FALSE KILLER WHALE (*Pseudorca crassidens*): Hawaiian Islands Stock Complex – Main Hawaiian Islands Insular, Northwestern Hawaiian Islands, and Hawai'i 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, Hawai'i, and the eastern tropical Pacific. False killer whales have been encountered during periodic shipboard line-transect surveys of the U.S. Exclusive Economic Zone (EEZ) around the Hawaiian Islands (Figure 1), and focused studies near the main and Northwestern Hawaiian Islands (NWHI) indicate that false killer whales occur in nearshore waters throughout the Hawaiian archipelago (Baird *et al.* 2008, 2013). This species also occurs in the U.S. EEZ around Palmyra and Johnston Atolls (Barlow *et al.* 2008) and American Samoa (Johnston *et al.* 2008, Oleson 2009). Genetic, photo-identification, and telemetry studies indicate there are several demographically independent populations of false killer whales throughout the Pacific and three in Hawaiian waters. Genetic analyses indicate restricted gene flow between island-associated populations of false killer whales sampled near the main Hawaiian Islands (MHI) and the NWHI, versus those in pelagic waters of the Eastern (ENP) and Central North Pacific (CNP) (Chivers *et al.* 2010; Martien 2014). The mtDNA analysis reveals strong phylogeographic patterns consistent with local evolution of haplotypes unique to false killer whales occurring nearshore within the Hawaiian Archipelago, while the nuDNA analysis suggests NWHI false killer whales are at least as differentiated from MHI animals as they are from offshore animals. Photo-ID 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 offshore waters, and satellite telemetry collected from 27 tagged MHI false killer whales shows movements restricted to the MHI (Baird *et al.* 2010, 2012). Further analysis of photographic and genetic data from individuals seen near the MHI suggests the occurrence of 4 separate social clusters (Mahaffy *et al.* 2023). 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). Additional evidence for the separation of false killer whales in Hawaiian waters into three separate stocks is summarized by Oleson *et al.* (2010, 2012).

Outside of the Hawaiian insular waters, population structure is also evident. Significant

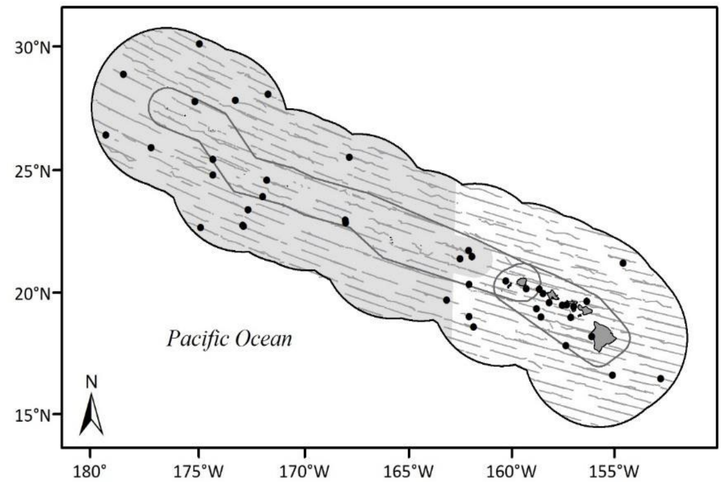

Figure 1. False killer whale sighting locations (circles) and survey effort (gray lines) during the 2002 (Barlow 2006), 2010 (Bradford *et al.* 2017), and 2017 (Yano *et al.* 2018) shipboard surveys of the U.S. EEZ around the Hawaiian Islands (outer black line). The MHI insular and NWHI false killer whale stock areas are marked by dark gray lines. Detail of stock boundaries shown in Figure 2. The Papahānaumokuākea Marine National Monument in the western portion of the EEZ is shaded gray.

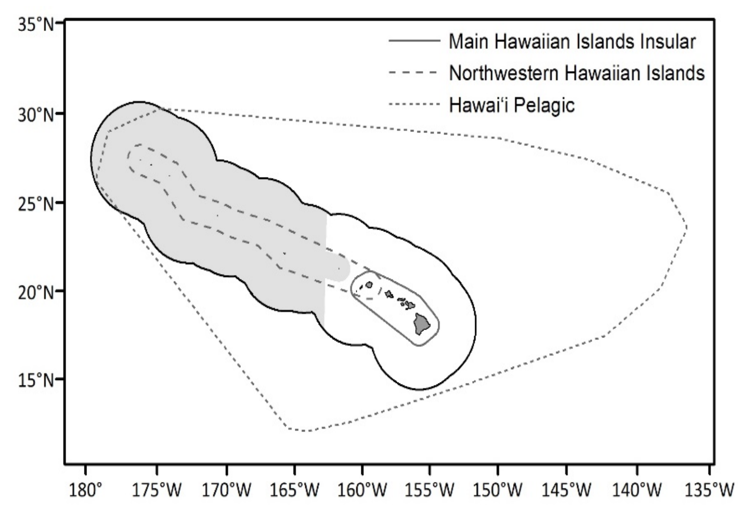

Figure 2. Boundaries for each of the false killer whale stock in Hawai'i: main Hawaiian Islands insular (solid gray), Northwestern Hawaiian Islands (dashed), and Hawai'i pelagic (dotted). Black line represents the U.S. EEZ. The Papahānaumokuākea Marine National Monument in the western portion of the EEZ is shaded gray.

differences in both mtDNA and nuDNA are evident between pelagic false killer whales in the ENP and CNP (Chivers *et al.* 2010, Martien *et al*. 2014) and telemetry data from 10 pelagic false killer whales tagged within the Hawaiian Islands EEZ indicates pelagic animals there also use waters to the east of the EEZ (Oleson *et al.* 2023). Large gaps in the genetic sample distribution throughout the tropical Pacific preclude finer delineation of population structure and boundaries for pelagic populations.

The stock range and boundaries for Hawaiʻi insular stocks of false killer whales are reviewed in Bradford *et al.* (2015), and the area used for assessing the Hawaiʻi pelagic false killer whale stock (assessment area) is reviewed in Oleson *et al.* (2023) (Figure 2, there referred to as management area). The three stocks have partially overlapping ranges within the Hawaiian Islands EEZ. MHI insular false killer whales have been satellite tracked as far as 115 km from the MHI. NWHI false killer whales have been seen up to 93 km from the NWHI and near shore around Kauaʻi and Oʻahu (Baird *et al.* 2012, Bradford *et al.* 2015). Hawaiʻi pelagic stock animals have been satellite tracked to within 5.6 km of the MHI, throughout the NWHI, and east outside of the EEZ to 138^0 W. 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 Kauaʻi and Niʻihau. The NWHI boundary is latitudinally expanded at the eastern end of the NWHI to encompass animal movements observed outside of the 93 km radius (Figure 2). The Hawaiʻi pelagic stock has no inner boundary within the EEZ. The assessment area for the Hawaiʻi pelagic stock is defined by an MCP around all genetic, telemetry, sighting, and bycatch location data known or assumed to be of Hawaiʻi pelagic stock animals with a 35 km buffer around the points (Oleson *et al.* 2023). This assessment area extends throughout most of the Hawaiian Islands EEZ, east to 132^0 W and south to 12^0 N with a complex shape (Figure 2). The construction of these stock boundaries results in multiple stock overlap zones. The entirety of the MHI insular stock area is an overlap zone between the MHI insular and Hawaiʻi pelagic stocks. The entirety of the NWHI stock range is an overlap zone between NWHI and Hawaiʻi pelagic false killer whales. All three stocks overlap out to the MHI insular stock boundary between Kauaʻi and Nihoa and to the NWHI stock boundary between Kauaʻi and Oʻahu (see Figure 2).

For the Marine Mammal Protection Act (MMPA) stock assessment reports, there are 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 MHI, 2) the Northwestern Hawaiian Islands stock, which includes animals inhabiting waters within a 93 km radius around the NWHI and Kauaʻi, with a latitudinal expansion of this area at the eastern end of the range, 3) the Hawaiʻi pelagic stock, which includes false killer whales inhabiting waters of the U.S. EEZ around Hawaiʻi and adjacent high seas waters, as defined by the Hawaiʻi pelagic false killer whale assessment area (Oleson *et al*. 2023), 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. Palmyra Atoll and American Samoa stocks appear in separate reports. False killer whales are also known to occur in other areas of U.S. jurisdiction in the Pacific Islands, though stock assessments have not yet been developed for those regions.

HUMAN-CAUSED MORTALITY AND SERIOUS INJURY

Fishery Information

Interactions with false killer whales, including depredation of pelagic fish catch, are identified in logbooks and NMFS observer records from Hawaiʻi 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)*, 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), and they are reported to take large fish from troll lines of commercial and recreational fishermen (Shallenberger 1981). There are anecdotal reports of marine mammal interactions in the commercial Hawaiʻi shortline fishery that sets gear at Cross Seamount and possibly around the MHI. The commercial shortline fishery is licensed to sell catch through the State of Hawaiʼi 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 MHI insular stock false killer whales. Evaluation of additional individuals with dorsal fin injuries and disfigurements suggests that the 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 (Baird *et al.* 2014). The commercial or recreational fishery or fisheries responsible for these injuries is unknown, though through examination of satellite telemetry dataset and commercial logbook effort data, it is clear that there are regions where such interactions are far more likely, including the Kohala coast of Hawaiʻi Island

and the waters extending from the southeast end of O‘ahu around to the north side of Maui and to the southwest side of Lāna‘i (Baird *et al.* 2021). A stranded MHI insular false killer whale in October 2013 had five fishing hooks and fishing line in its stomach, and another stranded animal in September 2016 had one fishing hook in its stomach (Bradford and Lyman 2018). Although the fishing gear is not believed to have caused the death of either whale, examinations confirm that MHI insular false killer whales consume previously hooked fish or are interacting with MHI hook and line fisheries. 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 originate from a variety of nearshore fisheries. No estimates of human-caused mortality or serious injury are currently available for nearshore hook and line or other fisheries because these fisheries are not monitored for protected species bycatch.

Because of high rates of false killer whale mortality and serious injury in Hawai‘i-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 Hawai’i pelagic, MHI insular, and Palmyra stocks of false killer whales in Hawai‘i-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. 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 (McCracken 2015).

There are two distinct longline fisheries based in Hawai‘i: 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 MHI 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. In August, 2016 the PMNM area was expanded to extend to the 200-nmi EEZ boundary west of 163° W.

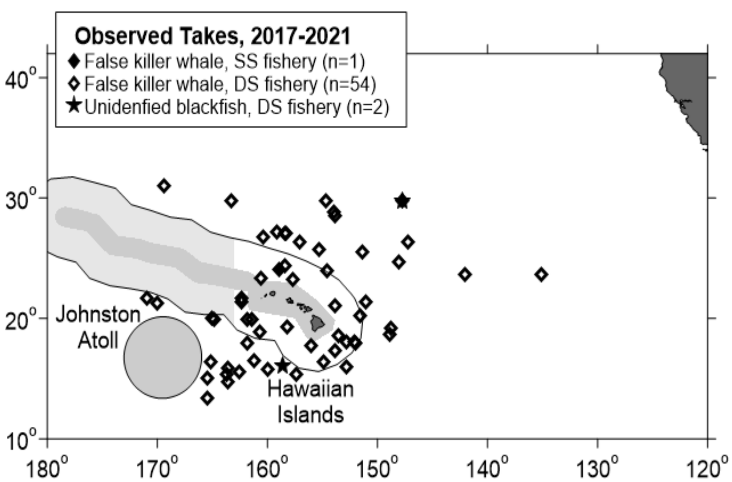

Figure 3. Locations of observed false killer whale takes within the shallow-set fishery (filled diamond), deep-set fishery (open diamonds), and possible takes (blackfish) of this species (closed stars) in the Hawaii-based longline fisheries, 2017-2021. Some take locations overlap. Stock boundaries for false killer whales are not shown. Solid lines represent the U.S. EEZ. Gray shading notes areas closed to longline fishing**.**

Between 2017 and 2021, one false killer whale was observed hooked or entangled in the SSLL fishery (100% observer coverage), and 54 false killer whales were observed taken in the DSLL fishery (15-21% observer coverage) (Bradford 2018, 2020, 2021, 2023, in review) (Figure 3). The severity of injuries resulting from interactions with longline gear is based on an evaluation of the observer’s description of each interaction and follows the most recently developed criteria for assessing serious injury in marine mammals (NMFS 2023b). In the DSLL fishery, 1 false killer whale was taken within the overlap area of the pelagic and NWHI stocks. Stock identity is not known for any bycaught whales, though those outside of the stock overlap areas are assumed to be Hawai‘i pelagic stock animals. Of the 54 bycaught whales, 7 were found dead, 37 were considered seriously injured, 8 non-seriously injured, and 2 had injuries with a severity that could not be determined based on the information provided by the observer. Two additional unidentified “blackfish” (unidentified cetaceans known to be either false killer whales or short-finned pilot whales) were also taken in the DSLL fishery outside of the Hawaiian Islands EEZ, with one considered seriously injured and one not seriously injured.

The SEZ, a large triggered closure area south of the MHI implemented under the TRP, was closed following the trigger of 2 serious injuries within the Hawaiian Islands EEZ in November 2018. This closure remained in effect through the remainder of calendar year 2018. Following re-opening of the SEZ on January 1, 2019, the SEZ was again closed in February 2019 following a serious injury and a mortality within the Hawaiian Islands EEZ. Following the closure there were 3 additional serious injuries within the Hawaiian Islands EEZ in 2019. The SEZ remained closed until August 2020. Following an increase in the trigger to 4 whales in 2021, an SEZ closure was triggered after a fourth and fifth serious injuries within the EEZ were reported in December 2021, though the SEZ was not closed given the closure would not have been effective until after the automatic reopening date at the start of the new calendar year.

Table 1. Summary of available information on incidental mortality and serious injury (MSI) of false killer whales (FKW) and unidentified blackfish (UB, false killer whale or short-finned pilot whale) in commercial longline fisheries, by stock and EEZ area, as applicable (McCracken and Cooper 2022b, 2023). Mean annual takes are presented for 2017-2021. Information on observed takes (T) and MSI is included. UB are prorated as either FKW or short-finned pilot whales based on distance from shore (McCracken 2010). CVs are estimated based on the combined variances of annual FKW and UB 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.

				Observed takes		**Estimated MSI (CV)**			
				FKW T/MSI UB T/MSI		**Hawai'i Pelagic Stock**			
Fishery Name	**Year**	**Data Type**	**Percent Observer Coverage**	**Outside U.S EEZ**	**Within Hawaiian Islands EEZ**	**Assessment Area Outside U.S EEZ**	**Assessment Area Within Hawaiian Islands EEZ**	**MHI insular Stock**	**NWHI Stock**
Hawaii-based deep-set longline fishery	2017	Observer data	20%	6/5† 0	2/1 0	29.7 (0.4)	8.4 (0.7)	0.1 (0.8)	0 (2.1)
	2018		18%	8/5 1/1	4/4 0	30.6 (0.4)	12.3 (0.5)	0.1 (0.6)	0 (2.0)
	2019		21%	9/7 1/0	6/5 0	38.7 (0.3)	26.0 (0.4)	0.0 (0.5)	0.6 (2.0)
	2020		15%	3/2† 0	1/1 0	14.2 (0.5)	5.1 (0.9)	0.0 (0.9)	0 (2.2)
	2021		18%	10/9† 0	5/5 0	37.0 (0.4)	32.1 (0.4)	0.2 (0.5)	0.1 (2.0)
Mean Estimated Annual Take (CV) 2017-2021						**30.0 (0.2)**	**16.8 (0.2)**	**0.1 (0.3)**	**0.2 (1.6)**
Hawaii-based shallow-set longline fishery	2017	Observer data	100%	0 0	0 0	0	0	0	0
	2018		100%	0 0	0 0	0	0	0	0
	2019		100%	0 0	0 0	0	0	0	0
	2020		100%	0 0	1/1 0	0	1	0	0
	2021		100%	0 0	0 0	0	0	0	0
Mean Annual Takes (100% coverage) 2017-2021						**0**	**0.2**	**0**	**0**
Minimum Total annual takes by stock (2017-2021)						**47.0 (0.2)**		**0.1 (0.3)**	**0.2 (1.6)**

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

The total estimated number of dead or seriously injured whales is calculated based on observer coverage rate, the location of the observed take (*i.e.* within or outside of the Hawai'i pelagic stock management area), and the ratio of observed dead and seriously injured whales versus those judged to be not seriously injured. Observer coverage is measured on a per-trip basis throughout the calendar year as described by McCracken (2019). In years with large fluctuations in observer coverage, such as during the early days of the COVID-19 pandemic when observer coverage dropped to less than 10% during the second quarter of the year, the annual bycatch estimation process was subset into several periods, as described in McCracken and Cooper (2022a). Prior to the implementation of the FKW TRP, for the period 2008 to 2012, the rate of dead and seriously injured false killer whales was 93% (McCracken 2014). 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 proportion of dead and seriously injured whales versus non-serious injuries is calculated annually based on the injury status of observed takes since the implementation of the TRP in 2013 (McCracken 2019).

Complete assessment of human-caused mortality within the full Hawai‘i pelagic false killer whale assessment area requires information on bycatch in foreign fleets. Foreign longline fleets operate within the tropical Pacific, including immediately outside of the Hawaiian Islands EEZ. Although the magnitude of foreign longline effort near the Hawaiian Islands EEZ is thought to be relatively low compared to that of the Hawai‘i-based fleet, there is considerable effort to the southwest of the EEZ and north of 30^0 N on the east side of the islands (based on Global Fishing Watch data). The Western and Central Pacific Fisheries Commission (WCPFC) has collated 76 interactions with false killer whales in the western and central Pacific across the member fleets, including reports from the Hawai‘i-based vessels from 2015 to 2020 (Williams *et al*. 2021). However, the WCPFC has not developed estimates of total bycatch for any segment of the fleet "given the low levels and imbalanced nature of observer coverage" (Peatman and Nicols 2020). Commercial fishing within the eastern portion of the Hawai‘i pelagic false killer whale assessment area is managed by the Inter-American Tropical Tuna Commission, though similar concerns about observer coverage have so far precluded any bycatch estimates for false killer whales in this region. The mortality rate of bycaught animals in foreign longline fleets may also be higher than in the U.S. fleet given the bycatch mitigation measures in place for the Hawai‘i-based fleet, leading to additional uncertainty in the magnitude of the impact on the stock (Oleson *et al.* 2023).

Biological samples or individual animal photographs are required to assign a take to a specific stock. Very few observed takes are identified to stock, as collection of such information is very rare. The pelagic stock is known to interact with longline fisheries based on a small number of genetic samples obtained by fishery observers (Chivers *et al.* 2010) both inside and outside of the Hawaiian Islands EEZ. No samples or photographs have been collected that can conclusively assign takes to stock within the MHI insular-pelagic overlap zone or the NWHI-pelagic stock overlap zone. However, 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 MHI insular stock animals have high rates of dorsal fin disfigurements consistent with injuries from unidentified fishing line (Baird and Gorgone 2005, Baird *et al.* 2014). When takes cannot be assigned to stock, 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. Following proration of unidentified blackfish takes to species, Hawaiian Islands 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 2020). Takes within the shallow-set longline fishery are assigned to the stock area in which they were observed. Estimated takes in the deep-set fishery within the Hawaiian Islands EEZ are apportioned to each stock area by first allocating take to each area based on relative annual fishing effort (by set) in that area. If an observed take occurred within the MHI-pelagic or NWHI-pelagic overlap zones, the take was assigned to that zone and the remaining estimated bycatch was assigned to stock areas as previously described. For both the shallow-set and deep-set fisheries, stock area bycatch estimates are then multiplied by the relative density of each stock within the stock area to estimate stock-specific bycatch for each year. 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. Proration of unidentified blackfish takes and of false killer whale takes within the stock overlap zones introduces unquantified uncertainty into the bycatch estimates, but until methods of determining stock identity for animals observed taken within the overlap zone are available, and all animals taken can be identified to species and stock (*e.g.,* with photos or tissue samples), these proration approaches are needed to ensure that potential impacts to all stocks are assessed in the overlap zones. 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.

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. Due to spatiotemporal biases imposed by sampling constraints, annual estimates reflected the abundance of MHI insular false killer whales within the surveyed area in that year, and therefore could 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 (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.* 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, based on sightings data collected near Hawaii using various methods. 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 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 (Oleson *et al.* 2010). Annual abundance estimates 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 animals present in the study area within 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 the MHI insular stock of 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). 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). Prior to the TRP, a seasonal contraction to the LLEZ potentially exposed a significant portion of the offshore range of the stock to longline fishing. 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. For the most recent 5-yr period, the estimate of mortality and serious injury (0.10) 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 ≥ 10% of PBR. The stock appears to be declining (Oleson *et al.*2010), though the cause of that decline has not been thoroughly assessed.

OTHER FACTORS THAT MAY BE CAUSING A DECLINE OR IMPEDING RECOVERY

The Status Review report produced by the Biological Review Team (BRT) (Oleson *et al.* 2010, amended in Oleson *et al.* 2012) found of the 29 identified threats to the population, 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 and Ito, 1993, Reeves *et al.* 2009); and hooking, entanglement, or intentional harm by fishermen to be the most substantial threats to the population. There is significant geographic overlap between various nearshore fisheries and evidence of interactions with hook-and-line gear (Baird *et al.* 2015, 2021), such that these fisheries may pose a threat to the stock. Six MHI insular false killer whales stranded between 2010 and 2021, including 4 from cluster 3 (Baird *et al.* 2023), a high rate for a single social cluster. High concentrations of polychlorinated biphenyls (PCBs) exceeding those proposed to cause adverse health effects (Kannan *et al.* 2020) were measured from 29 of 41 sampled individuals in the MHI insular stock (Kratofil *et al.* 2020). PCB concentrations from four stranded individuals within this population all revealed levels more than twice the highest suggested health threshold for PCBs, and had the highest levels of any sampled whales in the study. Differences in contaminant loads for various contaminant classes are also evident among social clusters, suggesting differences in exposure or consumption of contaminated prey based on preferred foraging regions (Kratofil *et al.* 2020).

HAWAII PELAGIC STOCK

POPULATION SIZE

Encounter data from shipboard line-transect surveys conducted throughout the central Pacific were used to estimate the density and abundance of all pelagic false killer whales in the central Pacific (Bradford *et al*. 2020). Density data from the central Pacific modeled area were used to extract the abundance of the Hawaiʻi pelagic false killer whale stock based on the assessment area (Oleson *et al.* 2023, there referred to as management area). The best estimate of abundance for the Hawaiʻi pelagic stock of false killer whales is 5,528 (CV = 0.35). Previous stock assessment reports for this stock provided abundance within the Hawaiian Islands EEZ. For comparison to prior reports, the same process was used to estimate abundance for the portion of the assessment area that is within the EEZ, resulting in an estimate of 2,038 (CV = 0.35).

Bradford *et al*. (2020) produced design- and model-based abundance estimates for false killer whales within each survey year for the full Hawaiian Islands EEZ, which can be compared to the abundance estimate within the EEZ portion of the assessment area above. While on average, the estimates are broadly similar between the two approaches, annual design-based estimates show much greater variability between years than 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 approach. Previous abundance estimates from the Hawaiian Islands EEZ and central Pacific (e.g., Barlow 2006, Barlow and Rankin 2007, Becker *et al.* 2012, Bradford *et al.* 2014, Forney *et al.* 2015) used subsets of the dataset and different line-transect parameters than those used by Bradford *et al.* (2020), such that these estimates have been superseded by the estimates presented here.

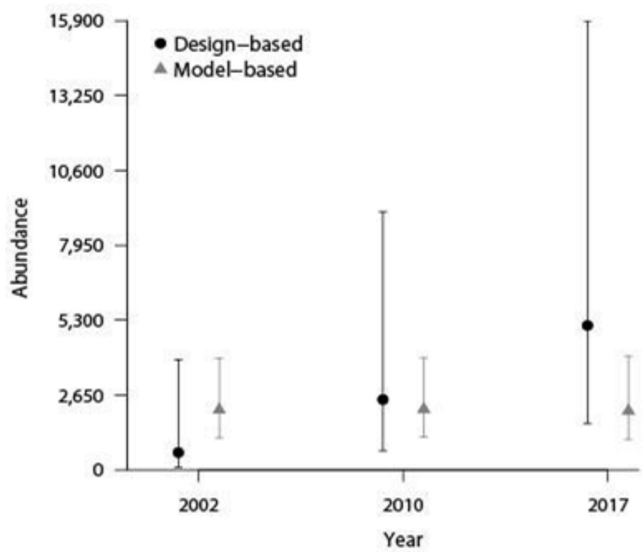

Figure 4. Comparison of design-based (circles) and model-based (triangles) estimates of abundance for false killer whales for each survey year (2002, 2010, 2017) (Bradford *et al*. 2020).

The reanalysis may still be subject to potential bias due to vessel attraction as described by Bradford *et al.* (2014), who reported that most (64%) false killer whale groups seen during the 2010 survey were 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 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 used a half-normal model to minimize the effect of vessel attraction. The abundance estimate may still be positively biased 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. The acoustic and visual data suggests vessel attraction (Bradford *et al.* 2014), though the extent of any bias created by this movement is unknown.

Minimum Population Estimate

The minimum population estimate for the Hawaiʻi pelagic stock of false killer whales is calculated as the lower 20th percentile of the log-normal distribution (Barlow *et al.* 1995) of the 2017 model-based abundance estimate. Using the full assessment area, the minimum population estimate is 4,152. As noted in Oleson *et al.* (2023), gaps in survey coverage and in the distribution of genetic samples preclude placement of a precise stock boundary, such that the Nmin for the assessment area may not represent the entire stock range. However, given the available data, the assessment area represents what is currently known about the stock range, and as such, the Nmin derived from it is the best available minimum population estimate for Hawai‘i pelagic false killer whales. For comparison to previous EEZ-based assessments of this stock, it is useful to calculate the minimum population estimate based only on the EEZ portion of the assessment area, or 1,531 Hawai‘i pelagic 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 in population size within the Hawaiian Islands EEZ; however, these changes can be largely explained by random variability in encounter rate common for species like false killer whales with low density and patchy distribution. Examination of population trend for the Hawai‘i pelagic stock of false killer whales requires additional data inside and outside of the Hawaiian Islands EEZ.

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 is calculated as the minimum population estimate (4,152) times one half the default maximum net growth rate for cetaceans (½ of 4%) times a recovery factor of 0.44, resulting in a PBR of 36 false killer whales per year. An intermediate value of the recovery factor was chosen to reflect different levels of uncertainty around mortality and serious injury estimates across the assessment area. Outside of the EEZ, there is significant uncertainty in the magnitude of mortality and serious injury in foreign longline fleets operating within the assessment area, as there are presently no mortality and serious injury estimates for any foreign fleet. Therefore, a recovery factor of 0.4 is appropriate in this portion of the assessment area given the unknown status of the stock and the unknown total mortality and serious injury rate (NMFS 2023a). However, within the EEZ portion of the assessment area, the mortality and serious injury CV is less than 0.3 so a recovery factor of 0.5 is appropriate (NMFS 2023a). Taken together, a final prorated recovery factor was calculated based on the proportion of total stock abundance inside and outside the EEZ, resulting in a final recovery factor of 0.44 for the stock. For comparison to PBR values reported in previous assessments for this stock, an EEZ-only-PBR was also calculated using the minimum population estimate for the portion of the assessment area within the EEZ (1,531), and a recovery factor of 0.5, resulting in an EEZ-only-PBR of 15 Hawai‘i pelagic false killer whales per year.

STATUS OF STOCK

The status of the Hawai‘i pelagic stock of false killer whales relative to OSP is unknown, and there are insufficient data to evaluate trends in abundance. 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 2023a), the status of this transboundary stock of false killer whales is provided based on the assessment area, defined using all available biological data for this population. Total 5-year mean mortality and serious injury of the stock for 2017-2021 (47) is more than PBR (36); therefore, this stock is considered a “strategic stock” under the MMPA. Total fishery mortality and serious injury for the Hawaii pelagic stock of false killer whales cannot be considered insignificant and approaching zero (*i.e*., less than 10% of PBR, or 3.6 animals per year). The estimated mortality and serious injury of Hawai‘i pelagic false killer whales in 2019 and 2021 were the highest recorded since before the TRP was implemented, with annual mortality and serious injury rates exceeding 60 animals per year. Take rates of false killer whales by the deep-set longline fishery outside of the EEZ continue to remain significantly higher since the TRP was implemented. Given survey and sampling limitations described in Oleson *et al*. (2023), the assessment area may not account for all animals in this stock, but does represent the best information available at this time. Although the assessment area may not represent the entire stock range, the abundance, PBR, and mortality and serious injury estimated for this area are subject to similar bias.

OTHER FACTORS THAT MAY BE CAUSING A DECLINE OR IMPEDING RECOVERY

The mean concentration of polychlorinated biphenyls (PCBs) in all Hawai‘i false killer whale populations, including individuals from the pelagic stock (Kratofil *et al.* 2020), has been shown to exceed the level proposed to cause adverse health effects in other cetaceans (Kannan *et al.* 2020).

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 NWHI false killer whales (Bradford *et al*. 2020; Table 3).

Table 2. Design-based line-transect abundance estimates for Northwestern Hawaiian Islands false killer whales derived from surveys of the entire Hawaiian Islands EEZ in 2002, 2010, and 2017 (Bradford *et al*. 2020).

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

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 using 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*. 2014), Bradford *et al*. (2020) used 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. The reanalysis may still be subject to potential bias due to vessel attraction as described by Bradford *et al.* (2014), who reported that most (64%) false killer whale groups seen during the 2010 HICEAS survey were 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) 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 abundance estimate for the NWHI stock (Bradford *et al.* 2020), or 178 false killer whales.

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.

CURRENT AND MAXIMUM NET PRODUCTIVITY RATES

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

POTENTIAL BIOLOGICAL REMOVAL

The potential biological removal (PBR) level for the NWHI false killer whale stock is calculated as the minimum population estimate (178) <u>times</u> one half the default maximum net growth rate for cetaceans (½ of 4%) <u>times</u> 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 1.43 false killer whales per year.

STATUS OF STOCK

The status of false killer whales in NWHI waters relative to OSP is unknown, and insufficient data exist to evaluate abundance trends. The mean concentration of polychlorinated biphenyls (PCBs) in all Hawai‘i false killer whale populations (Kratofil *et al.* 2020), including individuals from the NWHI stock, has been shown to exceed the level proposed to cause adverse health effects in other cetaceans (Kannan *et al.* 2020). Biomass of some false killer whale prey species may have declined around the NWHI (Oleson *et al.* 2010, Boggs and Ito 1993, Reeves *et al.* 2009), though waters within the original PMNM 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 (0.16) is less than the PBR (1.43 animals per year), though cannot be considered to be insignificant and approaching zero (<10% of PBR). 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.

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