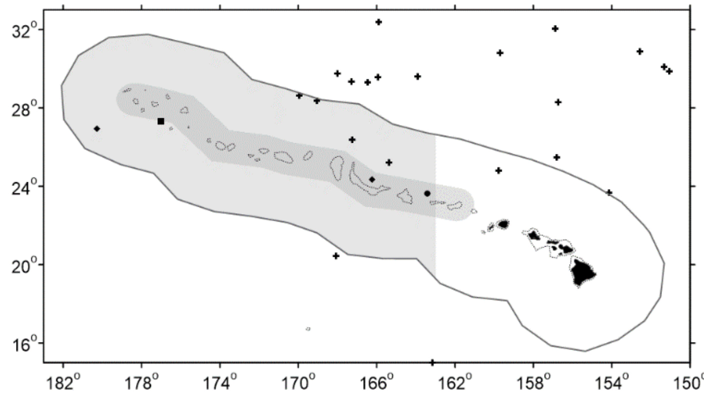

Figure 1. Locations of killer whale sightings from longline observer records (crosses; NMFS/PIR, unpublished data) and sighting locations during the 2002 (~~open~~ diamonds), ~~and~~ 2010 (~~black diamonds~~circle), and 2017 (square) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford *et al.* 2017, Yano *et al.* 2018~~; see Appendix 2 for details on timing and location of survey effort~~). Outer line represents approximate boundary of survey area and U.S. EEZ. Dark and light gray shading indicate the original and the 2016 Eexpanded areas of Papahanaumokuakea Marine National Monument. Dotted line represents the 1000 m isobath.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, eight killer whale stocks are recognized within the Pacific U.S. EEZ: 1) the Eastern North Pacific Alaska Resident stock - occurring from southeastern Alaska to the Aleutian Islands and Bering Sea, 2) the Eastern North Pacific Northern Resident stock - occurring from British Columbia through part of southeastern Alaska, 3) the Eastern North Pacific Southern Resident stock – occurring mainly within the inland waters of Washington State and southern British Columbia, but also in coastal waters from British Columbia through California, 4) the Eastern North Pacific Gulf of Alaska, Aleutian Islands, and Bering Sea Transient stock - occurring mainly from Prince William Sound through the Aleutian Islands and Bering Sea, 5) the AT1 Transient stock - occurring in Alaska from Prince William Sound through the Kenai Fjords, 6) the West Coast Transient stock - occurring from California through southeastern Alaska, 7) the Eastern North Pacific Offshore stock - occurring from California through Alaska, and 8) the Hawaiian stock (this report). The Hawaii stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters. Because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005). Stock assessment reports for the Southern Resident, Eastern North Pacific Offshore, and Hawaiian stocks can be found in the Pacific Region stock assessment reports; all other killer whale stock assessments are included in the Alaska Region stock assessments.

POPULATION SIZE

Encounter data from ~~a 2010~~ shipboard line-transect surveys of the entire Hawaiian Islands EEZ were recently reevaluated for each survey year, resulting in the following abundance estimates of killer whales in the Hawaii EEZ (Bradford *et al. in review*) (Table 1).

Table 1. Line-transect abundance estimates for killer whales derived from surveys of the entire Hawaii EEZ in 2002, 2010, and 2017 (Bradford *et al. in review*).

Year	Abundance	CV	95% Confidence Limits
2017	161	1.06	29-881
2010	145	0.98	29-726
2002	499	0.90	111-2,245

The updated design-based abundance estimates use sighting data from throughout the central Pacific to estimate the detection function and use Beaufort sea-state-specific trackline detection probabilities for killer whales from Barlow *et al.* (2015). Although previous estimates from the Hawaii EEZ have been published using subsets of this data, Bradford *et al. in review*, uses a consistent approach for estimating all abundance parameters and resulting estimates are considered the best available. The best estimate of abundance is based on the 2017 survey, or 161 (CV=1.06) killer whales. ~~using Beaufort sea-state-specific trackline detection probabilities for killer whales, resulting in an abundance estimate of 146 (CV = 0.96) killer whales (Bradford *et al.* 2017) in the Hawaii stock. A 2002 shipboard line-transect survey of the same area resulted in an abundance estimate of 349 (CV=0.98) killer whales (Barlow 2006). Species abundances estimated from the 2002 HICEAS survey used pooled small dolphin, large dolphin, and large whale g(0) (the probability of sighting and recording an animal directly on the track line) estimates stratified by group size (Barlow 1995). Since then, Barlow (2015) developed a more robust method for estimating species-specific g(0) values that are adjusted for the Beaufort sea states that are encountered during a survey. This new method was used for analyzing the data from the 2010 survey, but has not yet been used to analyze the 2002 data.~~

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) of the 2017~~2010~~ abundance estimate or ~~74~~78 killer whales within the Hawaiian Islands EEZ.

Current Population Trend

The three available abundance estimates for this stock have very broad and overlapping confidence intervals, precluding robust evaluation of population trend for this stock.~~Abundance analyses of the 2002 and 2010 datasets used different g(0) values. The 2002 survey data have not been reanalyzed using this method. This change precludes evaluation of population trends at this time. Assessment of population trend will likely require additional survey data and reanalysis of all datasets using comparable methods.~~

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current and maximum net productivity rate in Hawaiian waters.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size within the U.S. EEZ of the Hawaiian Islands (78 ~~74~~) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no known fishery mortality or serious injury within the Hawaiian Islands EEZ; Wade and Angliss 1997), resulting in a PBR of 0.8 ~~0.7~~ killer whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Information on fishery-related mortality and serious injury of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other U.S. fisheries~~ throughout U.S. waters~~. No interactions between nearshore fisheries and killer whales have been reported in Hawaiian waters. No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line or gillnet fisheries because these fisheries are not observed or monitored for protected species bycatch. Killer whale interactions with Hawaii fisheries appear to be rare. In 1990, a solitary killer whale was reported to have removed the catch from a longline in Hawaii (Dollar 1991). There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2014~~2011~~ and 2018~~2015~~, no killer whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (~~20~~18-22% observer coverage) (Bradford 2018a, 2018b, *in review*~~2017~~, Bradford and Forney 2017, McCracken~~ 2017~~ 2019).

STATUS OF STOCK

The Hawaii stock of killer whales is not considered strategic under the 1994 amendments to the MMPA. The status of killer whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. No habitat issues are known to be of concern for this stock. Killer whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Given the absence of recent recorded fishery-related mortality or serious injuries the total fishery mortality and serious injury can be considered to be insignificant and approaching zero. Desforges *et al*. (2018) compiled available data on blubber PCB concentrations in killer whales from populations around the world and compared these to established response relationships for reproductive impairment and immunotoxicity-related disease mortality using an individual-based model framework. Model forecasting over 100 years suggested large potential impact of PCBs on the size and long-term viability of some killer whales around the world. The model predicted that killer whales in Hawaiian waters are at high risk of decline due to PCB contaminants, similar to Bigg's killer whale populations sampled in the eastern North Pacific.

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SHORT-FINNED PILOT WHALE (*Globicephala macrorhynchus*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Short-finned pilot whales are found in all oceans, primarily in tropical and warm-temperate waters.~~ They are commonly observed around the main Hawaiian Islands and are also present around the Northwestern Hawaiian Islands (Shallenberger 1981, Baird et al. 2013, Bradford et al. 2013)~~. Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands resulted in 25 sightings in 2002, ~~and~~ 36 in 2010, and 35 in 2017 including a higher frequency of encounters near shore within the Northwestern Hawaiian Islands (Figure 1; Barlow 2006, Bradford et al. 2017, Yano *et al*. 2018). ~~Twenty-three strandings of short-finned pilot whales have been documented from the Hawaiian Islands since 1957, including five mass strandings in May and October of 1958 and 1959 (Tomich 1986; Nitta 1991; Maldini *et al.* 2005, NMFS-PIR Marine Mammal Response Network database). There have been four strandings since 2007.~~

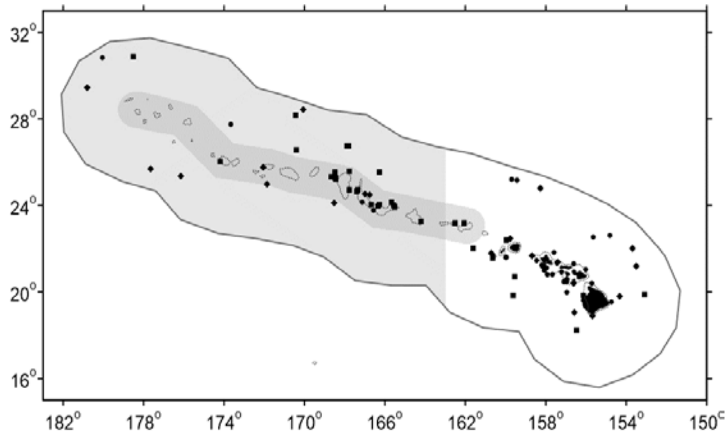

Figure 1. Short-finned pilot whale sighting locations during the 2002 (~~open~~ diamonds), ~~and~~ 2010 (circles~~black diamonds~~), and 2017 (squares) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2017, Yano *et al*. 2018)~~; see Appendix 2 for details on timing and location of survey effort~~). Outer solid line represents approximate boundary of survey area and U.S. EEZ. Gray shading indicates area of Papahanaumokuakea Marine National Monument with the lighter gray shading denoting the full 2016 Expansion area. Dotted line represents the 1000 m isobath.

Two forms of short-finned pilot whales have been identified in Japanese waters based on pigmentation patterns and differences in the shape of the heads of adult males (Kasuya et al. 1988). Genetic analysis of samples from throughout the global range of short-finned pilot whales suggest three types within the species, and Atlantic type, a western/central pacific and Indian Ocean (Naisa) type, and an eastern tropical Pacific and northern Japan (Shiho) type. Significant differentiation in mtDNA control region sequences further suggest that the three forms represent two subspecies, the shiho short-finned pilot whale an and the naisa short-finned pilot whale, with evidence of further divergence among the naisa types in the Atlantic and Pacific (Van Cise *et al*. 2019). The pilot whales in Hawaiian waters are ~~similar morphologically to the Japanese "southern form" or~~ of the naisa type ~~naisa morphotype~~. ~~Recent genetic analyses confirm that short-finned pilot whales in Hawaiian waters are genetically similar to this naisa morphotype and that they may be differentiated using mtDNA markers from those animals in the eastern tropical Pacific and temperate Pacific waters (Van Cise *et al.* 2015).~~ The shiho and naisa forms appear also to be distinguishable based on the acoustic features of their whistle and burst-pulse sounds, providing further evidence for divergence between these subspecies (Van Cise *et al*. 2017).

Photo-identification, ~~and~~ telemetry ~~studies~~, acoustic, and genetic studies suggest ~~there may be inshore and pelagic populations of~~that at least two demographically-independent population of short-finned pilot whales reside in Hawaiian waters. Resighting and social network analyses of individuals photographed off Hawaii Island suggest the occurrence of one large and several smaller social clusters that use those waters, with some individuals within the smaller social clusters commonly resighted off Hawaii Island (Mahaffy et al. 2015). Further, two groups of 14 individuals have been seen at Hawaii and elsewhere in the main Hawaiian Islands, one off Oahu and the other off Kauai, indicating some degree of connectivity within the main Hawaiian Islands (MHI). Satellite telemetry data from over 60 individuals tagged throughout the main Hawaiian Islands also support the occurrence of at least two populations (Baird 2016, Oleson *et al.* 2013). An assessment of foraging hotspots off Hawaii Island revealed tight association between satellite-tagged short-finned pilot whales and the 1000-2500m depth range (Abecassis *et al.* 2015). More recently, Van Cise *et al.* (2017) used nuclear SNPs to assess population structure within Hawaii short-finned pilot whales and found evidence for an island-associated population in the ~~main Hawaii Islands (~~MHI~~)~~.

Although there was some support for separation of short-finned pilot whales in the northwestern Hawaiian Islands (NWHI) from other pelagic animals, additional genetic samples may be required to test this separation further. In addition, genetic data combined with social affiliation and habitat associations suggest the MHI population is further divided into social groups, and these groups may even rise to the level of demographic-independence between those found primarily near Hawaii Island and those near Oahu and Kauai (Van Cise *et al.* 2017a). Differences in the acoustic features of short-finned pilot whale social clusters recorded within the MHI further supports the existence of several DIPs within the MHI (Van Cise *et al.* 2017b). ~~Delineation of island-associated stocks in Hawaii is under review.~~ Formal assessment of demographic-independence has not been completed, but division of this population into a separate island-associated stock may be warranted in the future.

~~Fishery interactions with short-finned pilot whales demonstrate that this species also occurs in U.S. EEZ waters of Palmyra Atoll and Johnston Atoll, but it is not known whether these animals are part of the Hawaii stock or whether they represent separate stocks of short-finned pilot whales.~~ For the Marine Mammal Protection Act (MMPA) stock assessment reports, short-finned pilot whales within the Pacific U.S. EEZ are divided into two discrete, non-contiguous areas: 1) Hawaiian waters (this report), and 2) waters off California, Oregon and Washington. The Hawaii stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters. The status of the Hawaii stock is evaluated based on abundance, distribution, and human-caused impacts within the Hawaiian Islands EEZ, as such datasets are largely lacking for high seas waters (NMFS 2005).

POPULATION SIZE

Encounter data from ~~a 2010~~ shipboard line-transect surveys of the entire Hawaiian Islands EEZ was recently reevaluated, resulting in updated model-based abundance estimates of short-finned pilot whales in the Hawaii EEZ (Becker *et al. in review*) (Table 1).

Table 1. Line-transect abundance estimates for short-finned pilot whales derived from surveys of the entire Hawaii EEZ in 2002, 2010, and 2017 (Becker et al. *in review*).

Year	Model-based abundance	CV	95% Confidence Limits
2017	12,607	0.18	8,8263-18,008
2010	15,343	0.17	11,039-21,326
2002	15,198	0.17	10,900-21,191

Sighting data from 2002 to 2017 within the Hawaii EEZ were used to derive habitat-based models of animal density for the overall period. The models were then used to predict density and abundance for each survey year based on the environmental conditions within that year (see Forney *et al.* 2015, Becker *et al.* 2016). The modeling framework incorporated Beaufort-specific trackline detection probabilities for short-finned pilot whales from Barlow *et al.* (2015). Bradford *et al.* (*in review*) produced design-based abundance estimates for short-finned pilot whales for each survey year that can be used as a point of comparison to the model-based estimates. While on average, the estimates are broadly similar between the two approaches, the annual design-based estimates show much greater variability between years than do the model-based estimates (Figure 2). The model-based approach reduces variability through explicit examination of habitat relationships across the full dataset, while the design-based approach evaluates encounter data for each year separately and thus is more susceptible to the effects of encounter rate variation. Model based-estimates are based on the implicit assumption that changes in abundance are attributed to environmental variability alone due to a lack of data to test for other effects. Despite not fully accounting for inter-annual variation in total abundance, the model-based estimates are

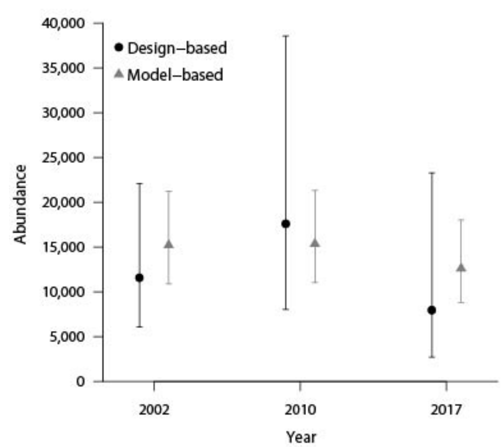

Figure 2. Comparison of design-based (circles, Bradford et al. *in review*) and model-based (triangles, Becker *et al. in* review) estimates of abundance for short-finned pilot whales for each survey year (2002, 2010, 2017).

considered the best available estimate for each survey year. Previously published design-based estimates for the Hawaii EEZ from 2002 and 2010 surveys (e.g. Barlow 2006, Bradford *et al.* 2017) used a subset of the dataset used by Becker *et al.* (*in review*) and Bradford et al. (*in review*) to derive line-transect parameters, such that these estimates have been superseded by the estimates presented here. The best estimate of abundance is based on the 2017 survey, or 12,607 (CV=0.18). ~~using Beaufort sea-state-specific trackline detection probabilities for short-finned pilot whales, resulting in an abundance estimate of 19,503 (CV = 0.49) short-finned pilot whales (Bradford *et al.* 2017) in the Hawaii stock. A 2002 shipboard line-transect survey of the same area resulted in an abundance estimate of 8,846 (CV=0.49) short-finned pilot whales (Barlow 2006). Species abundances estimated from the 2002 HICEAS survey used pooled small dolphin, large dolphin, and large whale g(0) (the probability of sighting and recording an animal directly on the track line) estimates stratified by group size (Barlow 1995). Since then, Barlow (2015) developed a more robust method for estimating species-specific g(0) values that are adjusted for the Beaufort sea states that are encountered during a survey. This new method was used for analyzing the data from the 2010 survey, but has not yet been used to analyze the 2002 data~~.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al. 1995) of the 2010 abundance estimate for the Hawaiian Islands EEZ or 10,847 ~~13,197~~ short-finned pilot whales.

Current Population Trend

The model-based abundance estimates for short-finned pilot whales provided by Becker *et al.* (*in review*) do not explicitly allow for examination of population trend other than that driven by environmental factors. Model-based examination of short-finned pilot whale population trends including sighting data beyond the Hawaii EEZ will be required to more fully examine trend for this stock. ~~Abundance analyses of the 2002 and 2010 datasets used different g(0) values. The 2002 survey data have not been reanalyzed using this method. This change precludes evaluation of population trends at this time. Assessment of population trend will likely require additional survey data and reanalysis of all datasets using comparable methods.~~

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii short-finned pilot whale stock is calculated as the minimum population estimate (10,847~~13,197~~) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.40 (for a species of unknown status with a Hawaiian Islands EEZ fishery mortality and serious injury rate CV> 0.80; Wade and Angliss 1997), resulting in a PBR of 87~~106~~ short-finned pilot whales per year.

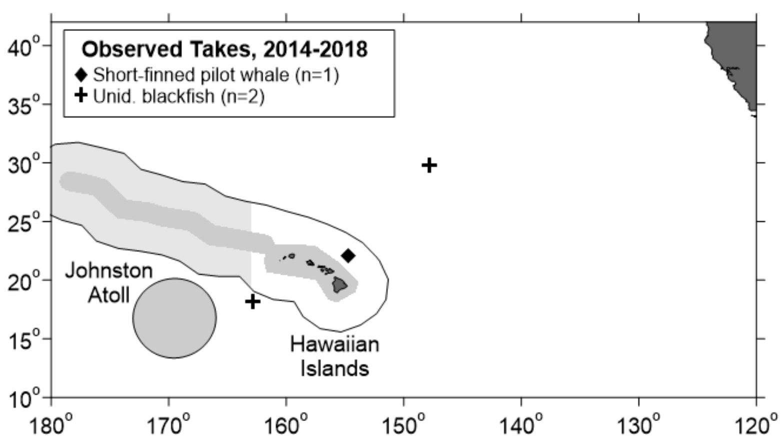

Figure 3~~2~~. Locations of short-finned pilot whale takes (filled diamonds) and possible takes of this species (~~open diamonds~~crosses) in Hawaii-based longline fisheries, 2014-2018~~2011-2015. Some take locations overlap~~. Solid lines represent the U. S. EEZ. Gray shading notes areas closed to longline fishing with the PMNM Expansion area closed since August 2016.~~. Fishery descriptions are provided in Appendix 1.~~

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. Entanglement in gillnets and hooking or entanglement in various hook and line fisheries have been reported for small cetaceans in Hawaii (Nitta & Henderson, 1993). Short-finned pilot whales have been observed with fishing gear trailing from their mouths, though the specific gear types have not been identified (Baird 2016). In 2014, a short-finned pilot whale was found stranded on Oahu with large amounts of debris in its stomach, including approximately 20 lbs. of fishing line, nets, and plastic drogues, though this gear was judged not to be the cause of death (Bradford and Lyman 2018~~in review~~). ~~The necropsy team judged that the whale had not eaten in at least 24 hrs, but it was not clear what role the debris played in the whale's death.~~ In 2017, two short-finned pilot whales stranded together as part of a mass stranding event on Kauai. One of the whales had 12-15 lbs of nylon line and plastic present within its forestomach and the other has scarring on the upper right jaw consistent with previous fisheries interaction, though in neither case were these findings considered to be related to the cause of death (Bradford and Lyman 2019). No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line or gillnet fisheries because these fisheries are not observed or monitored for protected species bycatch.

Table ~~1~~2. Summary of available information on incidental mortality and serious injury of short-finned pilot whales (Hawaii stock) and including those presumed to be short-finned pilot whales based on assignment of unidentified blackfish to this species in commercial longline fisheries, within and outside of the U.S. EEZs (McCracken 2019~~2017~~). Mean annual takes are based on 2014-2018~~2011-2015~~ data unless otherwise indicated. Information on all observed takes (T) and combined mortality events & serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome. Unidentified blackfish are pro-rated as either false killer whales or short-finned pilot whales according to their distance from shore (McCracken 2010). CVs are estimated based on the combination of annual short-finned pilot whale and blackfish variances and do not yet incorporate additional uncertainty introduced by prorating the unidentified blackfish.

Fishery Name	Year	Data Type	Percent Observer Coverage	Observed total interactions (T) and mortality events, and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) of short-finned pilot whales (GM)			
				Outside U.S. EEZs		Hawaiian EEZ	
				Obs. GM T/MSI Obs. UB T/MSI	Estimated M&SI (CV)	Obs. GM T/MSI Obs. UB T/MSI	Estimated M&SI (CV)
Hawaii-based deep-set longline fishery	~~2011~~	Observer data	~~20%~~	~~0~~ ~~1/0~~	~~1.6 (1.1)~~	~~0~~ ~~1/1~~	~~0.1 (0.9)~~
	~~2012~~		~~20%~~	~~0~~ ~~1/1~~	~~0.6 (0.8)~~	~~0~~ ~~0~~	~~0 (-)~~
	~~2013~~		~~20%~~	~~1/1~~ ~~0~~	~~4.1(0.9)~~	~~0~~ ~~0~~	~~0 (-)~~
	2014		21%	0 0	0 (-)	0 0	0 (-)
	2015		21%	0 1/1†	0.7 (0.9)	1/1 0	4.3 (0.9)
	2016		20%	0 0	0 (-)	0 0	0 (-)
	2017		20%	0 0	0 (-)	0 0	0 (-)
	2018		18%	0 1/1	0.8 (0.8)	0 0	0 (-)
Mean Estimated Annual Take (CV)					**~~1.4~~ 0.3 (~~1.5~~ 0.9)**		**0.9 (~~1.2~~ 1.1)**
Hawaii-based shallow-set longline fishery	~~2011~~	Observer data	~~100%~~	~~0~~ ~~1/1~~	~~0.3~~	~~0~~ ~~0~~	~~0~~
	~~2012~~		~~100%~~	~~0~~ ~~0~~	~~0~~	~~0~~ ~~0~~	~~0~~
	~~2013~~		~~100%~~	~~0~~ ~~0~~	~~0~~	~~0~~ ~~0~~	~~0~~
	2014		100%	0 0	0	0 0	0

	2015		100%	0 0	0	0 0	0
	2016		100%	0 0	0	0 0	0
	2017		100%	0 0	0	0 0	0
	2018		100%	0 0	0	0 0	0
Mean Annual Takes (100% coverage)					**~~0.1~~ 0**		**0**
Minimum total annual takes within U.S. EEZ							**0.9 (1.1~~1.2~~)**

† Injury status could not be determined based on information collected by the observer. Injury status is prorated (see text).

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas, but are prohibited from operating within the Papahanaumokuakea Marine National Monument, a region that extends 50 nmi from shore around the Northwestern Hawaiian Islands, and within the Longline Exclusion Area, a region extending 25-75 nmi from shore around the main Hawaiian Islands. Commercial fishing has also been banned within the expanded PMNM since August 2016. Between 2014~~2011~~ and 2018~~2015~~, no short-finned pilot whales were observed hooked or entangled in the SSLL fishery (100% observer coverage), and one~~two short-finned pilot whales were~~ was observed taken in the DSLL fishery (~~20~~18-21% observer coverage) (Figure 3, Bradford 2018a, 2018b, *in review* ~~2017~~, Bradford and Forney 2017, McCracken 2019~~2017~~), ~~one in high-seas waters and the other~~ inside the Hawaiian Islands EEZ. Based on an evaluation of the observer's description of the interaction and following the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012), this~~one~~ short-finned pilot whales was ~~observed dead and the other was~~ considered seriously injured (Bradford 2018a, 2018b, *in review* ~~2017~~, Bradford and Forney 2017). Two~~Five~~ additional unidentified "blackfish" (unidentified cetaceans known to be either false killer whales or short-finned pilot whales) were taken during 2014-2018~~2011-2015~~ (Bradford 2018a, 2018b, *in review* ~~2017~~, Bradford and Forney 2017), both within ~~one within the SSLL fishery and four in~~ the DSLL fishery. ~~The single SSLL interaction occurred outside the Hawaiian EEZ and the animal was considered seriously injured.~~ Both of ~~Of~~ the ~~four~~ DSLL interactions, ~~one~~ occurred ~~inside the Hawaii EEZ and was considered seriously injured, and three occurred~~ outside the Hawaii EEZ, with one considered seriously injured, ~~one considered not seriously injured,~~ and one whose injury status could not be determined based on the information provided by the observer. Unidentified blackfish are prorated to each stock based on distance from shore (McCracken 2010). The distance-from-shore model was chosen following consultation with the Pacific Scientific Review Group, based on the model's performance and simplicity relative to a number of other more complicated models with similar output (McCracken 2010). Proration of unidentified blackfish takes introduces unquantified uncertainty into the bycatch estimates, but until all animals taken can be identified to species (e.g., photos, tissue samples), this approach ensures that potential impacts to all stocks are assessed. Average 5-yr estimates of annual mortality and serious injury for 2014-2018~~2011-2015~~ are 1.5 (CV = 0.9~~1.5~~) short-finned pilot whales outside of U.S. EEZs and 0.9 (CV = 1.1~~1.2~~) within the Hawaiian Islands EEZ (Table 2). Four additional unidentified cetaceans were taken in the DSLL fishery~~, and one unidentified cetacean was taken in the SSLL fishery~~, some of which may have been short-finned pilot whales.

STATUS OF STOCK

The Hawaii stock of short-finned pilot whales is not considered strategic under the 1994 amendments to the MMPA. The status of short-finned pilot whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Short-finned pilot whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. The estimated rate of mortality and serious injury within the Hawaiian Islands EEZ (0.9 animals per year) is less than the PBR (87 ~~106~~). Based on the available data, which indicate total fishery-related takes are less than 10% of PBR, the total fishery mortality and serious injury for short-finned pilot whales can be considered to be insignificant and approaching zero. Two short-finned pilot whales were found stranded in separate incidents following Navy sonar training exercises in Hawaii in 2014 (Bradford and Lyman 2018). Examination of whales could did not conclusively link these stranding to use of sonar, though other blackfish have shown sensitivity to sonar training events in Hawaii waters (Southall *et al.* 2006) and elsewhere (Brownell *et al.* 2009).

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Revised ~~5/25/2018~~ 8/20/2020

BLAINVILLE'S BEAKED WHALE (*Mesoplodon densirostris*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Blainville's beaked whale has a cosmopolitan distribution in tropical and temperate waters, apparently the most extensive known distribution of any *Mesoplodon* species (Mead 1989). Forty-five sightings over 13 years were reported from the main islands by Baird *et al.* (2013), who indicated that Blainville's beaked whale represent a small proportion (2-3%) of all odontocete sightings in the main Hawaiian Islands. Shallenberger (1981) suggested that Blainville's beaked whales were present off the Waianae Coast of Oahu for prolonged periods annually. Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands, resulted in three sightings in 2002, ~~and~~ one in 2010; and eight in 2017, however, several sightings of unidentified *Mesoplodon* whales may have also been Blainville's beaked whale (Figure 1; Barlow 2006, Bradford *et al.* 2017, Yano *et al.* 2018).

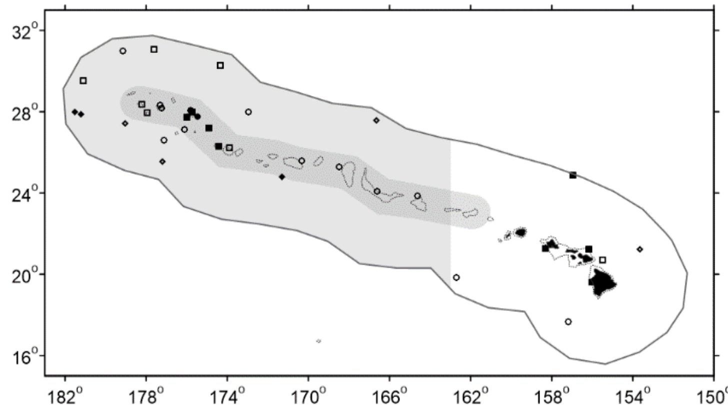

Figure 1. Sighting locations of *Mesoplodon densirostris* during the 2002 (diamond~~s~~), 2010 (circle), and 2017 (square) and unidentified *Mesoplodon* beaked whales ~~(squares)~~ during the 2002 (open ~~symbols~~diamond), ~~and~~ 2010 (~~black symbols~~open circle), and 2017 (open square) shipboard cetacean surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford *et al.* 2017, Yano *et al.* 2018~~; see Appendix 2 for details on timing and location of survey effort~~). Outer line indicates approximate boundary of survey area and U.S. EEZ. ~~Gray~~ Dark gray shading indicates the original ~~area of~~ Papahanaumokuakea Marine National Monument, with the lighter gray shading denoting the full 2016 Expansion area. Dotted line represents the 1~~,~~000m isobath.

Recent analysis of Blainville's beaked whale resightings and movements near the main Hawaiian Islands (MHI) suggest the existence of insular and offshore (pelagic) populations of this species in Hawaiian waters (McSweeney *et al.* 2007, Schorr *et al.* 2009, Baird *et al.* 2013, Baird 2019). Photo-identification of individual Blainville's beaked whales from Hawaii Island since 1986 reveal repeated use of this area by individuals for over 17 years (Baird *et al.* 2011) and 75% of individuals seen off Hawaii Island link by association into a single social network (Baird *et al.* 2013). Those individuals seen farthest from shore and in deep water (>2100m) have not been resighted, suggesting they may be part of an offshore, pelagic population (Baird *et al.* 2011). Twelve Blainville's beaked whales linked to the social network have been satellite tagged off Hawaii Island. All 12 individuals had movements restricted to the MHI, extending to nearshore waters of Oahu, with average distance from shore of 21.6 km (Baird *et al.* 2013, Abecassis *et al.* 2015). One individual tagged 32km from Hawaii Island did not link to the social network and had movements extending far from shore, moving over 900km from the tagging location in 20 days, approaching the edge of the Hawaiian EEZ west of Nihoa (Baird *et al.* 2011). An assessment of foraging hotspots off Hawaii Island revealed tight association between satellite-tagged Blainville's beaked whales and the 250-2500m depth contour and the occurrence of the island-associated deep mesopelagic boundary community (Abecassis *et al.* 2015). The available movement, social structure, and habitat data suggest there is likely a separate island-associated population of Blainville's beaked whales within the MHI (Baird 2019). Formal assessment of demographic-independence has not been completed, but division of this population into a separate island-associated stock may be warranted in the future.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, three *Mesoplodon* stocks are defined within the Pacific U.S. EEZ: 1) *M. densirostris* in Hawaiian waters (this report), 2) *M. stejnegeri* in Alaskan waters, and 3) all *Mesoplodon* species off California, Oregon and Washington. The Hawaii stock of Blainville's beaked whales includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters. Because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

Encounter data from ~~a 2010~~ shipboard line-transect surveys of the entire Hawaiian Islands EEZ were recently reevaluated for each survey year, resulting in the following abundance estimates of Blainville's beaked whales in the Hawaii EEZ (Bradford et al. *in review*) (Table 1).

Table 1. Line-transect abundance estimates for Blainville's beaked whales derived from surveys of the entire Hawaii EEZ in 2002, 2010, and 2017 (Bradford et al. *in review*).

Year	Abundance	CV	95% Confidence Limits
2017	1,132	0.99	224-5,731
2010	1,740	1.05	320-9,468
2002	839	1.05	155-4,536

The updated design-based abundance estimates use sighting data from throughout the central Pacific to estimate the detection function and use Beaufort sea-state-specific trackline detection probabilities for Blainville's beaked whales from Barlow et al. (2015). Although previous estimates from the Hawaii EEZ have been published using subsets of this data, Bradford et al. (*in review*), uses a consistent approach for estimating all abundance parameters and the resulting estimates are considered the best available for each survey year.~~using Beaufort sea-state-specific trackline detection probabilities for beaked whales. The new g(0) values allow for use of all on-effort survey data, and resulted in an abundance estimate of 2,105 (CV = 1.13) Blainville's beaked whales (Bradford *et al.* 2017) in the Hawaii stock. A 2002 shipboard line-transect survey of the same region resulted in an abundance estimate of 2,872 (CV=1.17) Blainville's beaked whales (Barlow 2006). Species abundances estimated from the 2002 HICEAS survey used species-specific g(0) values (Barlow 1999) (the probability of sighting and recording an animal directly on the track line) and limited the encounter data to beaufort 0-2 (Barlow 2006). Since then, Barlow (2015) developed a more robust method for estimating species-specific g(0) values that are adjusted for the Beaufort sea states that are encountered during a survey. This new method was used for analyzing the data from the 2010 survey, but has not yet been used to analyze the 2002 data.~~

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) of the 2010 abundance estimate or 564~~980~~ Blainville's beaked whales within the Hawaiian Islands EEZ.

Current Population Trend

The three available abundance estimates for this stock have very broad and overlapping confidence intervals, precluding robust evaluation of population trend for this stock~~Abundance analyses of the 2002 and 2010 datasets used different g(0) values. This change in analysis methodology resulted in far less extrapolation over the survey area. The 2002 survey data have not been reanalyzed using this method. This change precludes evaluation of population trends at this time. Assessment of population trend will likely require additional survey data and reanalysis of all datasets using comparable methods~~.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population estimate for the U.S. EEZ of the Hawaiian Islands (564 ~~980~~) 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 recent fishery mortality or serious injury within the Hawaiian Islands EEZ; Wade and Angliss 1997), resulting in a PBR of 5.6 ~~10~~ Hawaii Blainville's beaked whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaii fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. No interactions between nearshore fisheries and Blainville's beaked whales have been reported in Hawaiian waters. No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line fisheries because these fisheries are not observed or monitored for protected species bycatch.

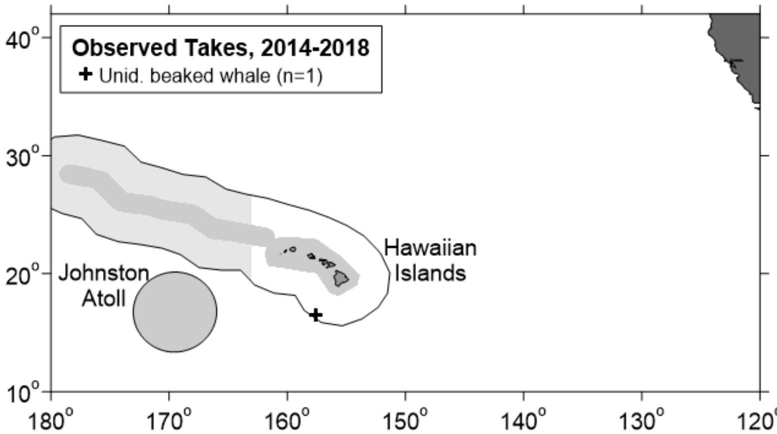

Figure 2. Location of an unidentified ~~the Blainville's~~ beaked whale take (cross) ~~and the possible takes of this species (filled diamond)~~ in Hawaii-based longline fisheries, 2014-2018~~2011-2015~~. Solid lines represent the U.S. EEZ. Gray shading notes areas closed to commercial fishing, with the PMNM Expansion area closed since August 2016.~~longline fishing. Fishery descriptions are provided in Appendix 1.~~

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2014~~2011~~ and 2018~~2015~~, no Blainville's beaked whale was observed killed or seriously injured in the SSLL fishery (100% observer coverage) or the DSLL fishery (~~20~~18-22% observer coverage) (Bradford ~~2017~~2018a, 2018b, *in review*, Bradford and Forney 2017, McCracken 2019~~7~~) within the Hawaiian EEZ. One unidentified ~~Blainville's~~ beaked whale was observed taken, but not seriously injured, within the Hawaiian EEZ ~~on the high seas~~ in the DSLL~~SSLL~~ fishery (Bradford ~~2017~~2018a).~~One unidentified *Mesoplodon* whale and two unidentified beaked whale were taken outside of the Hawaiian EEZ in the SSLL fishery and all were considered to be seriously injured.~~ Average 5-yr estimates of annual mortality and serious injury for 2014-2018~~2011-2015~~ are zero Blainville's beaked whales within or outside of the U.S. EEZs, and 0.5~~0.6~~ (CV = 1.2~~0~~) ~~*Mesoplodon* or~~ unidentified beaked whales ~~outside~~within the U.S. EEZs (Table 1). ~~Four unidentified cetaceans were taken in the DSLL fishery, and one unidentified cetacean was taken in the SSLL fishery, some of which may have been Blainville's beaked whales (Bradford 2018a, 2018b, *in review*2017, Bradford and Forney 2017).~~

Table 1. Summary of available information on incidental mortality and serious injury of Blainville's beaked whales (Hawaii stock) in commercial longline fisheries, within and outside of the Hawaiian Islands EEZ (McCracken ~~2017~~2019). Mean annual takes are based on 2014-2018~~2011-2015~~ data unless otherwise indicated. Information on all observed takes (T) and combined mortality events & serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome.

				Observed total interactions (T) and mortality events, and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) of Blainville's beaked whales (MD), unidentified Mesoplont whales (UM) and unidentified beaked whales (ZU)			
				Outside U.S. EEZs		Hawaiian EEZ	
Fishery Name	Year	Data Type	Percent Observer Coverage	Obs. MD T/MSI Obs. UM+ZU T/MSI	Estimated MD M&SI (CV) Estimated UM+ZU MSI (CV)	Obs. MD T/MSI Obs. UM+ZU T/MSI	Estimated MD M&SI (CV) Estimated UM+ZU MSI (CV)
	~~2011~~	Observer data	~~20%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
	~~2012~~		~~20%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~

Hawaii-based deep-set longline fishery	~~2013~~		~~20%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
	2014		21%	0	0 (-)	0	0 (-)
	2015		21%	0	0 (-)	0	0 (-)
	2016		20%	0	0	0 1/0	0 3 (0.9)
	2017		20%	0	0	0	0
	2018		18%	0	0	0	0
Mean Estimated Annual MD Take (CV)					**0 (-)**		**0 (-)**
Mean Estimated Annual UM+ZU Take (CV)					**0 (-)**		**~~0 (-)~~0.5 (1.2)**
Hawaii-based shallow-set longline fishery	~~2011~~	Observer data	~~100%~~	~~1/0~~ ~~2/2~~	~~0~~ ~~2~~	~~0~~	~~0~~
	~~2012~~		~~100%~~	~~0~~	~~0~~	~~0~~	~~0~~
	~~2013~~		~~100%~~	~~0~~ ~~2/1~~	~~0~~ ~~1~~	~~0~~	~~0~~
	2014		100%	0	0	0	0
	2015		100%	0	0	0	0
	2016		100%	0	0	0	0
	2017		100%	0	0	0	0
	2018		100%	0	0	0	0
Mean Annual MD Takes (100% coverage)					**0**		**0**
Mean Annual UM + ZU Takes (100% coverage)					**0.6**		**0**
Minimum total annual MD takes within U.S. EEZ							**0 (-)**

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. Similarly, Simonis *et al.* (2020) reported a statistically significant correlation between sonar use and single and mass stranding events of beaked whales in the Mariana Archipelago 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). The impact of sonar exercises on resident versus offshore beaked whales may be significantly different with offshore animals less frequently exposed, and possibly subject to more extreme reactions (Baird *et al.* 2009). No estimates of potential mortality or serious injury are available for U.S. waters.

STATUS OF STOCK

The Hawaii stock of Blainville's beaked whales is not considered strategic under the 1994 amendments to the MMPA The status of Blainville's beaked whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Blainville's beaked whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Given the absence of recorded recent fishery-related mortality or serious injuries within U.S. EEZs, the total fishery mortality and serious injury can be considered to be insignificant and approaching zero. The impacts of anthropogenic sound on beaked whales remain a concern (Barlow and Gisiner 2006, Cox *et al.* 2006, Hildebrand *et al.* 2005, Weilgart 2007). One Blainville's beaked whale found stranded on the main Hawaiian Islands has tested positive for *Morbillivirus* (Jacob *et al.* 2016). The presence of *morbillivirus* in the 3 known species of beaked whales in Hawaiian waters, raises concerns about the history and prevalence of this disease in Hawaii and the potential population impacts, including the cumulative impacts of disease with other stressors.

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Revised ~~5/31/2018~~ 9/5/2020

LONGMAN'S BEAKED WHALE (*Indopacetus pacificus*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Longman's beaked whale is considered one of the least known cetacean species (Jefferson *et al.* 1993; Rice 1998; Dalebout *et al.* 2003), originally ~~. Until recently, it was~~ known only from two skulls found in Australia and Somalia (Longman 1926; Azzaroli 1968). ~~Recent~~ ~~g~~Genetic studies (Dalebout *et al.* 2003) have revealed that sightings of 'tropical bottlenose whales' (*Hyperoodon* sp.; Pitman *et al.* 1999) in the Indo-Pacific region were in fact Longman's beaked whales, providing the first description of the external appearance of this species. Although originally described as *Mesoplodon pacificus* (Longman 1926), it has been proposed that this species is sufficiently unique to be placed within its own genus, *Indopacetus* (Moore 1968; Dalebout *et al.* 2003). The distribution of Longman's beaked whale, as determined from stranded specimens and sighting records of 'tropical bottlenose whales', includes tropical waters from the eastern Pacific westward through the Indian Ocean to the eastern coast of Africa. A single stranding of Longman's beaked whale has been reported in Hawaii, in 2010 near Hana, Maui (West *et al.* 2012), and there was a single sighting off Kona over 13 years of nearshore surveys off in the leeward waters of the main Hawaiian Islands (Baird ~~*et al.* 2013~~2016). Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands, resulted in one sighting in 2002, ~~and~~ three in 2010, and seven in 2017 (Barlow 2006, Bradford *et al.* 2017, Yano *et al.* 2018; Figure 1).

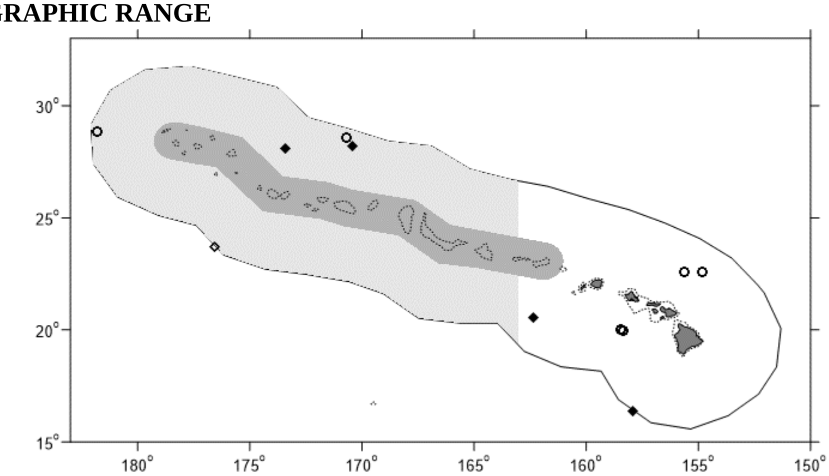

Figure 1. Sighting locations of Longman's beaked whale during the 2002 (~~open~~ diamond), ~~and~~ 2010 (~~black diamonds~~circle), and 2017 (square) shipboard cetacean surveys of U.S. waters surrounding the Hawaiian Islands (Barlow 2006, Bradford *et al.* 2017, Yano *et al.* 2018~~; see Appendix 2 for details on timing and location of survey effort~~). Outer line indicates approximate boundary of survey area and U.S. EEZ. Dark ~~g~~Gray shading indicates ~~area of~~ the original Papahanaumokuakea Marine National Monument, with the lighter gray shading denoting the full 2016 Expansion area. Dotted line represents the 1000 m isobath.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there is one Pacific stock of Longman's beaked whales, found within waters of the Hawaiian Islands EEZ. This stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

Encounter data from ~~a 2010~~ shipboard line-transect surveys of the entire Hawaiian Islands EEZ were recently reevaluated for each survey year~~using~~, resulting in the following abundance estimates of Longman's beaked whales in the Hawaii EEZ (Bradford *et al. in review*) (Table 1).

Table 1. Line-transect abundance estimates for Longman's beaked whale derived from surveys of the entire Hawaii EEZ in 2002, 2010, and 2017 (Bradford et al. *in review*).

Year	Abundance	CV	95% Confidence Limits
2017	2,550	0.67	771-8,432
2010	7,003	0.63	2,260-21,697
2002	871	1.06	158-4,798

The updated design-based abundance estimates use sighting data from throughout the central Pacific to estimate the detection function and use Beaufort sea-state-specific trackline detection probabilities for Longman's beaked whales from Barlow *et al.* (2015). Although previous estimates from the Hawaii EEZ have been published using subsets of this data, Bradford *et al. in review*, uses a consistent approach for estimating all abundance parameters and are considered the best available estimates for each survey year. The best estimate of abundance is based on the 2017 survey, or 2,550 (CV=0.67) whales. ~~Beaufort sea-state-specific trackline detection probabilities for Longman's beaked whales, resulting in an abundance estimate of 7,619 (CV = 0.66) Longman's beaked whales (Bradford *et al.* 2017) in the Hawaii stock. A 2002 shipboard line-transect survey of the same area resulted in an abundance estimate of 1,007 (CV=1.25) Longman's beaked whales (Barlow 2006). Species abundances estimated from the 2002 HICEAS survey used pooled small dolphin, large dolphin, and large whale g(0) (the probability of sighting and recording an animal directly on the track line) estimates stratified by group size (Barlow 1995). Since then, Barlow (2015) developed a more robust method for estimating species-specific g(0) values that are adjusted for the Beaufort sea states that are encountered during a survey. This new method was used for analyzing the data from the 2010 survey, but has not yet been used to analyze the 2002 data.~~

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) around the 2017 ~~2010~~ abundance estimate, or 1,527 ~~4,592~~ Longman's beaked whales within the Hawaiian Islands EEZ.

Current Population Trend

The three available abundance estimates for this stock have very broad and overlapping confidence intervals, precluding robust evaluation of population trend for this stock.~~Abundance analyses of the 2002 and 2010 datasets used different g(0) values. The 2002 survey data have not been reanalyzed using this method. This change precludes evaluation of population trends at this time. Assessment of population trend will likely require additional survey data and reanalysis of all datasets using comparable methods.~~

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for Longman's beaked whales.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size within the U.S. EEZ of the Hawaiian Islands (1,527 ~~4,592~~) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no known fishery mortality or serious injury within the Hawaiian Islands EEZ; Wade and Angliss 1997), resulting in a PBR of 15 ~~46~~ Longman's beaked whales per year.

HUMAN CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Information on fishery-related mortality and serious injury of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other U.S. fisheries ~~throughout U.S. waters~~. No interactions between nearshore fisheries and Longman's beaked whales have been reported in Hawaiian waters. No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line fisheries because these fisheries are not observed or monitored for protected species bycatch. There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate ~~with~~in U.S. waters and on the high seas. Between 2014 ~~2011~~ and 2018 ~~2015~~, no Longman's beaked whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (20-22% observer coverage) (Bradford 2018a, 2018b, *in review*, ~~Bradford 2017,~~ Bradford and Forney 2017, McCracken 2019~~2017~~). ~~However, four unidentified cetaceans, which may have been a Longman's beaked whale, were taken in the DSLL fishery, and one unidentified cetaceans, one unidentified Mesoplodon, and two unidentified beaked whale, which may have been Longman's beaked whales were taken in the SSLL fishery~~.

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~~ their 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. Similarly, Simonis *et al.* (2020) reported a statistically significant correlation between sonar use and single and mass stranding events of beaked whales in the Mariana Archipelago. In Hawaiian waters, Faerber and 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 foraging 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). No estimates of potential mortality or serious injury are available for U.S. waters.

STATUS OF STOCK

The Hawaii stock of Longman's beaked whales is not considered strategic under the 1994 amendments to the MMPA. The status of Longman's beaked whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Longmans' beaked whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Given the absence of recent recorded fishery-related mortality or serious injuries, the total fishery mortality and serious injury can be considered to be insignificant and approaching zero. The impacts of anthropogenic sound on beaked whales remain a concern (Barlow and Gisiner 2006, Cox *et al*. 2006, Hildebrand *et al*. 2005, Weilgart 2007). The first confirmed case of *morbillivirus* in a Hawaiian cetacean was found in a subadult Longman's beaked whale stranded on Maui in 2010 (West *et al*. 2012). The presence of *morbillivirus* in all 3 known species of beaked whales in Hawaiian waters (Jacob *et al*. 2016), raises concerns about the history and prevalence of this disease in Hawaii and the potential population impacts, including cumulative impacts of disease with other stressors.

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CUVIER'S BEAKED WHALE (*Ziphius cavirostris*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Cuvier's beaked whales occur in all oceans and major seas (Heyning 1989). Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands, resulted in ~~four~~ 4 sightings in 2002 ~~and~~ 22 in 2010, and 11 in 2017 including markedly higher sighting rates during nearshore surveys in the Northwestern Hawaiian Islands. (Figure 1; Barlow 2006, Bradford *et al.* 2017, Yano *et al.* 2018).

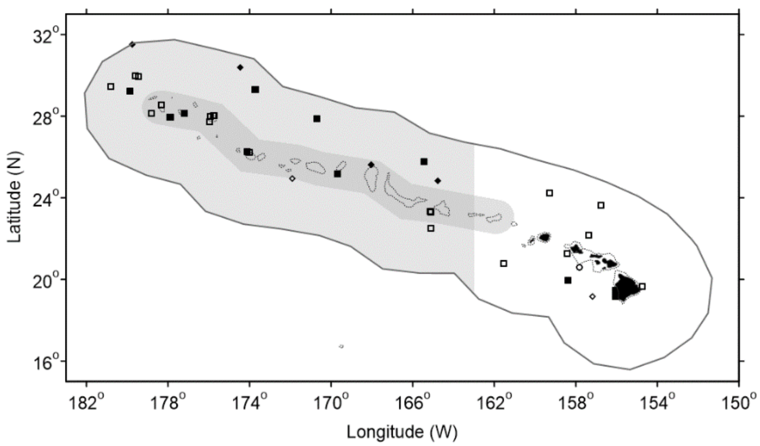

Figure 1. Cuvier's beaked whale sighting locations during the 2002 (~~open~~ diamonds), ~~and~~ 2010 (~~black diamonds~~circle), and 2017 (square) shipboard surveys, as well as sightings of unidentified *Ziphiid* during 2002 (open diamond), 2010 (open circle), and 2017 (open square) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford *et al.* 2017, Yano *et al.* 2018~~; see Appendix 2 for details on timing and location of survey effort~~). Outer line represents approximate boundary of survey area and U.S. EEZ. Dark g~~G~~ray shading indicates ~~area of~~of the original Papahanaumokuakea Marine National Monument, with the lighter gray shading denoting the full 2016 Expansion area. Dotted line represents the 1000 m isobath.

Resighting and movement data of individual Cuvier's beaked whales suggest the existence of insular and offshore populations of this species in Hawaiian waters (Baird 2019). A 21-yr study off Hawaii Island suggests long-term site fidelity and year round occurrence (McSweeney *et al.* 2007). Ten~~Eight~~ Cuvier's beaked whales have been tagged off Hawaii Island since 2006, with all remaining close to the island of Hawaii or to Maui for the duration of tag data received (Baird *et al.* 2013, Baird 2019). Approximately 95% of all locations were within 45 km of shore and the farthest offshore an individual was documented was 67 km (Baird *et al.* 2013). The available satellite data suggest that a resident population may occur near Hawaii Island, distinct from offshore, pelagic Cuvier's beaked whales. This conclusion is further supported by the long-term site fidelity evident from photo-identification data (McSweeney *et al.* 2007). ~~Division of this population into a separate island-associated stock may be warranted in the future.~~ The available movement, social structure, and habitat data suggest there is likely a separate island-associated population of Cuvier's beaked whales within the main Hawaiian Islands (Baird 2019). Formal assessment of demographic-independence has not been completed, but division of this population into a separate island-associated stock may be warranted in the future.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, Cuvier's beaked whales within the Pacific U.S. EEZ are divided into three discrete, non-contiguous areas: 1) Hawaiian waters (this report), 2) Alaskan waters, and 3) waters off California, Oregon and Washington. The Hawaii stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters. Because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

Encounter data from ~~a 2010~~ shipboard line-transect surveys of the entire Hawaiian Islands EEZ were recently reevaluated for each survey year, resulting in updated abundance estimates of Cuvier's beaked whale in the Hawaii EEZ (Bradford *et al. in review*) (Table 1).

Table 1. Line-transect abundance estimates for Cuvier's beaked whale derived from surveys of the entire Hawaii EEZ in 2002, 2010, and 2017 (Bradford *et al. in review*).

Year	Abundance	CV	95% Confidence Limits
2017	4,431	0.41	2,036-9,644
2010	338	1.02	65-1,771
2002	1,216	0.77	319-4,633

The updated design-based abundance estimates use sighting data from throughout the central Pacific to estimate the detection function and use Beaufort sea-state-specific trackline detection probabilities for Cuvier's beaked whale from Barlow *et al.* (2015). Although previous estimates from the Hawaii EEZ have been published using subsets of this data, Bradford *et al.* (*in review*), uses a consistent approach for estimating all abundance parameters and the resulting estimates are considered the best available for each survey year. ~~using Beaufort sea-state-specific trackline detection probabilities for beaked whales. The new g(0) values allow for use of all on-effort survey data, and resulted in an abundance estimate of 723 (CV = 0.69) Cuvier's beaked whales (Bradford *et al.* 2017) in the Hawaii stock. A 2002 shipboard line-transect survey of the same region resulted in an abundance estimate of 15,242 (CV=1.43) Cuvier's beaked whales (Barlow 2006). Species abundances estimated from the 2002 HICEAS survey used species-specific g(0) values (Barlow 1999) (the probability of sighting and recording an animal directly on the track line) and limited the encounter data to Beaufort 0-2 (Barlow 2006). Since then, Barlow (2015) developed a more robust method for estimating species-specific g(0) values that are adjusted for the Beaufort sea states that are encountered during a survey. This new method was used for analyzing the data from the 2010 survey, but has not yet been used to analyze the 2002 data.~~ Wade and Gerrodette (1993) estimated population size for Cuvier's beaked whales in the eastern tropical Pacific, but it is not known whether any of these animals are part of the same population that occurs around the Hawaiian Islands.

Minimum Population Estimate

Minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) of the 2010 abundance estimate, or 3,180~~428~~ Cuvier's beaked whales.

Current Population Trend

The three available abundance estimates for this stock have very broad confidence intervals, and for 2010 and 2017, they do not overlap. Annual encounter rate variation may have a large impact on abundance estimates for species with low density and patchy distribution. Bradford *et al.* (*in review*) indicate that the high sighting rate, and correspondingly higher abundance estimate, may be the result of extreme encounter rate variability for this species, though animal movement in response to environmental conditions or the influence of sightings of island-associated groups during systematic survey in 2017 cannot be discounted. ~~The significant decrease in abundance estimates between the 2002 and 2010 surveys is attributed to the use of higher sea states (beaufort 0-6) in estimating the trackline detection probability for the 2010 survey, compared to the 2002 survey, which utilized only beaufort sea state data 0 through 2 (Bradford *et al.* 2017). This change in analysis methodology resulted in far less extrapolation over the survey area, resulting in a more representative estimate of abundance. The 2002 survey data have not been reanalyzed using this method. . Assessment of population trend will likely require additional survey data and reanalysis of all datasets using comparable methods~~.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the pelagic stock of Cuvier's beaked whales is calculated as the minimum population estimate for the U.S. EEZ of the Hawaiian Islands (3,180 ~~428~~) 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 within the Hawaiian Islands EEZ; Wade and Angliss 1997), resulting in a PBR of 32 ~~4.3~~ Cuvier's beaked whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. ~~In 1998, a Cuvier's beaked whale stranded possibly entangled, with scars and cuts from fishing gear along its body (Bradford and Lyman 2013). The gear was not described. No other interactions between nearshore fisheries and Cuvier's beaked whales have been reported in Hawaiian waters.~~ No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line fisheries because these fisheries are not observed or monitored for protected species bycatch.

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2014~~2011~~ and 2018~~02015~~, no Cuvier's beaked whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (~~20~~18-22% observer coverage) (Bradford~~ 2017~~2018a, 2018b, *in review*, Bradford and Forney 2017, McCracken 201~~7~~9). One~~Two~~ unidentified beaked whales was taken, but not seriously injured, within the Hawaiian EEZ in the DSLL~~SSLL~~ fishery (Bradford 2018a~~ and considered seriously~~. Average 5-yr estimates of annual mortality and serious injury for 2014-2018~~2011-2015~~ are zero Cuvier's beaked whales within or outside of the U.S. EEZs, and 0.5~~0.4~~ (CV = 1.2) unidentified beaked whales within ~~outside~~ the U.S. EEZs (Table ~~1~~2).

Table 2. Summary of available information on incidental mortality and serious injury of Cuvier's beaked whales (Hawaii stock) in commercial longline fisheries, within and outside of the Hawaiian Islands EEZ (McCracken 2019). Mean annual takes are based on 2014-2018 data unless otherwise indicated. Information on all observed takes (T) and combined mortality events & serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome.

Fishery Name	Year	Data Type	Percent Observer Coverage	Observed total interactions (T) and mortality events, and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) of Cuvier's beaked whales (ZI),and unidentified beaked whales (ZU)			
				Outside U.S. EEZs		Hawaiian EEZ	
				Obs. ZI T/MSI Obs. ZU T/MSI	Estimated ZI M&SI (CV) Estimated ZU MSI (CV)	Obs. ZI T/MSI Obs. ZU T/MSI	Estimated ZI M&SI (CV) Estimated ZU MSI (CV)
Hawaii-based deep-set longline fishery	2014	Observer data	21%	0	0 (-)	0	0 (-)
	2015		21%	0	0 (-)	0	0 (-)
	2016		20%	0	0	0 1/0	0 3 (0.9)
	2017		20%	0	0	0	0
	2018		18%	0	0	0	0
Mean Estimated Annual ZI Take (CV)					**0 (-)**	-	**0 (-)**
Mean Estimated Annual ZU Take (CV)					**0 (-)**	-	**0.5 (1.2)**
Hawaii-based shallow-set longline fishery	2014	Observer data	100%	0	0	0	0
	2015		100%	0	0	0	0
	2016		100%	0	0	0	0
	2017		100%	0	0	0	0
	2018		100%	0	0	0	0
Mean Annual ZI Takes (100% coverage)					**0**	-	**0**
Mean Annual ZU Takes (100% coverage)					**0.6**	-	**0**
Minimum total annual ZI takes within U.S. EEZ				-	-	-	**0 (-)**

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. Similarly, Simonis *et al.* (2020) reported a statistically significant correlation between sonar use and single and mass stranding events of beaked whales in the Mariana Archipelago. In Hawaiian waters, Faerber and 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). The impact of sonar exercises on resident versus offshore beaked whales may be significantly different with offshore animals less frequently exposed, and possibly subject to more extreme reactions (Baird *et al.* 2009). No estimates of potential mortality or serious injury are available for U.S. waters.

STATUS OF STOCK

The Hawaii stock of Cuvier's beaked whales is not considered strategic under the 1994 amendments to the MMPA. The status of Cuvier's beaked whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Cuvier's beaked whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. There have been no reported fishery related mortality or injuries within the Hawaiian Islands EEZ, such that the total mortality and serious injury can be considered to be insignificant and approaching zero. The impacts of anthropogenic sound on beaked whales remain a concern (Barlow and Gisiner 2006, Cox *et al.* 2006, Hildebrand *et al.* 2005, Weilgart 2007). One Cuvier's beaked whale found stranded on the main Hawaiian Islands tested positive for *Morbillivirus* (Jacob *et al.* 2016). The presence of *morbillivirus* in all 3 known species of beaked whales in Hawaiian waters (Jacob *et al*. 2016), raises concerns about the history and prevalence of this disease in Hawaii and the potential population impacts, including the cumulative impacts of disease with other stressors.

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Revised ~~6/4/2014~~ 8/25/2020

PYGMY SPERM WHALE (*Kogia breviceps*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Pygmy sperm whales are found throughout the world in tropical and warm-temperate waters (Caldwell and Caldwell 1989). Pygmy sperm whales have been observed in nearshore waters off Oahu, Maui, Niihau, and Hawaii Island (Shallenberger 1981, Mobley et al. 2000, Baird 2005, Baird *et al*. 2013). Two sightings were made during a 2002, and three during 2017 shipboard survey of waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands (Figure 1; Barlow 2006, Yano *et al.* 2018). A freshly dead pygmy sperm whale was picked up approximately 100 nmi north of French Frigate Shoals on a similar 2010 survey (NMFS, unpublished data). Nothing is known about stock structure for this species.

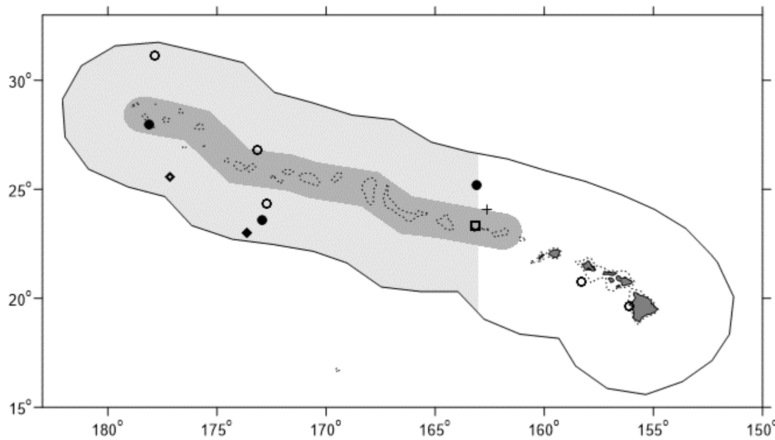

Figure 1. Sighting locations for ~~P~~pygmy sperm whales during 2002 (~~open~~ filled diamond) and 2017 (square) shipboard surveys, as well as sightings of and unidentified *Kogia* during 2002 (open diamond~~open square~~) ~~sighting locations during the 2002 shipboard survey and unidentified *Kogia*~~ 2010 (~~filled square~~open circle), and 2017 (open square) ~~during the 2010~~ shipboard cetacean surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2013, Yano *et al.* 2018~~; see Appendix 2 for details on timing and location of survey effort~~). A freshly dead pygmy sperm whale was also retrieved during the 2010 survey (cross). Outer line indicates approximate boundary of survey area and U.S. EEZ. Dark g~~G~~ray shading indicates the original ~~area of~~ Papahanaumokuakea Marine National Monument, with the lighter gray shading denoting the full 2016 Expansion area. Dotted line represents the 1000 m isobath.

For the Marine Mammal Protection Act (MMPA) stock assessment reports, pygmy sperm whales within the Pacific U.S. EEZ are divided into two discrete areas: 1) Hawaiian waters (this report), and 2) waters off California, Oregon and Washington. The Hawaii stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

Encounter data from shipboard line-transect surveys of the entire Hawaiian Islands EEZ were recently reevaluated for each survey year, resulting in the following abundance estimates of pygmy sperm whales in the Hawaii EEZ (Bradford *et al. in review*) (Table 1). A 2010 shipboard line-transect survey within the Hawaiian EEZ did not result in any sightings of pygmy sperm whales (Bradford *et al*. ~~2013~~2017).

Table 1. Line-transect abundance estimates for pygmy sperm whales derived from surveys of the entire Hawaii EEZ in 2002, 2010, and 2017 (Bradford *et al. in review*).

Year	Abundance	CV	95% Confidence Limits
2017	42,083	0.64	13,406-132,103
2010	N/A		
2002	12,036	1.04	2,248-64,434

The updated design-based abundance estimates use sighting data from throughout the central Pacific to estimate the detection function and use Beaufort sea-state-specific trackline detection probabilities for pygmy sperm whales from Barlow *et al.* (2015). Although previous estimates from the Hawaii EEZ have been published using subsets of this data, estimates within Bradford *et al.* (*in review*) use a consistent approach for estimating all abundance parameters and are considered the best available estimates for each survey year. The best estimate of abundance is from the 2017 survey, or 42,083 (CV=0.64) whales. ~~A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 7,138 (CV=1.12) pygmy sperm whales (Barlow 2006), including a correction factor for missed diving animals. This estimate for the Hawaiian EEZ is more than 8 years old and therefore will no longer be used based on NMFS Guidelines for Assessing Marine Mammal Stocks (NMFS 2005). A 2010 shipboard line-transect survey within the Hawaiian EEZ did not result in any sightings of pygmy sperm whales (Bradford et al. 2013).~~

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al*. 1995) around the 2017 abundance estimate, or 25,695 pygmy sperm whales within the Hawaiian Islands EEZ. ~~No minimum estimate of abundance is available for pygmy sperm whales, as there were no on-effort sightings during a 2010 shipboard line-transect survey of the Hawaiian EEZ.~~

Current Population Trend

No data are available on current population abundance or trend.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size within the U.S EEZ of the Hawaiian Islands (25,695) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no known fishery mortality or serious injury within the Hawaiian Islands EEZ; Wade and Angliss 1997), resulting in a PBR of 257 pygmy sperm whales per year. ~~Because there is no minimum population size estimate for pygmy sperm whales in Hawaii, the PBR is undetermined.~~

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

~~New Serious Injury Guidelines~~

~~NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.~~

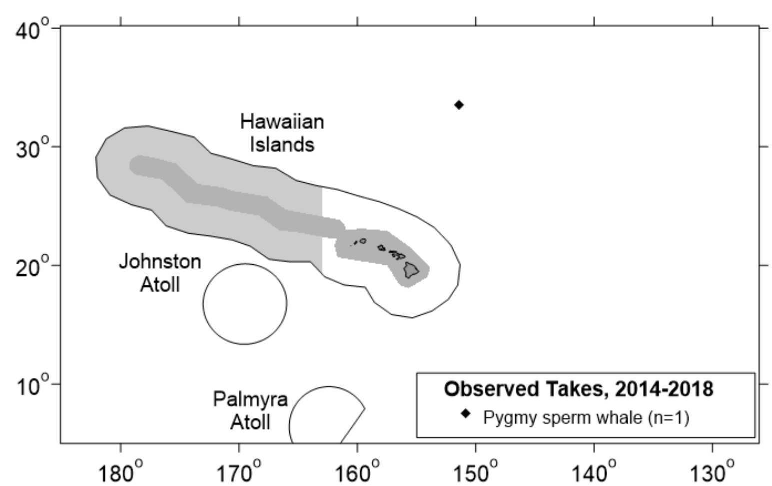

Figure 2. Location of pygmy or dwarf sperm whale takes (filled diamond) in Hawaii-based longline fisheries, 2014-2018~~2007-2011~~. Solid lines represent the U.S. EEZs. Gray shading notes areas closed to commercial fishing, with the PMNM Expansion area closed since August 2016. ~~Fishery descriptions are provided in Appendix 1.~~

Fishery Information

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S.

waters. ~~One pygmy sperm whale was found entangled in fishing gear off Oahu in 1994 (Bradford & Lyman 2013), but the gear was not described and the fishery not identified.~~ No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line fisheries because these fisheries are not observed or monitored for protected species bycatch.

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2014~~2007~~ and 2018~~2011~~, one pygmy ~~or dwarf~~ sperm whale was observed hooked in the DSLL~~SSLL~~ fishery (~~100~~20-22% observer coverage) (Figure 2, ~~Bradford & Forney 2013, McCracken 2013~~ Bradford 2018a, 2018b, *in review*, Bradford and Forney 2017, McCracken 2019). Based on an evaluation of the observer's description of the interaction and following the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012), this animal was considered ~~not~~ seriously injured (Bradford and Forney 2017~~2013~~). No pygmy sperm whales were observed hooked or entangled in the SSLL~~DSLL~~ fishery (~~20-22~~100% observer coverage). There was one additional unidentified cetacean taken in the DSLL fishery during this period that was likely a species of *Kogia*, based on the Observer's description~~Eight unidentified cetaceans were taken in the DSLL fishery, and two unidentified cetaceans were taken in the SSLL fishery, some of which may have been pygmy sperm whales.~~

Table ~~1~~2. Summary of available information on incidental mortality and serious injury of pygmy sperm whales (Hawaiian stock) in commercial longline fisheries within and outside of the Hawaiian Islands EEZ (McCracken 2019~~2013~~). Mean annual takes are based on 2014-2018~~2007-2011~~ data unless otherwise indicated. Information on all observed takes (T) and combined mortality events & serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome.

Fishery Name	Year	Data Type	Percent Observer Coverage	Observed total interactions (T) and mortality events, and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) of pygmy sperm whales			
				Outside U.S. EEZs		Inside Hawaiian EEZ	
				Obs. T/MSI	Estimated M&SI (CV)	Obs. T/MSI	Estimated M&SI (CV)
Hawaii-based deep-set longline fishery	~~2007~~2014	Observer data	20%	~~0~~1/1	~~0 (-)~~10 (0.9)	0	0 (-)
	~~2008~~2015		22%	0	0 (-)	0	0 (-)
	~~2009~~2016		21%	0	0 (-)	0	0 (-)
	~~2010~~2017		21%	0	0 (-)	0	0 (-)
	~~2011~~2018		20%	0	0 (-)	0	0 (-)
Mean Estimated Annual Take (CV)					**~~0 (-)~~2.0 (1.2)**		**0 (-)**
Hawaii-based shallow-set longline fishery	2014~~2007~~	Observer data	100%	0	0	0	0
	2015~~2008~~		100%	~~1*/~~0	0	0	0
	2016~~2009~~		100%	0	0	0	0
	2017~~2010~~		100%	0	0	0	0
	2018~~2011~~		100%	0	0	0	0
Mean Annual Takes (100% coverage)					**0**		**0**
Minimum total annual takes within U.S. EEZ							**0 (-)**

~~*One animal was identified as either a pygmy sperm whale or a dwarf sperm whale.~~

STATUS OF STOCK

The Hawaii stock of pygmy sperm whales is not considered strategic under the 1994 amendments to the MMPA. The status of pygmy sperm whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Pygmy sperm whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. ~~Given the absence of recent recorded fishery-related mortality or serious injuries within the Hawaiian Islands EEZ, the total fishery mortality and serious injury can be considered to be insignificant and approaching zero.~~ The estimated rate of mortality and serious injury within the Hawaiian Islands EEZ (zero animals per year) is less than the PBR (257). Based on the available data, which indicate total fishery-related takes are less than 10% of PBR, the total fishery mortality and serious injury for pygmy sperm whales can be considered to be insignificant and approaching zero. The increasing level of anthropogenic noise in the world's oceans has been suggested to be a habitat concern for whales (Richardson et al. 1995), particularly for deep-diving whales like pygmy sperm whales that feed in the oceans' "sound channel". One pygmy sperm whale found stranded in the main Hawaiian Islands tested positive for *Morbillivirus* (Jacob 2012).

Although *morbillivus* is known to trigger lethal disease in cetaceans (Van Bressem et al. 2009), its impact on the health of the stranded animal is unknown (Jacob 2012). The presence of *morbillivirus* in 10 species of cetacean in Hawaiian waters (Jacob 2012) raises concerns about the history and prevalence of this disease in Hawaii and the potential population impacts on Hawaiian cetaceans.

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Revised ~~6/4/2014~~ 8/20/2020

DWARF SPERM WHALE (*Kogia sima*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Dwarf sperm whales are found throughout the world in tropical to warm-temperate waters (Nagorsen 1985). ~~At least eight strandings of dwarf sperm whales have been documented in Hawaii since 1985 (Tomich 1986; Nitta 1991; Maldini et al. 2005, NMFS PIR Marine Mammal Response Network database), including two since 2007. From 2002 and 2012, dwarf sperm whales have been seen near Niihau, Kauai, Oahu, Lanai, and Hawaii during small boat surveys (Baird et al. 2005, Baird et al. 2013).~~ Dwarf sperm whales are seen infrequently during nearshore surveys. Although they have been seen throughout the main Hawaiian Islands, they appear to be more common near Kauai, Niihau, and Oahu than around the other islands (Baird 2016). Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands resulted in five sightings of dwarf sperm whales during 2002 and one during 2010 (Figure 1; Barlow 2006, Bradford et al. 2013). There were no sightings of confirmed dwarf sperm whales during a 2017 survey, though five sightings of *Kogia* sp., not identified to species, were recorded (Yano et al. 2018).

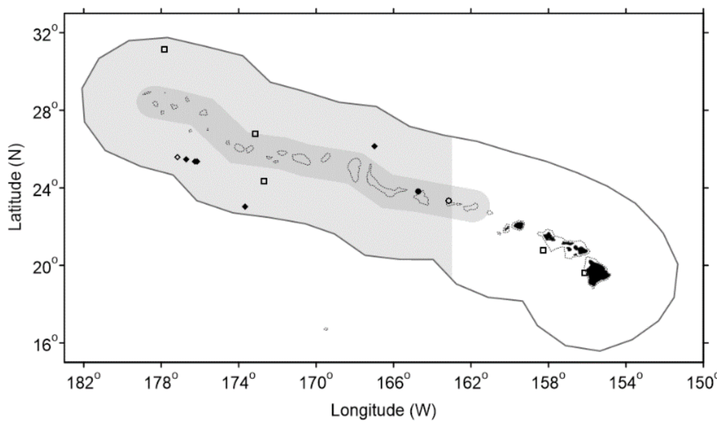

Figure 1. Dwarf sperm whale sighting locations during the 2002 (diamonds) and 2010 (circle) shipboard surveys, as well as sightings of ~~and~~ unidentified *Kogia* during 2002 (open diamond), 2010 (open circle), and 2017 (open squares) ~~sighting locations during the 2002 (open symbols) and 2010 (black symbols)~~ shipboard cetacean surveys of U.S. waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2013;~~see Appendix 2 for details on timing and location of survey effort~~). Outer line indicates approximate boundary of survey area and U.S. EEZ. Dark g~~G~~ray shading indicates ~~area of~~of the original Papahanaumokuakea Marine National Monument, with the lighter gray shading denoting the full 2016 Expansion area. Dotted line represents the 1000 m isobath.

Small boat surveys within the main Hawaiian Islands (MHI) since 2002 have documented dwarf sperm whales on 73 occasions, most commonly in water depths between 500m and 1,000m (Baird et al. 2013). Long-term site-fidelity is evident off Hawaii Island, with one third of the distinctive individuals seen there encountered in more than one year. Resighting data from 25 individuals documented at Hawaii Island suggest an island-resident population with restricted range, with all encounters in less than 1,600m water depth and less than 20 km from shore (Baird et al 2013). Division of this population into a separate island-associated stock may be warranted in the future. For the Marine Mammal Protection Act (MMPA) stock assessment reports, dwarf sperm whales within the Pacific U.S. EEZ are divided into two discrete, non-contiguous areas: 1) Hawaiian waters (this report), and 2) waters off California, Oregon and Washington. The Hawaii stock includes animals found within the Hawaiian Islands EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

~~A 2002 shipboard line-transect survey of the entire Hawaiian Islands EEZ resulted in an abundance estimate of 17,519 (CV=0.74) dwarf sperm whales (Barlow 2006), including a correction factor for missed diving animals. There were no on-effort sightings of dwarf sperm whales during the 2010 shipboard survey of the Hawaiian EEZ (Bradford et al 2013), such that there is no current abundance estimate for this stock.~~ Encounter data from shipboard line-transect surveys of the entire Hawaiian Islands EEZ was recently reevaluated for each survey year, resulting in updated abundance estimates of dwarf sperm whales in the Hawaii EEZ (Bradford et al. *in review*) (Table 1).

Table 1. Line-transect abundance estimates for dwarf sperm whales or unidentified *Kogia* derived from surveys of the

entire Hawaii EEZ in 2017 (Bradford et al. *in review*).

Year	Species	Abundance	CV	95% Confidence Limits
2017	Unidentified *Kogia*	53,421	0.63	17,083-167,056
2010		NA		
2002	Dwarf sperm whale	37,440	0.78	9,758-143,648

The updated design-based abundance estimates use sighting data from throughout the central Pacific to estimate the detection function and use Beaufort sea-state-specific trackline detection probabilities for *Kogia* from Barlow et al. (2015). Although previous estimates from the Hawaii EEZ have been published using subsets of this data, Bradford et al. (*in review*), uses a consistent approach for estimating all abundance parameters and resulting estimates are considered the best available for each survey year. Wade and Gerrodette (1993) provided an estimate for the eastern tropical Pacific, but it is not known whether these animals are part of the same population that occurs in the central North Pacific. This species' small size, tendency to avoid vessels, and deep-diving habits, combined with the high proportion of *Kogia* sightings that are not identified to species, may result in negatively biased estimates of relative abundance in this region.

Minimum Population Estimate

The log-normal 20th percentile of the 2002 abundance estimate (Bradford et al. *in review* ~~Barlow 2006~~) is 20,953~~10,043~~ dwarf sperm whales within the Hawaiian Islands EEZ; however, the minimum abundance estimate for the entire Hawaiian EEZ is ≥ 8 years old and will no longer be used (NMFS 2005). No minimum estimate of abundance is available for this stock, as there were no sightings of dwarf sperm whales during a 2017~~2010~~ shipboard line-transect survey of the Hawaiian EEZ.

Current Population Trend

No data are available on current population abundance or trend.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for this stock is calculated as the minimum population size within the U.S. EEZ of the Hawaiian Islands times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no known fishery mortality or serious injury within the Hawaiian Islands EEZ; Wade and Angliss 1997). Because there is no minimum population size estimate for Hawaii pelagic dwarf sperm whales, the PBR is undetermined.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

~~**New Serious Injury Guidelines**~~

~~NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.~~

Fishery Information

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. No interactions between nearshore fisheries and dwarf sperm whales have been reported in Hawaiian waters. No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line fisheries because these fisheries are not observed or monitored for protected species bycatch.

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2014~~2007~~ and 2018~~2011~~, one unidentified cetacean, identified as probable pygmy or dwarf sperm whale (Kogia sp.) was observed hooked in the DSLL~~SSLL~~ fishery (~~100~~18% observer coverage)

(~~Figure 2, McCracken 2013,~~ Bradford *in review*). Based on an evaluation of the observer's description of the interaction and following the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012), the injury state could not be determined~~this animal was considered not seriously injured~~ (Bradford *in review*~~&and Forney 20137~~). No dwarf sperm whales were observed hooked or entangled in the SSLL~~DSLL~~ fishery (~~20-22~~100% observer coverage). ~~Eight unidentified cetaceans were taken in the DSLL fishery, and two unidentified cetaceans were taken in the SSLL fishery, some of which may have been dwarf sperm whales.~~

~~**Table 1.** Summary of available information on incidental mortality and serious injury of dwarf sperm whales (Hawaii stock) in commercial longline fisheries, within and outside of the Hawaiian Islands EEZ (McCracken 2013). Mean annual takes are based on 2007-2011 data unless otherwise indicated. Information on all observed takes (T) and combined mortality events & serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome.~~

~~Fishery Name~~	~~Year~~	~~Data Type~~	~~Percent Observer Coverage~~	~~Observed total interactions (T) and mortality events, and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) of dwarf sperm whales~~			
				~~Outside U.S. EEZs~~		~~Inside Hawaiian EEZ~~	
				~~Obs. T/MSI~~	~~Estimated M&SI (CV)~~	~~Obs. T/MSI~~	~~Estimated M&SI (CV)~~
~~Hawaii-based deep-set longline fishery~~	~~2007~~	~~Observer data~~	~~20%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
	~~2008~~		~~22%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
	~~2009~~		~~21%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
	~~2010~~		~~21%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
	~~2011~~		~~20%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
~~Mean Estimated Annual Take (CV)~~					~~0 (-)~~	-	~~0 (-)~~
~~Hawaii-based shallow-set longline fishery~~	~~2007~~	~~Observer data~~	~~100%~~	~~0~~	~~0~~	~~0~~	~~0~~
	~~2008~~		~~100%~~	~~1*/0~~	~~0~~	~~0~~	~~0~~
	~~2009~~		~~100%~~	~~0~~	~~0~~	~~0~~	~~0~~
	~~2010~~		~~100%~~	~~0~~	~~0~~	~~0~~	~~0~~
	~~2011~~		~~100%~~	~~0~~	~~0~~	~~0~~	~~0~~
~~Mean Annual Takes (100% coverage)~~					~~0~~	-	~~0~~
~~Minimum total annual takes within U.S. EEZ~~				-	-	-	~~0 (-)~~

~~*One animal was identified as either a pygmy sperm whale or a dwarf sperm whale.~~

STATUS OF STOCK

The Hawaii stock of dwarf sperm whales is not considered strategic under the 1994 amendments to the MMPA. The status of dwarf sperm whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Dwarf sperm whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. There have been no reported fishery related mortality or injuries within the Hawaiian Islands EEZ, such that the total mortality and serious injury can be considered to be insignificant and approaching zero. The increasing levels of anthropogenic noise in the world's oceans has been suggested to be a habitat concern for whales (Richardson et al. 1995), particularly for deep-diving whales like dwarf sperm whales that feed in the oceans' "sound channel".

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Revised ~~5/27/2018~~ 8/25/2020

SPERM WHALE (*Physeter macrocephalus*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

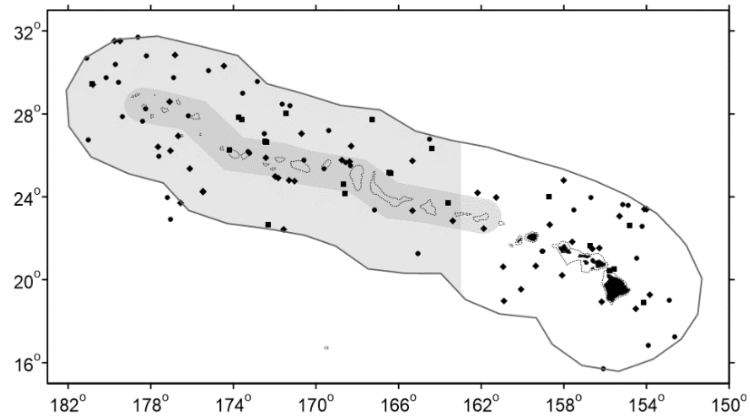

Figure 1. Sperm whale sighting locations during the 2002 (~~open~~ diamond~~s~~), ~~and~~ 2010 (~~black diamonds~~circle), and 2017 (square) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2017, Yano *et al.* 2018~~; see Appendix 2 for details on timing and location of survey effort~~). Outer line represents approximate boundary of survey area and U.S. EEZ. Dark g~~G~~ray shading indicates the original~~area of~~ Papahanaumokuakea Marine National Monument, with the lighter gray shading denoting the full 2016 Expansion area. Dotted line represents the 1000 m isobaths.

Sperm whales are widely distributed across the entire North Pacific and into the southern Bering Sea in summer but the majority are thought to be south of 40ºN in winter (Rice 1974, 1989; Gosho *et al.* 1984; Miyashita *et al.* 1995). For management, the International Whaling Commission (IWC) had divided the North Pacific into two management regions (Donovan 1991) defined by a zig-zag line which starts at 150ºW at the equator to 160ºW between 40-50ºN, and ending at 180ºW north of 50ºN; however, the IWC has not reviewed this stock boundary in many years (Donovan 1991). Summer/fall surveys in the eastern tropical Pacific (Wade and Gerrodette 1993) show that although sperm whales are widely distributed in the tropics, their relative abundance tapers off markedly westward towards the middle of the tropical Pacific (near the IWC stock boundary at 150ºW) and tapers off northward towards the tip of Baja California. The Hawaiian Islands marked the center of a major nineteenth century whaling ground for sperm whales (Gilmore 1959; Townsend 1935). ~~Since 1936, at least 28 strandings have been reported from the Hawaiian Islands (Woodward 1972; Nitta 1991; Maldini *et al.* 2005, NMFS PIR Marine Mammal Response Network database), including 7 since 2007.~~ Sperm whales have ~~also~~ been sighted throughout the Hawaiian EEZ, including nearshore waters of the main and Northwestern Hawaiian Islands (NWHI) (Rice 1960; Baird 2016, ~~Barlow 2006,~~ Lee 1993; Mobley *et al.* 2000, Shallenberger 1981). In addition, the sounds of sperm whales have been recorded throughout the year within the main and NWHI ~~off Oahu~~ (Thompson and Friedl 1982, Merkens *et al.* 2019). Summer/fall shipboard surveys of waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands resulted in 43 sperm whale sightings in 2002, ~~and~~ 46 in 2010, and 24 in 2017 throughout the study area (Figure 1; Barlow 2006, Bradford et al. 2017, Yano *et al.* 2018).

The stock identity of sperm whales in the North Pacific has been inferred from historical catch records (Bannister and Mitchell 1980) and from trends in CPUE and tag-recapture data (Ohsumi and Masaki 1977). A 1997 survey designed specifically to investigate stock structure and abundance of sperm whales in the northeastern temperate Pacific revealed no apparent hiatus in distribution between the U.S. EEZ off California and areas farther west, out to Hawaii (Barlow and Taylor 2005). Recent genetic analyses revealed significant differences in mitochondrial and nuclear DNA and in single-nucleotide polymorphisms between sperm whales sampled off the coast of California, Oregon and Washington and those sampled near Hawaii and in the eastern tropical Pacific (ETP) (Mesnick et al. 2011). These results suggest demographic independence between matrilineal groups found California, Oregon, and Washington, and those found elsewhere in the central and eastern tropical Pacific. Further, assignment tests identified male sperm whales sampled in the sub-Arctic with each of the three regions, suggesting mixing of males from potentially several populations during the summer (Mesnick *et al.* 2011).

For the Marine Mammal Protection Act (MMPA) stock assessment reports, sperm whales within the Pacific U.S. EEZ are divided into three discrete, non-contiguous stocks: 1) waters around Hawaii (this report), 2) California, Oregon and Washington waters, and 3) Alaskan waters. The Hawaii stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of the Hawaii stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

Encounter data from ~~a 2010~~ shipboard line-transect surveys of the entire Hawaiian Islands EEZ was recently reevaluated for each survey year, resulting in the following abundance estimates of sperm whales in the Hawaii EEZ (Becker *et al*. *in review*, (Table 1).

Table 1. Model-based line-transect abundance estimates for sperm whales derived from surveys of the entire Hawaii EEZ in 2002, 2010, and 2017 (Becker *et al. in review*).

Year	Model-based abundance	CV	95% Confidence Limits
2017	5,707	0.23	2,961-10.998
2010	5,497	0.22	2,863-10.555
2002	5,387	0.22	2,668-10,878

Sighting data from 2002 to 2017 within the Hawaii EEZ were used to derive habitat-based models of animal density for the overall period. The models were then used to predict density and abundance for each survey year based on the environmental conditions within that year (see Forney *et al.* 2015, Becker *et al.* 2016). The modeling framework incorporated Beaufort-specific trackline detection probabilities for sperm whales from Barlow et al. (2015). Bradford *et al.* (*in review*) produced design-based abundance estimates for sperm whales for each survey year that can be used as a point of comparison to the model-based estimates. While on average, the estimates are quite similar between the two approaches, the annual design-based estimates show much greater uncertainty for some years than do the model-based estimates (Figure 2). The model-based approach reduces variability through explicit examination of habitat relationships across the full dataset, while the design-based approach evaluates encounter data for each year separately and thus is more susceptible to the effects of encounter rate variation. Model based-estimates are based on the implicit assumption that changes in abundance are attributed to environmental variability alone due to a lack of data to test for other effects. Despite not fully accounting for inter-annual variation in total abundance, the model-based estimates are considered the best available estimate for each survey year. Previously published design-based estimates for the Hawaii EEZ from 2002 and 2010 surveys (e.g. Barlow 2006, Bradford et al. 2017) used a subset of the dataset used by Becker et al. (*in review*) and Bradford et al. (*in review*) to derive line-transect parameters, such that these estimates have been superseded by the estimates presented here. The best estimate of abundance is from the 2017 survey, or 5,707 (CV=0.23). ~~using Beaufort sea-state-specific trackline detection probabilities for sperm whales, resulting in an abundance estimate of 4,559 (CV = 0.33) sperm whales (Bradford *et al.* 2017) in the Hawaii stock. A 2002 shipboard line-transect survey of the same area resulted in an abundance estimate of 6,919 (CV=0.81) sperm whales (Barlow 2006). Species abundances estimated from the 2002 HICEAS survey used pooled small dolphin, large dolphin, and large whale g(0) (the probability of sighting and recording an animal directly on the track line) estimates stratified by group size (Barlow 1995). Since then, Barlow (2015) developed a more robust method for estimating species-specific g(0) values that are adjusted for the Beaufort sea states that are encountered during a survey. This new method was used for analyzing the data from the 2010 survey, but has not yet been used to analyze the 2002 data.~~

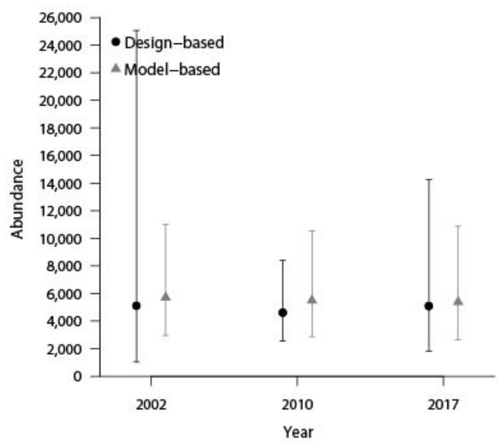

Figure 2. Comparison of design-based (circles, Bradford *et al.* in review) and model-based (triangles, Becker *et al.* in review) estimates of abundance for sperm whales for each survey year (2002, 2010, 2017).

A large 1982 abundance estimate for the entire eastern North Pacific (Gosho *et al*. 1984) was based on a CPUE method which is no longer accepted as valid by the International Whaling Commission. A spring 1997 combined visual and acoustic line-transect survey conducted in the eastern temperate North Pacific resulted in estimates of 26,300 (CV=0.81) sperm whales based on visual sightings, and 32,100 (CV=0.36) based on acoustic detections and visual group size estimates (Barlow and Taylor 2005). Sperm whales appear to be a good candidate for acoustic surveys due to the increased range of detection; however, visual estimates of group size are still required (Barlow and Taylor 2005). In the eastern tropical Pacific, the abundance of sperm whales has been estimated as 22,700 (95% C.I.=14,800-34,600; Wade and Gerrodette 1993). However, it is not known whether any or all of these animals routinely enter the U.S. EEZ of the Hawaiian Islands.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow et al. 1995) around the 2017 ~~2010~~ abundance estimate or 4,486 ~~3,478~~ sperm whales within the Hawaiian Islands EEZ.

Current Population Trend

The model-based abundance estimates for sperm whales provided by Becker *et al.* (*in review*) do not explicitly allow for examination of population trend other than that driven by environmental factors. Model-based examination of sperm whale population trends including sighting data beyond the Hawaii EEZ will be required to more fully examine trend for this stock. .~~Abundance analyses of the 2002 and 2010 datasets used different g(0) values. The 2002 survey data have not been reanalyzed using this method. This change precludes evaluation of population trends at this time. Assessment of population trend will likely require additional survey data and reanalysis of all datasets using comparable methods.~~

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data on current or maximum net productivity rate are available.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii stock of sperm whales is calculated as the minimum population size (4,486 ~~3,478~~) within the U.S. EEZ of the Hawaiian Islands times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.2 (for an endangered species with N_{min} > 1,500 and CV_N <=~~>~~ 0.50, with low vulnerability to extinction; (Taylor et al. 2003), resulting in a PBR of 18 ~~14~~ sperm whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Information on fishery-related mortality of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. ~~One stranded sperm whale was found with fishing line and netting its stomach, though it is unclear whether the gear caused its death, nor what fisheries the gear came from (NMFS PIR MMRN).~~ No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line fisheries because these fisheries are not observed or monitored for protected species bycatch.

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2014~~2011~~ and 2018~~2015~~, no sperm whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) ~~and one was observed either hooked or entangled~~ or in the DSLL fishery (~~20~~18-21% observer coverage) (~~Bradford 2017~~ Bradford 2018a, 2018b, *in review*, Bradford and Forney 2017). On unidentified cetacean taken in the DSLL fishery was identified as a large whale based on the Observer's description and may have been a sperm whale.~~The observer could not determine whether the whale was hooked or entangled; however, the mainline came under tension when the animal surfaced. The whale was cut free with the hook, 0.5m wire leader, 45g weight, 12m of branchline, and 25-30 ft of mainline possibly attached. This interaction was prorated as 75% probability of serious injury because the whale was hooked or entangled but the exact nature of the injury could not be determined (Bradford & Forney 2017).~~

~~This determination is based on an evaluation of the observer's description of the interaction and following the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2012). The prorating of serious injury is based on the proportion of known outcomes for whales with similar fisheries interactions in other regions. Average 5-yr estimates of annual mortality and serious injury for sperm whales during 2011-2015 are zero sperm whales outside of U.S. EEZs, and 0.7 (CV = 0.9) within the Hawaiian Islands EEZ (Table 1, McCracken 2017).~~

~~**Table 1.** Summary of available information on incidental mortality and serious injury of sperm whales in commercial longline fisheries, within and outside of the U.S. EEZs (McCracken 2017). Mean annual takes are based on 2011-2015 data. Information on all observed takes (T) and combined mortality events & serious injuries (MSI) is included. Total takes were prorated to deaths, serious injuries, and non-serious injuries based on the observed proportions of each outcome.~~

				~~**Observed total interactions (T) and mortality events, and serious injuries (MSI), and total estimated mortality and serious injury (M&SI) of sperm whales**~~			
				~~**Outside U.S. EEZs**~~		~~**Hawaiian EEZ**~~	
~~**Fishery Name**~~	~~**Year**~~	~~**Data Type**~~	~~**Percent Observer Coverage**~~	~~**Obs. T/MSI**~~	~~**Estimated M&SI (CV)**~~	~~**Obs. T/MSI**~~	~~**Estimated M&SI (CV)**~~
~~**Hawaii-based deep-set longline fishery**~~	~~2011~~	~~Observer data~~	~~20%~~	~~0~~	~~0 (-)~~	~~1/1*~~	~~3 (0.8)~~
	~~2012~~		~~20%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
	~~2013~~		~~20%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
	~~2014~~		~~21%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
	~~2015~~		~~21%~~	~~0~~	~~0 (-)~~	~~0~~	~~0 (-)~~
~~**Mean Estimated Annual Take (CV)**~~					~~**0 (-)**~~	-	~~**0.7 (0.9)**~~
~~**Hawaii-based shallow-set longline fishery**~~	~~2011~~	~~Observer data~~	~~100%~~	~~0~~	~~0~~	~~0~~	~~0~~
	~~2012~~		~~100%~~	~~0~~	~~0~~	~~0~~	~~0~~
	~~2013~~		~~100%~~	~~0~~	~~0~~	~~0~~	~~0~~
	~~2014~~		~~100%~~	~~0~~	~~0~~	~~0~~	~~0~~
	~~2015~~		~~100%~~	~~0~~	~~0~~	~~0~~	~~0~~
~~**Mean Annual Takes (100% coverage)**~~					-	-	~~**0**~~
~~**Minimum total annual takes within U.S. EEZ**~~				-	-	-	~~**0.7 (0.9)**~~

~~*This injury was prorated 75% probability of being a serious injury based on known outcomes from other whales with this injury type (NOAA 2012).~~

Historical Mortality

Between 1800 and 1909, about 60,842 sperm whales were estimated taken in the North Pacific (Best 1976). The reported take of North Pacific sperm whales by commercial whalers between 1947 and 1987 totaled 258,000 (C. Allison, pers. comm.). Factory ships operated as far south as 20ºN (Ohsumi 1980). Ohsumi (1980) lists an additional 28,198 sperm whales taken mainly in coastal whaling operations from 1910 to 1946. Based on the massive under-reporting of Soviet catches, Brownell et al. (1998) estimated that about 89,000 whales were additionally taken by the Soviet pelagic whaling fleet between 1949 and 1979. Japanese coastal operations apparently also under-reported catches by an unknown amount (Kasuya 1998). Thus a total of at least 436,000 sperm whales were taken between 1800 and the end of commercial whaling for this species in 1987. Of this grand total, an estimated 33,842 were taken by Soviet and Japanese pelagic whaling operations in the eastern North Pacific from the longitude of Hawaii to the U.S. West coast, between 1961 and 1976 (Allen 1980, IWC statistical Areas II and III), and 965 were reported taken in land-based U.S. West coast whaling operations between 1947 and 1971 (Ohsumi 1980). In addition, 13 sperm whales were taken by shore whaling stations in California between 1919 and 1926 (Clapham et al. 1997). There has been a prohibition on taking sperm whales in the North Pacific since 1988, but large-scale pelagic whaling stopped earlier, in 1980. Some of the whales taken during the whaling era were certainly from a population or populations that occur within Hawaiian waters.

STATUS OF STOCK

The only estimate of the status of North Pacific sperm whales in relation to carrying capacity (Gosho et al. 1984) is based on a CPUE method which is no longer accepted as valid. The status of sperm whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Sperm whales are formally listed as "endangered" under the Endangered Species Act (ESA), and consequently the Hawaiian stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. ~~The estimated rate of fisheries related mortality or serious injury within the Hawaiian Islands EEZ (0.7 animals per year) is less than the PBR (13.9). Insufficient information is available to determine whether the total fishery mortality and serious injury for sperm whales is insignificant and approaching zero mortality and serious injury rate.~~ Given the absence of recent recorded fishery-related mortality or serious injuries in U.S. EEZ waters, total fishery mortality and serious injury for sperm whales can be considered insignificant and approaching zero. The increasing level of anthropogenic noise in the world's oceans has been suggested to be a habitat concern for whales (Richardson et al. 1995), particularly for deep-diving whales like sperm whales that feed in the oceans' "sound channel". One sperm whale stranded in the main Hawaiian Islands tested positive for both *Brucella* and *Morbillivirus* (Jacob et al. 2016). *Brucella* is a bacterial infection that if common in the population may limit recruitment by compromising male and female reproductive systems, and can also cause neurological disorders that may result in death (Van Bressem et al. 2009). *Morbillivus* is known to trigger lethal disease in cetaceans (Van Bressem et al. 2009); however, investigation of the pathology of the stranded sperm whale suggests that *Brucella* was more likely the cause of death in this sperm whale. The presence of *Morbillivirus* in 10 species (Jacob et al. 2016) and *Brucella* in 3 species (Cherbov 2010) raises concerns about the history and prevalence of these diseases in Hawaii and the potential population impacts on Hawaiian cetaceans. It is not known if *Brucella or Morbillivirus* are common in the Hawaii stock.

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Revised ~~5/31/2018~~ 9/5/2020

FIN WHALE (*Balaenoptera physalus physalus*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

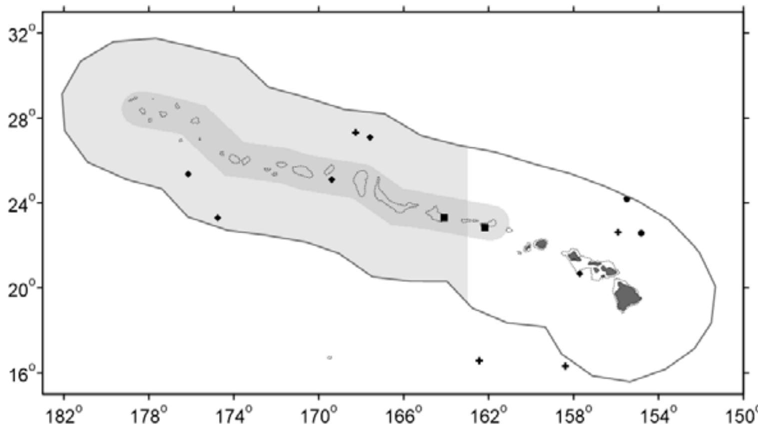

Figure 1. Locations of fin whale sightings from longline observer records (crosses; NMFS/PIR, unpublished data) and sighting locations during the 2002 (~~open~~ diamonds), ~~and~~ 2010 (~~black diamonds~~circle), and 2017 (square) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford *et al*. 2017, Yano *et al.* 2018~~; see Appendix 2 for details on timing and location of survey effort~~). Outer line represents approximate boundary of survey area and U.S. EEZ. Dark g~~G~~ray shading indicates ~~area of~~of the original Papahanaumokuakea Marine National Monument, with the lighter gray shading denoting the full 2016 Expansion area. Dotted line represents the 1000 m isobath.

Fin whales are found from temperate to subpolar ocean around the world, with a distributional hiatus between the Northern and Southern Hemispheres between 20° and 30° on either side of the equator (Edwards et al. 2015).~~throughout all oceans and seas of the world from tropical to polar latitudes.~~ In the North Pacific fin whales tend to occur in temperate to sub-polar latitudes (Mizroch et al. 1984, 2009). North Pacific fin whales are genetically distinct from those in the North Atlantic and Southern Hemisphere (Archer et al. 2013), and detailed recent examination of the mitochondrial DNA control region and on 23 single-nucleotide polymorphisms (SNPs) from 144 fin whales sampled in the three regions revealed that North Pacific and North Atlantic whales should be recognized as separate subspecies (Archer et al. 2019a). Fin whales~~They~~ have been considered rare in Hawaiian waters, though occasional sightings have been reported ~~and are absent to rare in eastern tropical Pacific waters (Hamilton *et al.* 2009)~~. Balcomb (1987) observed 8-12 fin whales in a multispecies feeding assemblage on 20 May 1966 approx. 250 mi. south of Honolulu. Additional sightings were reported north of Oahu in May 1976, in the Kauai Channel in February 1979 (Shallenberger 1981), north of Kauai in February 1994 (Mobley *et al.* 1996), and off Lanai in 2012 (Baird 2016). Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands resulted in five sightings in 2002, ~~and~~ two sightings in 2010, and two sightings in 2017 (Figure 1; Barlow ~~2003~~ 2006, Bradford *et al*. 2017, Yano *et al.* 2018~~; Figure 1~~). ~~A single stranding was reported on Maui in 1954 (Shallenberger 1981). Thompson and Friedl (1982; and see Northrop *et al.* 1968) suggested that fin whales migrate into Hawaiian waters mainly in fall and winter, based on acoustic recordings off Oahu and Midway Islands. Although the exact positions of the whales producing the sounds could not be determined, at least some of them were almost certainly within the U.S. EEZ. More recently, McDonald and Fox (1999) reported an average of 0.027 calling fin whales per 1000² km (grouped by 8-hr periods) based on passive acoustic recordings within about 16 km of the north shore of Oahu.~~ Oleson et al. (2014) reported fin whale song recorded near Hawaii Island from October through April, and noted the occurrence of a predominant song pattern similar to that recorded off southern California and in the Bering Sea, suggesting a broadly connected population throughout that range. Further examination of the spectral features of individual fin whale song notes and the inter-note timing within fin whale song throughout the Pacific indicates a broad diversity of song types, with songs recorded in Hawaii being distinctly different than those heard at the other eastern and central Pacific monitoring sites or in arctic waters (Archer et al. 2019b)

The International Whaling Commission (IWC) recognized two stocks of fin whales in the North Pacific: the East China Sea and the rest of the North Pacific (Donovan 1991). Mizroch *et al.* (1984) cite evidence for additional fin whale subpopulations in the North Pacific, and acoustic evidence provides additional support for finer population structure (Archer et al. 2019b). There is still insufficient information to accurately determine population structure, but from a conservation perspective it may be risky to assume panmixia in the entire North Pacific. In the

North Atlantic, fin whales were locally depleted in some feeding areas by commercial whaling (Mizroch *et al.* 1984), in part because subpopulations were not recognized. The Marine Mammal Protection Act (MMPA) stock assessment reports recognize three stocks of fin whales in the North Pacific: 1) the Hawaii stock (this report), 2) the California/Oregon/Washington stock, and 3) the Alaska stock. The Hawaiian stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

Encounter data from ~~a 2010~~ summer/fall shipboard line-transect surveys of the entire Hawaiian Islands EEZ were recently reevaluated for each survey year, resulting in the following abundance estimates of fin whales in the Hawaii EEZ (Bradford *et al. in review*) (Table 1).

Table 1. Line-transect abundance estimates for fin whales derived from surveys of the entire Hawaii EEZ in 2002, 2010, and 2017 (Bradford *et al. in review*).

Year	Abundance	CV	95% Confidence Limits
2017	203	0.99	40-1,028
2010	158	1.07	29-871
2002	509	0.73	141-1,842

The updated design-based abundance estimates use sighting data from throughout the central Pacific to estimate the detection function and use Beaufort sea-state-specific trackline detection probabilities for fin whales from Barlow *et al.* (2015). Although previous estimates from the Hawaii EEZ have been published using subsets of this data, Bradford *et al.* (*in review*), uses a consistent approach for estimating all abundance parameters and resulting estimates are considered the best available for the summer/fall period. Winter surveys have not been carried out in the Hawaiian Archipelago and it is likely that winter abundance of this migratory species within the Hawaiian EEZ is not accurately reflected by the summer/fall estimates. The best estimate of abundance is 203 (CV=0.99) fin whales based on a 2017 survey (Bradford *et al. in review*).~~using Beaufort sea-state-specific trackline detection probabilities for fin whales, resulting in an abundance estimate of 154 (CV=1.05) fin whales (Bradford *et al.* 2017) in the Hawaii stock. This is currently the best available abundance estimate for this stock within the Hawaii EEZ, but the majority of fin whales would be expected to be at higher latitudes feeding grounds at this time of year. A 2002 shipboard line-transect survey of the same area resulted in an abundance estimate of 174 (CV=0.72) fin whales (Barlow 2003). Species abundances estimated from the 2002 HICEAS survey used pooled small dolphin, large dolphin, and large whale g(0) (the probability of sighting and recording an animal directly on the track line) estimates stratified by group size (Barlow 1995). Since then, Barlow (2015) developed a more robust method for estimating species-specific g(0) values that are adjusted for the Beaufort sea states that are encountered during a survey. This new method was used for analyzing the data from the 2010 survey, but has not yet been used to analyze the 2002 data.~~ Using passive acoustic detections from a hydrophone north of Oahu, MacDonald and Fox (1999) estimated an average density of 0.027 calling fin whales per 1000 km^2 within about 16 km from shore. However, the relationship between the number of whales present and the number of calls detected is not known, and therefore this acoustic method does not provide an estimate of absolute abundance for fin whales.

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al*. 1995) around the 2017~~2010~~ abundance estimate or 101~~75~~ fin whales within the Hawaiian Islands EEZ during the summer/fall survey period.

Current Population Trend

Trend information for this stock cannot be assessed from summer/fall abundance surveys alone, as the species is not expected to reside in Hawaiian waters in large numbers during that period. Winter surveys or alternative observations (e.g. acoustic studies) will be required to assess the trend for fin whales in Hawaiian waters.~~Abundance analyses of the 2002 and 2010 datasets used different g(0) values. The 2002 survey data have not been reanalyzed using this method. This change precludes evaluation of population trends at this time. Assessment of population trend will likely require additional survey data and reanalysis of all datasets using comparable~~

~~methods.~~

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii stock of fin whales is calculated as the minimum population size within the U.S EEZ of the Hawaiian Islands (101 ~~75~~) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.1 (the default value for an endangered species with Nmin <1500; Taylor *et al*. 2003), resulting in a PBR of 0.2 ~~0.1~~ fin whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2014~~2011~~ and 2018~~2015~~, one fin whale~~s~~ was observed entangled in the SSLL fishery (100% observer coverage), and none were observed in the DSLL fishery (~~20~~18-22% observer coverage) (Bradford, McCracken 2019~~7~~). The SSLL entanglement occurred outside of the Hawaiian Islands EEZ and the whale was judged to be not seriously injured (Bradford and Forney 2017). The 5-yr annual mortality and serious injury estimate for fin whales is 0 both inside and outside the Hawaiian Islands EEZ (McCracken ~~2017~~2019). Two additional unidentified cetaceans judged to be large whales based on the observer's description were taken in the DSLL, and some of these may have been fin whales.

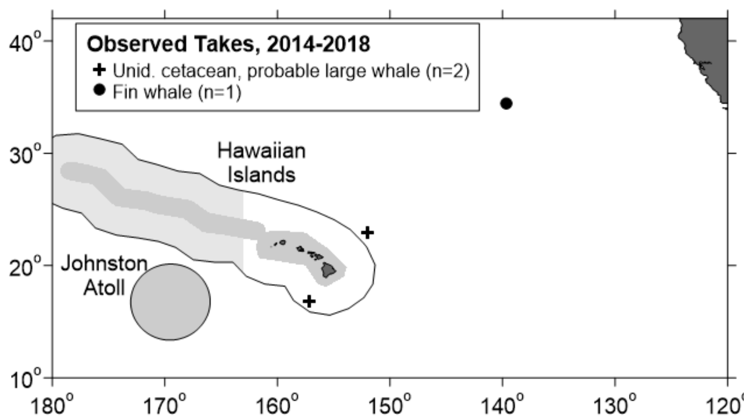

Figure 2. Location of observed fin whale take within the shallow-set fishery (circle), and unidentified cetaceans considered to be large whales based on the observer's description (crosses) in the deep-set fishery, 2014-2018. Solid lines represent the U. S. EEZ. Gray shading notes areas closed to commercial fishing, with the PMNM Expansion area closed since August 2016.

Historical Mortality

Large numbers of fin whales were taken by commercial whalers throughout the North Pacific from the early 20th century until the 1970s (Tønnessen and Johnsen 1982). Approximately 46,000 fin whales were taken from the North Pacific by commercial whalers between 1947 and 1987 (C. Allison, IWC, pers. comm.). Some of the whales taken may have been from a population or populations that migrate seasonally into the Hawaiian EEZ. The species has been protected in the North Pacific by the IWC since 1976.

STATUS OF STOCK

The status of fin whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Fin whales are formally listed as "endangered" under the Endangered Species Act (ESA), and consequently the Hawaiian stock is automatically considered as a "depleted" and "strategic" stock under the MMPA. Because there have been no reported fishery related mortality or serious injuries within the Hawaiian Islands EEZ, the total fishery-related mortality and serious injury of this stock can be considered to be insignificant and approaching zero. Increasing levels of anthropogenic sound in the world's oceans has been suggested to be a habitat concern for whales, particularly for baleen whales that may communicate using low-frequency sound (Croll *et al.* 2002). Behavioral changes associated with exposure to simulated mid-frequency sonar, including no change in behavior, cessation of feeding, increased swimming speeds, and movement away from simulated sound sources has been documented in tagged blue whales (Goldbogen *et al.* 2013), but it is unknown if fin whales respond in the same manner to such sounds.

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Revised ~~5/28/2018~~ 8/4/2020

BRYDE'S WHALE (*Balaenoptera edeni*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

Bryde's whales occur in tropical and warm temperate waters throughout the world. Leatherwood *et al.* (1982) described the species as relatively abundant in summer and fall on the Mellish and Miluoki banks northeast of Hawaii and around Midway Island. Ohsumi and Masaki (1975) reported the tagging of "many" Bryde's whales between the Bonin and Hawaiian Islands in the winters of 1971 and 1972 (Ohsumi 1977). Summer/fall shipboard surveys of the waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands resulted in 13 Bryde's whale sightings throughout the study area in 2002 ~~and~~, 30 in 2010, and 2 in 2017 (Figure 1; Barlow 2006, Bradford *et al.* 2017, Yano *et al.* 2018). There is currently no biological basis for defining separate stocks of Bryde's whales in the central North Pacific. Bryde's whales were seen occasionally off southern California (Morejohn and Rice 1973) in the 1960s, but their seasonal occurrence has increased since at least 2000 based on detection of their distinctive calls (Kerosky *et al.* 2012).

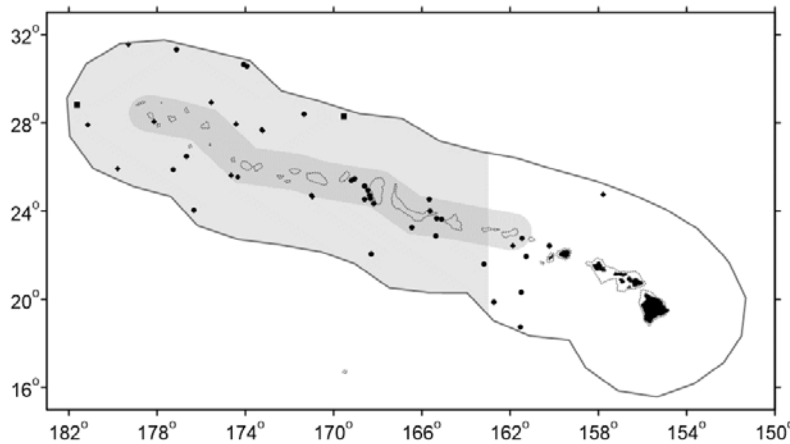

Figure 1. Bryde's whale sighting locations during the 2002 (~~open~~ diamonds), ~~and~~ 2010 (~~black diamonds~~circle), and 2017 (square) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford *et al.* 2017, Yano *et al.* 2018~~; see Appendix 2 for details on timing and location of survey effort~~). Outer line represents approximate boundary of survey area and U.S. EEZ. Dark ~~G~~gray shading indicates ~~area of~~ the original Papahanaumokuakea Marine National Monument, with the lighter gray shading denoting the full 2016 Expansion area. Dotted line represents the 1000 m isobath.

For the MMPA stock assessment reports, Bryde's whales within the Pacific U.S. EEZ are divided into two areas: 1) Hawaiian waters (this report), and 2) the eastern Pacific (east of 150ºW and including the Gulf of California and waters off California). The Hawaiian stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

Encounter data from ~~a 2010~~ shipboard line-transect surveys of the entire Hawaiian Islands EEZ was recently reevaluated, resulting in updated model-based abundance estimates of Bryde's whales in the Hawaii EEZ (Becker et al. *in review*) (Table 1).

Table 1. Model-based line-transect abundance estimates for Bryde's whales derived from surveys of the entire Hawaii EEZ in 2002, 2010, and 2017 (Becker et al. *in review*).

Year	Model-based Abundance	CV	95% Confidence Limits
2017	602	0.22	397-842
2010	822	0.20	554-1,220
2002	562	0.21	375-842

Sighting data from 2002 to 2017 within the Hawaii EEZ were used to derive habitat-based models of animal density for the overall period. The models were then used to predict density and abundance for each survey year based on the environmental conditions within that year (see Forney et al. 2015, Becker et al. 2016). The modeling framework incorporated Beaufort-specific trackline detection probabilities for Bryde's whales from Barlow et al. (2015). Bradford et al. (*in review*) produced design-based abundance estimates for Bryde's whales for each survey year that can be used as a point of comparison to the model-based estimates. While on average, the estimates are broadly similar between the two approaches, the annual design-based estimates show much greater variability between years than do the model-based estimates (Figure 2). The model-based approach reduces variability through explicit examination of habitat relationships across the full dataset, while the design-based approach evaluates encounter data for each year separately and thus is more susceptible to the effects of encounter rate variation. Bradford et al. (*in review*) found through simulation that the pronounced decrease in the design-based estimates between 2010 and 2017 could not be explained by encounter rate variation alone and likely reflected true changes in distribution of Bryde's whales in the study area between those survey years. The model based-estimates demonstrated a much smaller decrease between 2010 and 2017, but are based on the implicit assumption that changes in abundance are attributed to environmental variability alone due to a lack of data to test for other effects. Despite not fully accounting for inter-annual variation in total abundance, the model-based estimates are considered the best available estimate for each survey year. Previously published design-based estimates for the Hawaii EEZ from 2002 and 2010 surveys (e.g. Barlow 2006, Bradford et al. 2017) used a subset of the dataset used by Becker et al. (*in review*) and Bradford et al. (*in review*) to derive line-transect parameters, such that these estimates have been superseded by the estimates presented here. ~~using Beaufort sea state-specific trackline detection probabilities for Bryde's whales, resulting in an abundance estimate of 1,751 (CV = 0.29) Bryde's whales (Bradford *et al.* 2017) in the Hawaii stock. A 2002 shipboard line-transect survey of the same region resulted in an abundance estimate of 469 (CV=0.45) Bryde's whales (Barlow 2006). Species abundances estimated from the 2002 HICEAS survey used pooled small dolphin, large dolphin, and large whale g(0) (the probability of sighting and recording an animal directly on the track line) estimates stratified by group size (Barlow 1995). Since then, Barlow (2015) developed a more robust method for estimating species-specific g(0) values that are adjusted for the Beaufort sea states that are encountered during a survey. This new method was used for analyzing the data from the 2010 survey, but has not yet been used to analyze the 2002 data.~~

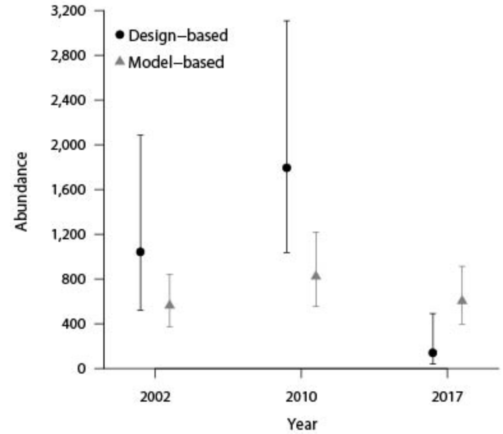

Figure 2. Comparison of design-based (circles, Bradford et al. *in review*) and model-based (triangles, Becker et al. *in* review) estimates of abundance for Bryde's whales for each survey year (2002, 2010, 2017).

Tillman (1978) concluded from Japanese and Soviet CPUE data that the stock size in the North Pacific pelagic whaling grounds, mostly to the west of the Hawaiian Islands, declined from approximately 22,500 in 1971 to 17,800 in 1977. An estimate of 13,000 (CV=0.202) Bryde's whales was made from vessel surveys in the eastern tropical Pacific between 1986 and 1990 (Wade and Gerrodette 1993). The area to which this estimate applies is mainly east and somewhat south of the Hawaiian Islands, and it is not known whether these animals are part of the same population that occurs around the Hawaiian Islands.

Minimum Population Estimate

Minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) of the 2017~~2010~~ abundance estimate, or 501~~1,378~~ Bryde's whales.

Current Population Trend

The model-based abundance estimates for Bryde's whales provided by Becker *et al.* (*in review*) do not explicitly allow for examination of population trend other than that driven by environmental factors. Although annual encounter rate variation may have a large impact on abundance estimates for species with low density and patchy distribution, Bradford *et al.* (*in review*) suggest that the very high sighting rate in 2010 and very low sighting rate in 2017 cannot be explained through encounter rate variation alone and that there may be true fluctuations in Bryde's

whale abundance within the Hawaii EEZ. Model-based examination of Bryde's whale population trends including sighting data beyond the Hawaii EEZ will be required to more fully examine trend for this stock.
~~Abundance analyses of the 2002 and 2010 datasets used different g(0) values. The 2002 survey data have not been reanalyzed using this method. This change precludes evaluation of population trends at this time. Assessment of population trend will likely require additional survey data and reanalysis of all datasets using comparable methods.~~

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii stock of Bryde's whales is calculated as the minimum population size within the U.S EEZ of the Hawaiian Islands (501~~1,378~~) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.50 (for a stock of unknown status with no known fishery mortality or serious injury within the Hawaiian Islands EEZ; Wade and Angliss 1997), resulting in a PBR of 5.0~~14~~ Bryde's whales per year.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2014~~2011~~ and 2018~~2015~~, no Bryde's whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (18~~20~~-22% observer coverage) (Bradford~~ 2017~~2018a, 2018b, *in review*, Bradford and Forney 2017, McCracken ~~2017~~2019). Large whales have been observed entangled in longline gear off the Hawaiian Islands in the past (Forney 2010).

Historical Mortality

Small numbers of Bryde's whales were taken near the Northwestern Hawaiian Islands by Japanese and Soviet whaling fleets in the early 1970s (Ohsumi 1977). Pelagic whaling for Bryde's whales in the North Pacific ended after the 1979 season (IWC 1981), and coastal whaling for this species ended in the western Pacific in 1987 (IWC 1989).

STATUS OF STOCK

The Hawaii stock of Bryde's whales is not considered strategic under the 1994 amendments to the MMPA. The status of Bryde's whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Bryde's whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Given the absence of recent recorded fishery-related mortality or serious injuries within the Hawaiian Islands EEZ, the total fishery mortality and serious injury can be considered to be insignificant and approaching zero. The increasing level of anthropogenic noise in the world's oceans has been suggested to be a habitat concern for whales (Richardson *et al.* 1995, Weilgart 2007).

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Revised ~~6/4/2014~~ 9/5/2020

MINKE WHALE (*Balaenoptera acutorostrata scammoni*): Hawaii Stock

STOCK DEFINITION AND GEOGRAPHIC RANGE

The International Whaling Commission (IWC) recognizes 3 stocks of minke whales in the North Pacific: one in the Sea of Japan/East China Sea, one in the rest of the western Pacific west of 180ºN, and one in the "remainder" of the Pacific (Donovan 1991). The "remainder" stock only reflects the lack of exploitation in the eastern Pacific and does not imply that only one population exists in that area (Donovan 1991). In the "remainder" area, minke whales are relatively common in the Bering and Chukchi seas and in the Gulf of Alaska, but are not considered abundant in any other part of the eastern Pacific (Leatherwood et al. 1982, Brueggeman et al. 1990). In the Pacific, minke whales are usually seen over continental shelves (Brueggeman et al. 1990). In the extreme north, minke whales are believed to be migratory, but in inland waters of Washington and in central California they appear to establish home ranges (Dorsey et al. 1990).

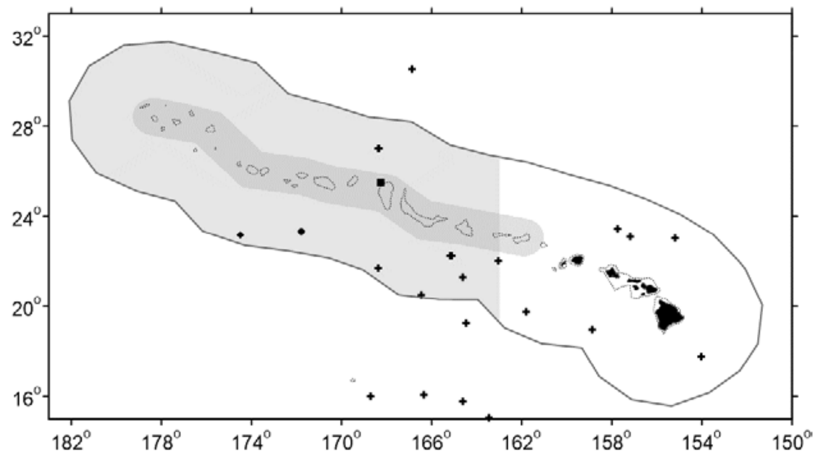

Figure 1. Locations of minke whale sightings from longline observer records (crosses; NMFS/PIR, unpublished data), and sighting locations ~~made~~ during the 2002 (~~open~~ diamond), ~~and~~ 2010 (~~black diamond~~circle), and 2017 (square) shipboard surveys of U.S. EEZ waters surrounding the Hawaiian Islands (Barlow 2006, Bradford et al. 2013, Yano et al. 2018). ~~; see Appendix 2 for details on timing and location of survey effort).~~ Outer line indicates approximate boundary of survey area and U.S. EEZ. Dark g~~G~~ray shading indicates the original ~~area of~~ Papahanaumokuakea Marine National Monument, with the lighter gray shading denoting the full 2016 Expansion area. Dotted line represents the 1000 m isobath.

Minke whales occur seasonally around the Hawaiian Islands (Barlow 2003, Rankin and Barlow, 2005), and their migration routes or destinations are unknown. Minke whale "boing" sounds have been detected near the Hawaiian Islands for decades, with detections by the U.S. Navy during February and March (Thompson and Friedl 1982) and at the ALOHA Cabled Observatory 100km north of Oahu from October to May (Oswald et al. 2011). ~~Minke whales were observed within 22km of Kauai in February 2005 (Rankin et al. 2007) and by observers in the Hawaii-based longline fishery since 1994 (Figure 1; NMFS/PIR unpublished data). Two~~ Three confirmed sightings of minke whale were made, one in ~~November~~ 2002, ~~and the other~~one in ~~during October~~ 2010, and one in 2017 during shipboard surveys of waters within the U.S. Exclusive Economic Zone (EEZ) of the Hawaiian Islands (Barlow 2003, Bradford et al. 2013, Yano *et al.* 2018). ~~There are no known stranding records of this species from the main islands (Nitta 1991, Maldini et al. 2005).~~

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there are three stocks of minke whale within the Pacific U.S. EEZ: 1) a Hawaiian stock (this report), 2) a California/Oregon/ Washington stock, and 3) an Alaskan stock. The Hawaiian stock includes animals found both within the Hawaiian Islands EEZ and in adjacent high seas waters; however, because data on abundance, distribution, and human-caused impacts are largely lacking for high seas waters, the status of this stock is evaluated based on data from U.S. EEZ waters of the Hawaiian Islands (NMFS 2005).

POPULATION SIZE

Encounter data from a 2017 summer/fall shipboard line-transect surveys of the entire Hawaiian Islands EEZ were used to estimate the seasonal abundance of minke whales in Hawaiian waters. The design-based abundance estimate for 2017 is 438 (CV = 1.05) animals in the Hawaiian EEZ during the summer/fall (Bradford *et al. in review*). The abundance estimate use sighting data from throughout the central Pacific to estimate the detection function and Beaufort sea-state-specific trackline detection probabilities for minke whales from Barlow et al. (2015). Summer/fall 2002 and 2010 shipboard line-transect surveys of the Hawaiian EEZ each resulted in one 'off effort' sighting of a minke whale (Barlow 2003, Bradford *et al*. 2013). These sightings were not part of regular survey operations and, therefore, could not be used to calculate estimates of abundance. The majority of each of these~~this~~ surveys took place during summer and early fall, when the Hawaiian stock of minke whale would be expected to be farther north. ~~There currently is no abundance estimate for this stock of minke whales, which appears to occur seasonally (about October - April) around the Hawaiian Islands.~~ Using passive acoustic detections from an array of seafloor hydrophones north of Kauai, Martin et al. (2012) estimate a preliminary average density of 2.15 "boing" calling minke whales per 1000 km^2 during the period February through April and within an area of 8,767 km^2 centered on the seafloor array positioned roughly 50km from shore. However, the relationship between the number of whales present and the number of calls detected is not known, and therefore this acoustic method does not provide an estimate of absolute abundance for minke whales. ~~Summer/fall 2002 and 2010 shipboard line-transect surveys of the entire Hawaiian Islands EEZ each resulted in one 'off effort' sighting of a minke whale (Barlow 2003, Bradford et al. *in review* 2013). These sightings were not part of regular survey operations and, therefore, could not be used to calculate estimates of abundance (Barlow 2003, Bradford et al. *in review* 2013).~~

Minimum Population Estimate

The minimum population size is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) of the 2017 abundance estimate or 212 minke whales. ~~There is no minimum population estimate for the Hawaiian stock of minke whales.~~

Current Population Trend

No data are available on population size or current population trend.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

No data are available on current or maximum net productivity rate for Hawaiian minke whales.

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the Hawaii stock of minke whales is calculated as the minimum population estimate (212) 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 estimated fishery mortality or serious injury within the U.S. EEZ of the Hawaiian Islands; Wade and Angliss 1997) resulting in a PBR of 2.1 minke whales per year. ~~Because there is no minimum population estimate for Hawaii minke whales, the PBR is undetermined.~~

HUMAN CAUSED MORTALITY AND SERIOUS INJURY

~~**New Serious Injury Guidelines**~~

~~NMFS updated its serious injury designation and reporting process, which uses guidance from previous serious injury workshops, expert opinion, and analysis of historic injury cases to develop new criteria for distinguishing serious from non-serious injury (Angliss and DeMaster 1998, Andersen et al. 2008, NOAA 2012). NMFS defines serious injury as an "*injury that is more likely than not to result in mortality*". Injury determinations for stock assessments revised in 2013 or later incorporate the new serious injury guidelines, based on the most recent 5-year period for which data are available.~~

Fishery Information

Information on fishery-related mortality and serious injury of cetaceans in Hawaiian waters is limited, but the gear types used in Hawaiian fisheries are responsible for marine mammal mortality and serious injury in other fisheries throughout U.S. waters. There are currently two distinct longline fisheries based in Hawaii: a deep-set longline (DSLL) fishery that targets primarily tunas, and a shallow-set longline fishery (SSLL) that targets swordfish. Both fisheries operate within U.S. waters and on the high seas. Between 2014~~2007~~ and 2018~~2011~~, no minke whales were observed hooked or entangled in the SSLL fishery (100% observer coverage) or the DSLL fishery (18~~20~~-22% observer coverage) (Bradford 2018a, 2018b, *in review*, Bradford and Forney 2017~~McCracken 2013~~).

STATUS OF STOCK

The Hawaii stock of minke whales is not considered strategic under the 1994 amendments to the MMPA. The status of minke whales in Hawaiian waters relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. Minke whales are not listed as "threatened" or "endangered" under the Endangered Species Act (1973), nor designated as "depleted" under the MMPA. Because there has been no reported fisheries related mortality or serious injury within the Hawaiian Islands EEZ, the total fishery mortality and serious injury for minke whales can be considered insignificant and approaching zero mortality and serious injury rate. A recent examination of the behavioral response of minke whales to mid-frequency sonar transmissions within the Pacific Missile Range Facility north of Kauai indicated a reduction in minke whale calling during sonar operations (Harris et al. 2019). Whether the reduction in calling was the result of displacement or a change in vocal behavior could not be determined with the data available, but does suggest that minke whales are responsive to military sonar activity within their range. The increasing level of anthropogenic sound in the world's oceans has been suggested to be a habitat concern for whales (Richardson et al. 1995). Minke whale increase the source level of their calls during periods of higher ambient noise, though are either unable or unwilling to increase calling levels at the same rate as increases in noise (Helble et al. 2020) suggesting masking of calls will occur at high noise levels.

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Appendix 2. Pacific reports revised in 2020 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	Total Annual Mortality + Serious Injury	Annual Fishery Mortality + Serious Injury	Strategic Status	Recent Abundance Surveys			SAR Last Revised
California Sea Lion	United States	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	179,000	n/a	81,368	0.12	1	4,882	8.8	4	N	2002	2005	2010	2014
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	~~1,351~~	0.03	~~1,325~~	0.07	0.1	~~4.6~~	~~≥3.0~~	~~≥1.6~~	S	~~2015~~	~~2016~~	~~2017~~	~~2019~~
		1,437		1,374			4.8	≥4.8	≥2.0		2016	2017	2018	2020
Harbor porpoise	Morro Bay	4,255	0.56	2,737	0.097	0.5	66	≥0.4	≥0.2	N	2008	2011	2012	2019
Harbor porpoise	Monterey Bay	3,455	0.58	2,197	0.042	0.5	23	≥0.2	≥0.2	N	2011	2012	2013	2019
Harbor porpoise	San Francisco - Russian River	7,524	0.57	4,801	0.04	0.5	48	≥0.6	≥0.6	N	2014	2016	2017	2019
Harbor porpoise	Northern CA/Southern OR	24,195	0.4	17,447	0.04	1	349	≥0.2	0	N	2011	2014	2016	2019
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	25,750	0.45	17,954	0.04	0.48	172	0.3	0.3	N	2005	2008	2014	2016
Pacific white-sided dolphin	California/Oregon/Washington	26,814	0.28	21,195	0.04	0.45	191	7.5	1.1	N	2005	2008	2014	2016
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	1,924	0.54	1,255	0.04	0.45	11	≥1.6	≥1.6	N	2005	2008	2014	2016
Striped dolphin	California/Oregon/Washington	29,211	0.20	24,782	0.04	0.48	238	≥0.8	≥0.8	N	2005	2008	2014	2016
Common dolphin, short-beaked	California/Oregon/Washington	969,861	0.17	839,325	0.04	0.5	8,393	≥40	≥40	N	2005	2008	2014	2016
Common dolphin, long-beaked	California	101,305	0.49	68,432	0.04	0.48	657	≥35.4	≥32.0	N	2005	2008	2014	2016
Northern right whale dolphin	California/Oregon/Washington	26,556	0.44	18,608	0.04	0.48	179	3.8	3.8	N	2005	2008	2014	2016
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	~~75~~	n/a	~~75~~	0.035	0.1	0.13	~~0~~	~~0~~	S	~~2016~~	~~2017~~	~~2018~~	~~2019~~
		73		73				≥0.4	0		2017	2018	2019	2020
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	2,697	0.6	1,633	0.04	0.5	16.0	0	0	N	2005	2008	2014	2017
Mesoplodont beaked whales	California/Oregon/Washington	3,044	0.54	1,967	0.04	0.5	20.0	0.1	0.1	N	2005	2008	2014	2017
Cuvier's beaked whale	California/Oregon/Washington	3,274	0.67	2,059	0.04	0.5	21	<0.1	<0.1	N	2005	2008	2014	2017

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Species	Stock	N est	CV N est	N min	R max	Fr	PBR	Total Annual Mortality + Serious Injury	Annual Fishery Mortality + Serious Injury	Strategic Status	Recent Abundance Surveys			SAR Last Revised
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
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	1.0	801	~~139~~	~~9.6~~	N	2011	2015	2016	~~2018~~
								131	9.3					2020
Gray whale	Western N Pacific	290	n/a	271	0.062	0.1	0.12	unk	unk	S	2014	2015	2016	~~2018~~
														2020
Humpback whale	California/Oregon/Washington	2,900	0.05	2,784	0.08	0.3	16.7	≥ 42.1	≥ 19.4	S	2011	2013	2014	2019
Blue whale	Eastern N Pacific	1,496	0.44	1,050	0.04	0.1	1.2	≥ 19.4	≥ 1.44	S	2008	2011	2014	2019
Fin whale	California/Oregon/Washington	9,029	0.12	8,127	0.04	0.5	81	~~≥ 43.5~~	~~≥ 0.5~~	S	2005	2008	2014	~~2018~~
								≥ 43.7	≥ 0.67					2020
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	636	0.72	369	0.04	0.48	3.5	≥ 1.3	≥ 1.3	N	2005	2008	2014	2016
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	Hawaii	~~72,528~~	~~0.39~~	~~52,833~~	0.04	~~0.4~~	~~423~~	~~2.1~~	~~2.1~~	N		~~2002~~	~~2010~~	~~2017~~
		76,375	0.41	54,804		0.5	548	0	0		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	Hawaii	~~11,613~~	~~0.43~~	~~8,210~~	0.04	0.5	~~82~~	0	0	N		~~2002~~	~~2010~~	~~2017~~
		7,385	0.22	6,150			61				2002	2010	2017	2020
Common Bottlenose dolphin	Hawaii Pelagic	~~21,815~~	~~0.57~~	~~13,957~~	0.04	0.5	~~140~~	0	0	N		~~2002~~	~~2010~~	~~2017~~
		unk	unk	unk			undet				2002	2010	2017	2020
Common Bottlenose dolphin	Kaua'i and Ni'ihau	unk	unk	97	0.04	0.5	1.0	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
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	Hawaiian Island	unk	unk	91	0.04	0.5	0.9	unk	unk	N	2002	2003	2006	2017
Pantropical Spotted dolphin	Hawaii Pelagic	~~55,795~~	~~0.40~~	~~40,338~~	0.04	0.5	~~403.0~~	0	0	N		~~2002~~	~~2010~~	~~2017~~
		39,798	0.51	26,548			265				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	Hawaii Island	unk	unk	unk	0.04	0.5	undet	≥ 0.2	≥ 0.2	N			n/a	2017
Spinner dolphin	Hawaii 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

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Species	Stock	N est	CV N est	N min	R max	Fr	PBR	Total Annual Mortality + Serious Injury	Annual Fishery Mortality + Serious Injury	Strategic Status	Recent Abundance Surveys			SAR Last Revised
Striped dolphin	Hawaii Pelagic	~~61,021~~	~~0.38~~	~~44,922~~	0.04	0.5	~~449~~	0	0	N		~~2002~~	~~2010~~	~~2017~~
		35,179	0.23	29,058			291				2002	2010	2017	2020
Fraser's dolphin	Hawaii	~~51,491~~	~~0.66~~	~~31,034~~	0.04	0.5	~~310~~	0	0	N		~~2002~~	~~2010~~	~~2017~~
		40,960	0.70	24,068			241				2002	2010	2017	2020
Melon-headed whale	Hawaiian Islands	~~8,666~~	~~1.00~~	~~4,299~~	0.04	0.5	~~43~~	0	0	N		~~2002~~	~~2010~~	~~2017~~
		40,647	0.74	23,301			233				2002	2010	2017	2020
Melon-headed whale	Kohala Resident	~~447~~	~~0.12~~	~~404~~	0.04	0.5	~~4.0~~	0	0	N			~~2009~~	~~2013~~
		unk	unk	unk			undet				2002	2010	2017	2020
Pygmy killer whale	Hawaii	~~10,640~~	~~0.53~~	~~6,998~~	0.04	~~0.4~~	~~56.0~~	~~1.1~~	~~1.1~~	N		~~2002~~	~~2010~~	~~2017~~
		10,328	0.75	5,885		0.5	59	0	0		2002	2010	2017	2020
False killer whale	NW Hawaiian Islands	~~617~~	~~1.11~~	~~290~~	0.04	0.4	~~2.3~~	~~0.4~~	~~0.4~~	N			~~2010~~	~~2017~~
		477	1.71	178			1.8	0.01	0.01		2002	2010	2017	2020
False killer whale	Hawaii Pelagic	~~1,540~~	~~0.66~~	~~928~~	0.04	0.5	~~9.3~~	~~7.6~~	~~7.6~~	N		~~2002~~	~~2010~~	~~2017~~
		2,086	0.35	1,567			16	6.5	6.5		2002	2010	2017	2020
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	Main Hawaiian Islands Insular	167	0.14	149	0.04	0.1	0.30	0.0	~~0.0~~	S	2013	2014	2015	~~2017~~
									0.03					2020
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	Hawaii	~~146~~	~~0.96~~	~~74~~	0.04	0.5	~~0.7~~	0	0	N		~~2002~~	~~2010~~	~~2017~~
		161	1.06	78			0.8				2002	2010	2017	2020
Pilot whale, short-finned	Hawaii	~~19,503~~	~~0.49~~	~~13,197~~	0.04	0.4	~~106~~	0.9	0.9	N		~~2002~~	~~2010~~	~~2017~~
		12,607	0.18	10,847			87				2002	2010	2017	2020
Blainville's beaked whale	Hawaii Pelagic	~~2,105~~	~~1.13~~	~~980~~	0.04	0.5	~~10.0~~	0	0	N		~~2002~~	~~2010~~	~~2017~~
		1,132	0.99	564			5.6				2002	2010	2017	2020
Longman's Beaked Whale	Hawaii	~~7,619~~	~~0.66~~	~~4,592~~	0.04	0.5	~~46.0~~	0	0	N		~~2002~~	~~2010~~	~~2017~~
		2,550	0.67	1,527			15				2002	2010	2017	2020
Cuvier's beaked whale	Hawaii Pelagic	~~723~~	~~0.69~~	~~428~~	0.04	0.5	~~4.3~~	0	0	N		~~2002~~	~~2010~~	~~2017~~
		4,431	0.41	3,180			32				2002	2010	2017	2020
Pygmy sperm whale	Hawaii	~~unk~~	~~unk~~	~~unk~~	0.04	0.5	~~undet~~	0	0	N		~~2002~~	~~2010~~	~~2013~~
		42,083	0.64	25,695			257				2002	2010	2017	2020
Dwarf sperm whale	Hawaii	unk	unk	unk	0.04	0.5	undet	0	0	N		~~2002~~	~~2010~~	~~2013~~
											2002	2010	2017	2020
Sperm whale	Hawaii	~~4,559~~	~~0.33~~	~~3,478~~	0.04	~~0.1~~	~~14~~	~~0.7~~	~~0.7~~	S		~~2002~~	~~2010~~	~~2017~~
		5,707	0.23	4,486		0.2	18	0	0		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

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Species	Stock	N est	CV N est	N min	R max	Fr	PBR	Total Annual Mortality + Serious Injury	Annual Fishery Mortality + Serious Injury	Strategic Status	Recent Abundance Surveys			SAR Last Revised
Fin whale	Hawaii	~~154~~	~~1.05~~	~~75~~	0.04	0.1	~~0.1~~	0	0	S		~~2002~~	~~2010~~	~~2017~~
		203	0.99	101			0.2				2002	2010	2017	2020
Bryde's whale	Hawaii	~~1,751~~	~~0.29~~	~~1,378~~	0.04	0.5	~~13.8~~	0	0	N		~~2002~~	~~2010~~	~~2017~~
		602	0.22	501			5.0				2002	2010	2017	2020
Sei whale	Hawaii	391	0.90	204	0.04	0.1	0.4	0.2	0.2	S		2002	2010	2017
Minke whale	Hawaii	~~unk~~	~~unk~~	~~unk~~	0.04	0.5	~~undet~~	0	0	N		~~2002~~	~~2010~~	~~2013~~
		438	1.05	212			2.1				2002	2010	2017	2020
Humpback whale	American Samoa	unk	unk	150	0.106	0.1	0.4	0	0	S	2006	2007	2008	2009
Sea Otter	Southern (California)	3,272	n/a	3,272	0.06	0.1	10	≥5.2	≥0.4	S	2014	2015	2016	2017
Sea Otter	Northern (Washington)	n/a	n/a	1,806	0.2	0.1	18	≥1.0	≥0.4	N	2014	2015	2016	2018