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Introduction

Most species of cetaceans in the central Pacific Ocean are thought to have extensive pelagic distributions, both within and beyond the boundaries of the U.S. Exclusive Economic Zone (EEZ). Stocks assessed and managed under the U.S. Marine Mammal Protection Act (MMPA) are generally designated following identification and delineation of demographically independent populations (DIPs) within species (NMFS 2021). Although, within vast pelagic areas, the number and range of DIPs is often unknown and very difficult to assess without extensive telemetry, genetic, distribution, or habitat datasets (Martien et al. 2019a). Most large-scale assessment surveys for cetaceans are conducted within the U.S. EEZ, leading to an incomplete assessment of abundance and status across the full ocean-basin range of these species. In Hawaiʻi, NOAA Fisheries recognizes most cetacean stocks with pelagic distribution as transboundary with ranges including, and extending beyond the EEZ, around the Hawaiian Islands (Hawaiian Islands EEZ); however, the formal assessment of these stocks is based on the Hawaiian islands EEZ, since it is within this space that we can often best estimate both abundance and removals from fisheries or other human-caused impacts. Defaulting to an EEZ area is not necessarily aligned with current assessment guidance (NMFS 2023) and other options for designating management units should be considered, particularly when high rates of human-caused mortality and serious injury (MSI) may be adversely impacting animals outside of the U.S. EEZ.

In 2010, NMFS convened the False Killer Whale Take Reduction Team (FKW TRT) as a response to unsustainable levels of bycatch of the Hawaiʻi pelagic stock of false killer whales by the Hawaiʻi-based deep-set longline fishery. Since that time, with an assessment based on the Hawaian Islands EEZ only, there has been a notable spatial mismatch in the assessment approach for this stock. The Hawaiʻi-based deep-set fishery area has been expanding to the northeast on the high seas (outside of the Hawaiian Islands EEZ) over the last two decades (Woodworth-Jefcoats et al. 2018). Following the implementation of the Take Reduction Plan in 2012, this fishing area shift has also been accompanied by an increase in MSI on the high seas (Carretta et al 2023, Appendix). With an assessment approach currently based on the Hawaiian Islands EEZ, the impact of the deep-set fishery on the portion of the stock outside of U.S. waters cannot be assessed or managed effectively. Therefore, we have defined a new management area that accounts for what is known about the distribution of Hawaiʻi pelagic false killer whales outside the Hawaiian Islands EEZ. This report serves to provide the rationale for the proposed management area along with additional information about the datasets available to support this boundary choice and other management areas that were considered.

False killer whale ecology and distribution in the central Pacific

False killer whales are highly social odontocetes (Stacey and Baird 1991). In regions where sufficient time series of observations and sampling (photo-ID and genetic) of false killer whales have been possible, studies have found that populations include significant social structure (Baird et al. 2008, 2016) governed by familial relationships (Martien et al. 2014, 2019b) and exhibiting high site fidelity (Acevedo-Gutierrez et al. 1997, Baird et al. 2008, Palmer et al. 2023, Zaeschmar et al. 2013). These studies also indicate that false killer whales broadly demonstrate a high degree of learning and cultural transmission (Oleson et al. 2010), evidenced by frequent food sharing (Baird et al. 2008) and high rates of fisheries interactions within specific social clusters (Baird et al. 2014). While existing times series generally describe coastal false killer whale populations with strong island or continental associations, the consistency of these features across regions suggests that similar social dynamics are likely also prevalent in data-poor pelagic populations. The data-intensive nature of identifying and defining population structure means that such structure is difficult to assess at scales larger than archipelagos or coastlines, let alone within ocean basins.

Habitat-based predictive species distribution models (SDMs) have been developed to examine patterns in the distribution and abundance of several cetacean species based on decades of line-transect surveys in waters around the Hawaiian Islands, U.S. West Coast, eastern tropical Pacific (ETP), and in high sea waters between these areas (e.g., Forney et al. 2012, 2015, Becker et al. 2017). In oligotrophic waters, such as the central Pacific, cetacean habitat associations may vary from those in more productive regions like the ETP, such that the models are often built separately for each region. Further, building models for species with both insular and pelagic stocks requires careful consideration of the potential influence of the unique habitat relationships that define insular stocks. Data from the insular stocks should generally be omitted to avoid influencing assessments of pelagic distribution and density.

An SDM for pelagic false killer whales in the central Pacific was developed to provide spatially-explicit abundance data from the equator to 43°N and from 175°E to 132°W (Figure 1, Bradford et al. 2020). Sightings of false killer whales from the main Hawaiian Islands (MHI) insular and northwestern Hawaiian Islands stocks were excluded to avoid the influence of their association with steep slopes and shallower water depths (Bradford et al. 2015), characteristics that are likely less influential to the distribution of pelagic whales (Anderson et al. 2020). This model suggests an association with temperature and mixed layer depth, resulting in a general latitudinal gradient with higher densities near the equator and lower densities north of the MHI as well as increased density to the east, likely influenced by increased productivity of the adjacent ETP. Ferguson & Barlow (2003) developed gridded densities using survey data from the ETP and found the highest densities in the western portion of the study area, which overlaps the easternmost edge of the Bradford et al. (2020) model and near the equator. Both are areas of high density in the central Pacific false killer whale SDM.

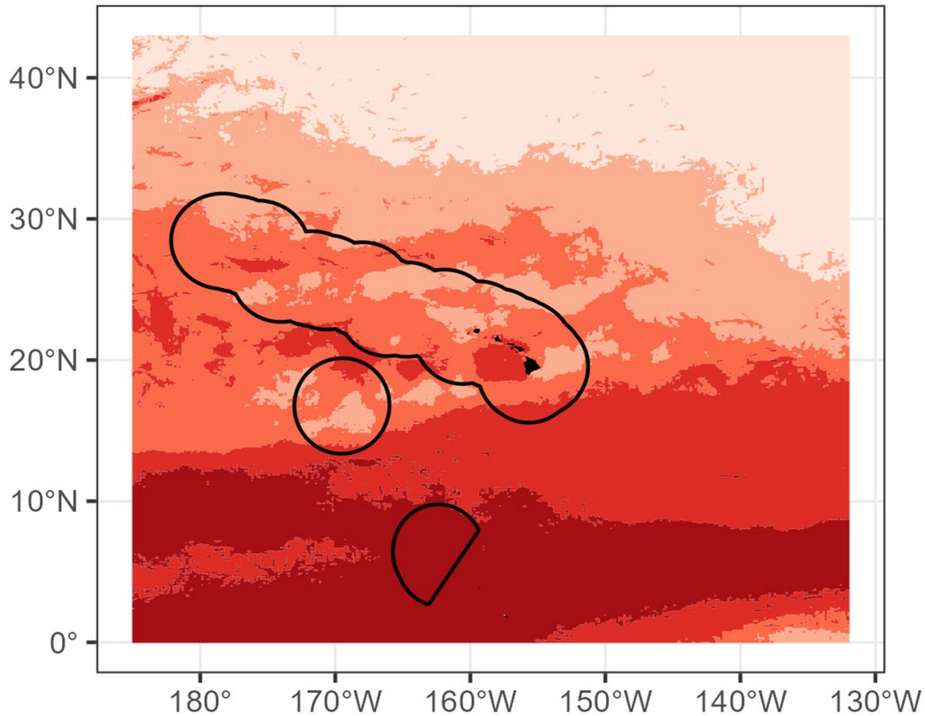

Figure 1. Recolored from Bradford et al. (2020). Overall pelagic false killer whale density predicted by the species distribution model for the central Pacific. Low densities are illustrated by lighter pink and higher density with darker red.

The central Pacific false killer whale SDM has been used to extract the abundance of pelagic false killer whales within the Hawaiian Islands EEZ, providing the primary assessment metrics for the Hawai‘i pelagic stock. However, the model may also be used to extract density and abundance for any region of interest within the model bounds. Therefore, the model can serve as a foundation for deriving abundance estimates that reflect the broader distribution of the Hawai‘i pelagic stock, assuming an appropriate boundary for that stock can be established. Due to the occurrence of other populations of pelagic false killer whales across the tropical Pacific (Martien et al. 2014, Figure 2) and significant uncertainty in the ranges and overlap of these populations, particularly outside of surveyed areas, careful consideration of which portion of the modeled area to use in assessing and managing the Hawai‘i pelagic stock is required.

Defining a management area for Hawaiʻi pelagic false killer whales

NOAA Fisheries Guidelines for Assessing Marine Mammal Stocks (GAMMS; NMFS 2023) states that "whenever possible, a single demographically independent population of marine mammals should be designated and managed as a stock." Hawaiʻi pelagic false killer whales are demographically independent from insular populations around Hawaiʻi and from pelagic false killer whales in the ETP. Telemetry data has shown that the Hawaiʻi pelagic stock of false killer whales ranges throughout the Hawaiian Islands EEZ eastward to at least 138°W (Bradford et al. 2015). Additionally, the stock is significantly genetically differentiated from animals in the ETP and from insular populations around Hawaiʻi (Chivers et al. 2010, Martien et al. 2014).

However, uncertainty remains in the range of this pelagic population and in the potential degree of overlap with other pelagic stocks in the tropical Pacific. Relative to some other pelagic species, encounter rates with false killer whales in surveyed areas are low (e.g., Bradford et al. 2021), limiting opportunities to collect genetic samples or deploy satellite telemetry tags. Relatively limited sample sizes preclude a robust evaluation of finer genetic structure across the central Pacific. Further, there are large areas of the central Pacific that have not been surveyed or that have only been surveyed once. These data gaps drive much of the uncertainty about Hawaiʻi pelagic false killer whale stock distribution outside of the Hawaiian Islands EEZ. Given this uncertainty and the potential for overlap with other pelagic stocks, the full spatial extent of the central Pacific SDM is not appropriate to use as the management area for Hawaiʻi pelagic false killer whales.

Despite the data gaps, there are biological and ecological data available to establish the minimum range of this stock outside of the Hawaiian Islands EEZ. In cases of transboundary stocks with incomplete information, GAMMS (NMFS 2023) suggests that management units may be defined, assuming the MMPA definition of a stock can be assured (i.e., individuals share a common spatial arrangement and interbreed when mature). In these cases, GAMMS states that a "stock's geographic range should not be based on anthropogenic boundaries (e.g., political boundaries such as the U.S. [EEZ]) as such areas do not represent true biological and ecological ranges and are counter to the MMPA objective of maintaining stocks as functioning elements of their ecosystems." Delineation of the management unit may be influenced by regions with high rates of human-caused MSI. Further, when adequate information to delineate DIPs is unavailable over large geographic areas, information from other parts of the species' range may be considered to draw inferences by analogy. Given the recently updated GAMMS guidance, we have endeavored to derive a management area that reflects what we know of Hawaiʻi pelagic false killer whale distribution and allows for a more complete assessment of fishery impacts on this stock. The data available to develop the management area is described in detail below.

The initial process to derive a management area for the Hawaiʻi pelagic stock included a review by the Pacific Scientific Review Group (PSRG)[1] of the underlying management need and some potential management area options. The PSRG is the external review group responsible for reviewing assessments for NOAA Fisheries under the MMPA. The PSRG was

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[1] PSRG Meeting Minutes, 6-10 March, 2023. https://www.fisheries.noaa.gov/s3/2023-07/PSRG-2023-Meeting-Minutes-FINAL.pdf

particularly concerned about two potential sources of uncertainty in the eventual assessment: 1) uncertainty in the SDM predictions for unsurveyed regions, and 2) uncertainty in the magnitude and influence of bycatch in foreign fishing fleets outside of the Hawaiian Islands EEZ. However, they recognized that some portion of the high seas should be included in the management area. Given their concerns, the PSRG recommended only including areas where Hawaiʻi pelagic false killer whales were known to occur, thereby reducing extrapolation of abundance into regions where false killer whale occurrence predicted by the SDM could not be validated by observations of false killer whales identified as the Hawaiʻi pelagic stock.

Available biological data for Hawaiʻi pelagic false killer whales

Satellite telemetry data

Ten satellite telemetry tags have been deployed on Hawaiʻi pelagic false killer whales, all within the Hawaiian Islands EEZ at the time tagging took place (Table 1). These records range in duration from 3 days (1 track) to 4-6 months (3 tracks). The longest tracks suggest some fidelity to the Hawaiian Islands with tracks demonstrating movements over 200 nmi from land, but with periodic return to relatively nearshore waters, and, in the case of the longest track, a doubling back toward Hawaiʻi before the tag ceased transmission. Published analyses of tagged Hawaiʻi pelagic false killer whale movements (e.g., Anderson et al. 2020, Fader et al. 2021) have been limited to examining the prevalence of fishery interactions and distance from U.S. longline fisheries and have not provided insight into habitat preferences or associations for this stock.

Table 1. Summary of satellite telemetry tags (n=10) deployed on Hawaiʻi pelagic false killer whales in the Hawaiian Islands EEZ between 2008-2020 by the Cascadia Research Collective (CRC) or Pacific Islands Fisheries Science Center (PIFSC). The tag data may be obtained from the Animal Tracking Network (ATN).

ATN Track ID	Contributor	Contributor Track ID	Track start	Track end
77250	CRC	PCTag004	4/22/2008	5/6/2008
128881	PIFSC	PCTagP01	5/15/2013	10/16/2013
128883	PIFSC	PCTagP02	5/26/2013	6/9/2013
109825	CRC	PCTag039	10/22/2013	11/3/2013
98365	CRC	PCTag040	10/22/2013	11/7/2013
98364	CRC	PCTag041	10/22/2013	2/22/2014
141702	PIFSC	PCTagP04	9/12/2017	3/9/2018
141703	PIFSC	PCTagP05	9/13/2017	10/4/2017
141695	PIFSC	PCTagP03	9/13/2017	9/16/2017
173817	CRC	PCTag065	5/15/2020	5/31/2020

Genetic sample data

In a study of population structure in north Pacific false killer whales, Martien et al. (2014) demonstrated significant genetic differentiation between whales found in a specified central north Pacific (CNP) stratum versus those samples in an ETP stratum (Figure 2). These differences existed in both mitochondrial (mtDNA) and nuclear (nuDNA) DNA, indicating demographic independence between these areas. Sample sizes were not large enough to evaluate the possibility of structure within either of these strata. Consequently, it is unknown whether the CNP or ETP strata are each composed of a single DIP or multiple DIPs.

Martien et al (2014) delineated the CNP and ETP strata based on oceanographic and biogeographic features (Reilly 1990; Longhurst 1998)—as well as on sample distribution—with the goal of maintaining adequate sample sizes within strata to allow for frequency-based analyses of genetic differentiation. Most samples from the ETP were collected east of 115 W, while samples from the CNP were all collected west of 130 W. The large sampling gap between these two areas makes it impossible to determine the location of the boundary between them. Thus, it is unclear whether the population represented by the ETP stratum extends into the area considered by the central pacific SDM. Based on oceanographic differences between the CNP and ETP (e.g., Ballance et al. 2006, Fiedler et al 2008, Kessler 2006), we expect that animals found in the highly productive western ETP area (west of the ETP stratum) may be part of the ETP population. This uncertainty extends to animals found near Palmyra Atoll, where highly productive equatorial waters may support a different population of false killer whales. It is also possible that additional genetic samples could reveal finer scale populations structure across the central and eastern Pacific.

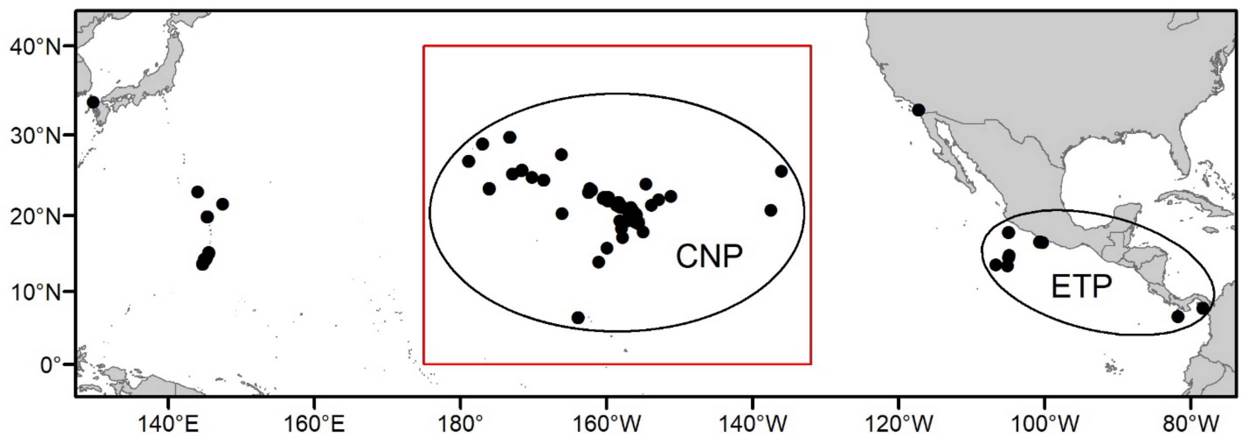

Figure 2. Collection locations of false killer whale samples in the north Pacific and geographic stratification used for genetic analysis in Martien et al. (2014). The red box is the extent of the central Pacific species distribution model for pelagic false killer whales (Bradford et al. 2020).

Sample locations within the central north Pacific were compiled for use in defining the Hawai'i pelagic false killer whale management area. All processed samples collected to date were included, excluding those from the MHI insular and Northwestern Hawaiian Islands stocks (identified as unique haplotypes 1, 2, and 31; Martien et al. 2014). This set includes additional samples beyond those analyzed as part of Martien et al. (2014) including four with new haplotypes that are within one base pair change from those most commonly identified in the CNP region. A small subset of samples have not been analyzed, or require reanalysis for mtDNA haplotype. Nuclear genotyping may be required to identify finer-scale population structure and has not been carried out on any pelagic samples since Martien et al. (2014). Sample data—including location, date, mitochondrial DNA haplotype, and sex—can be downloaded from Github.

Survey sighting data

NOAA Fisheries has conducted line-transect surveys for cetaceans in the eastern and central Pacific since the mid-1980s. These surveys initially focused on the ETP due to concerns about unsustainable dolphin mortality in tuna purse-seine nets (reviewed by Gerrodette 2009). Surveys in the central Pacific have generally focused on the Hawaiian Islands EEZ with two surveys near Palmyra, one around Johnston Atoll, and other efforts carried out as ship-time was available. Sighting and effort data from all NOAA Fisheries surveys are available from OBIS-Seamap. The full collection of surveys extends beyond the central Pacific false killer whale SDM.

Survey sightings of false killer whales within the area of the central Pacific false killer whale SDM were extracted to help guide the definition of the Hawai'i pelagic false killer whale management area. All sightings to date (i.e., through the winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey of 2020; Yano et al. 2020) were included, excluding those from the MHI insular and Northwestern Hawaiian Islands stocks (if identified to stock via genetic, photo, or other data). Sighting data—including location, date, ship and other effort details, and additional stock information—can be downloaded from GitHub.

Fishery interaction data

The Hawai'i-based longline fisheries are observed by the PIRO Observer Program with 100% coverage of the shallow-set swordfish-target fleet and approximatly 20% coverage of the deep-set tuna-target fleet. Specific data collection protocols have evolved over time, however, general observations of the cetacean species bycaught and the amount and type of gear remaining on the animal have been collected since the early 2000s. Photographs or video of bycaught whales regularly accompany observer notes about fishery interactions, and biopsy samples are rarely collected to confirm species and stock identity of the bycaught animal.

To-date, all false killer whale interactions with the Hawai'i-based longline fisheries have occurred within the area of the central Pacific false killer whale SDM. All interactions from 2001 through 2022 were included. Interaction data—including location, date, fishery, injury determination, and additional stock information—can be downloaded from GitHub. When tissue samples were available, genetic analyses were carried out and the results are included among other samples collected across the Pacifc (see section Genetic sample data).

Other data sources

Since 2003 fishery observers have collected information on “mammal damage” or depredation of target catch by marine mammals. These observations have helped inform examination of the ecological or fishery-related factors that may lead to interactions between the longline fleet and false killer whales (e.g. Forney et al. 2011, Fader et al. 2021) as most of this depredation is assumed to be carried out by false killer whales. Depredation rates are highest in regions with the greatest fishery effort (Forney et al. 2011, Fader et al.

2021), however, they extend throughout the range of fishery operations. Depredation patterns were not included in the development of the management area because the marine mammal species responsible for depredation cannot be identified, and the stock identity of the depredating whale cannot be known with the information available. Regardless, nearly all depredation records are included within the bounds of the proposed management area or are further south where other stocks of false killer whales may be implicated.

Fishery observer reported sightings of false killer whales also were not included in the delineation of the management area. Unlike sightings during NMFS line-transect surveys, species attribution cannot be confirmed without expert review of observer collected video or photographs, in cases where they are available. Such review could not be undertaken within the timeline required for delineation of the management area. Fishery observer sightings that can be confirmed as false killer whales may be considered in future boundary revisions. However, like NMFS cetacean survey sightings, stock identity of the sighted whales is not known without additional genetic or photo-ID data, such that those sightings are less informative with regard to boundary placement.

Although foreign fleet fishing effort and bycatch rates are not informative with respect to the distribution of Hawai‘i pelagic false killer whales, they are an important to consider as part of a full assessment of human-caused MSI for this stock. Foreign longline fleets operate within the tropical Pacific including immediately outside of the Hawaiian Islands EEZ. Estimates of “hours fished” from Global Fishing Watch indicate that the magnitude of foreign longline effort near the Hawaiian Islands EEZ is relatively low compared to that of the Hawai‘i-based fleet. Additionally, foreign longline effort near Hawai‘i is highest to the southwest of the EEZ and north of 30^0 on the east side of the islands. 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 segement of the fleet “given the low levels and imbalanced nature of observer coverage” (Peatman and Nicols 2020). The eastern portion of the central Pacific SDM is managed by the Inter-American Tropical Tuna Commission (IATTC), where bycatch reporting is unreliable, hindering development of annual or spatially-explicit bycatch estimates. 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.

Proposed Hawaiʻi pelagic false killer whale management area

Using available biological data for pelagic false killer whales in the central Pacific, we developed a management area for Hawaiʻi pelagic false killer whales that reflects the known range of this stock (Figure 3). To establish the known range, we identified the locations known, or assumed to be, Hawaiʻi pelagic false killer whales from the compiled satellite telemetry, genetic sample, survey sighting, and fishery interaction data. The population identity of survey sightings and fisheries interactions without genetic samples was assumed based on location, especially their proximity to telemetry and genetic sample locations. Next, we bounded the identified locations by a minimum convex polygon (MCP). To account for animal movement and group structure, a 35-km buffer was added to the MCP. The buffer distance was chosen based on the maximum spread of subgroups documented during the Hawaiian Islands Cetacean and Ecosystem Assessment Survey of 2010, when data collection protocols were specifically designed to account for all subgroups in a group (Bradford et al. 2014).

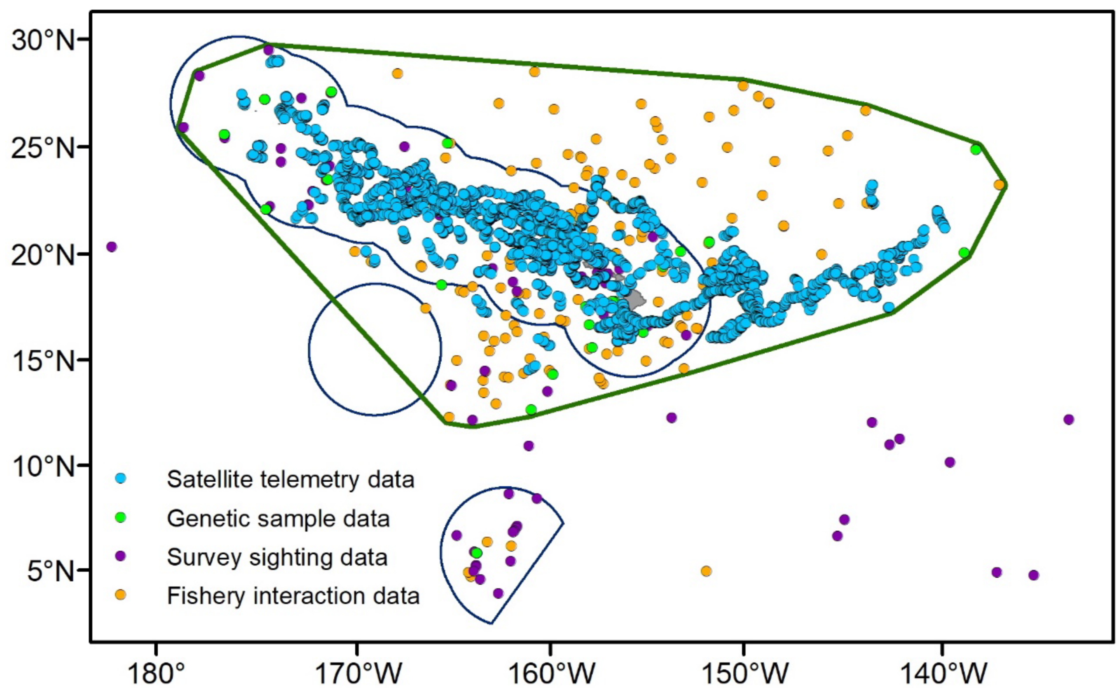

Figure 3. Management area for Hawaiʻi pelagic false killer whales (green line). The area is defined by a minimum convex polygon surrounding all available satellite telemetry (blue), genetic sample (green), survey sighting (purple), and fishery interaction (orange) locations known or assumed to be part of the Hawaiʻi pelagic stock including a 35 km buffer. The U.S. EEZ around the Hawaiian Islands and Johnston Atoll is outlied in blue.

The most influential data in the derivation of the management area boundary are the telemetry data from known Hawaiʻi pelagic false killer whales and the genetic data that provide insight into population assignment. Given the potential for overlap with other pelagic false killer whale populations occurring in the tropical and subtropical Pacific, we consider it especially important that the management area is bounded in large part by telemetry and genetic sample locations in this region. In contrast, given the general latitudinal dependance on false killer whale density (Bradford et al. 2020), there is relatively low risk of inappropriately expanding the boundary in this northern region as small changes in the boundary position result in small changes to overall management area density and abundance. As such, the fishery interaction data were particularly informative in defining the northern extent of the management area boundary where genetic and telemetry data are generally unavailable. A shapefile of this management area can be downloaded from GitHub.

Abundance and potential biological removal

The density and abundance of false killer whales within the management area was extracted from the central Pacific SDM, resulting in an overall abundance estimate of 5,528 (CV=0.35) whales. Potential biological removal (PBR) was computed using a recovery factor (F_r) of 0.4, reflecting significant uncertainty in total MSI by foreign fleets outside of the Hawaiian Islands EEZ. As noted above, the PSRG expressed significant concern about the impact of foreign take on the Hawai'i pelagic false killer whale population. Without data available to estimate that take, the uncertainty is reflected with a lower F_r, consistent with GAMMS (NMFS 2023). The resulting PBR is 33 whales. MSI of false killer whales was estimated within the new management area is 47 false killer whales (McCracken & Cooper 2023).

Other management areas considered

In addition to the management area proposed above, we evaluated two alternative management areas, both of which were defined in part by the distribution of fishing effort for the Hawai'i-based deep-set longline fishery, which is responsible for most of the known MSI of Hawai'i pelagic false killer whales. The distribution of effort by this fishery varies over time as fishermen respond to shifts in the distribution of their target species, bigeye tuna, but also in response to regulatory measures, such as the expansion of the Papahānaumokuākea Marine National Monument (PMNM), Pacific Remote Island Areas Marine National Monument, and other factors. We used the timing of the PMNM expansion in 2016, which displaced a portion of the fishing effort out of the PMNM into the remaining Hawaiian Islands EEZ and nearby high seas waters, as our starting point for examining the fishery area.

Fishing effort (set locations) occurring from 2017 to 2021 was extracted from logbook data and used to derive a 95% kernel density estimate (KDE) of the fishery area (Figure 3), omitting areas with sporadic fishing effort, primarily to the south and east of the Hawaiian Islands. A 99% KDE was also generated, but we determined that the 95% KDE was more suitable for this purpose because 1) it is within the extent of the central Pacific SDM for false killer whales (the 99% KDE extends beyond the eastern boundary), and 2) all observed false killer whales fishery interactions between 2017-2021 occurred within the 95% KDE. The 95% KDE-derived fishery area informed two alternative management areas that were considered for the purpose of further assessing the impact of the Hawai'i-based deep-set longline fishery on the Hawai'i pelagic false killer whale stock.

Define a management area based on the fishery area

Under this option, the management area was defined as the 95% KDE of the 2017-2021 deep-set fishing effort (Figure 4). An assessment approach with this fishery effort-based management area provides for a comparison of Hawai'i pelagic false killer whale abundance and MSI that is tightly linked to the spatial extent of the Hawai'i-based longline fleet. This management area does not incorporate regions where Palmyra Atoll or eastern Pacific stocks of false killer whales are known to occur. However, based on the telemetry and genetic data currently available, the fishery area does not account for all animals known to be part of the Hawai'i pelagic stock (e.g., whales within the PMNM), yielding a management area that explicitly divides the stock into two assessment units by excluding whales that are not using this space but are clearly part of the broader biological population. Further, during the discussion of this potential management area with the False Killer Whale Take-Reduction Team, industry-associated team members noted that the derviation of a management area based on the fishery area alone could be considered punitive to the fishery. Thus, essentially concentrating management attention to their area of operation while ignoring the known occurrence of whales from this stock that exist outside of proposed area. Further, a management area defined using fishery effort data would be dynamic, requiring regular redefinition of the management area and complicating management of this stock. The PSRG was not supportive of a dynamic management area boundary.

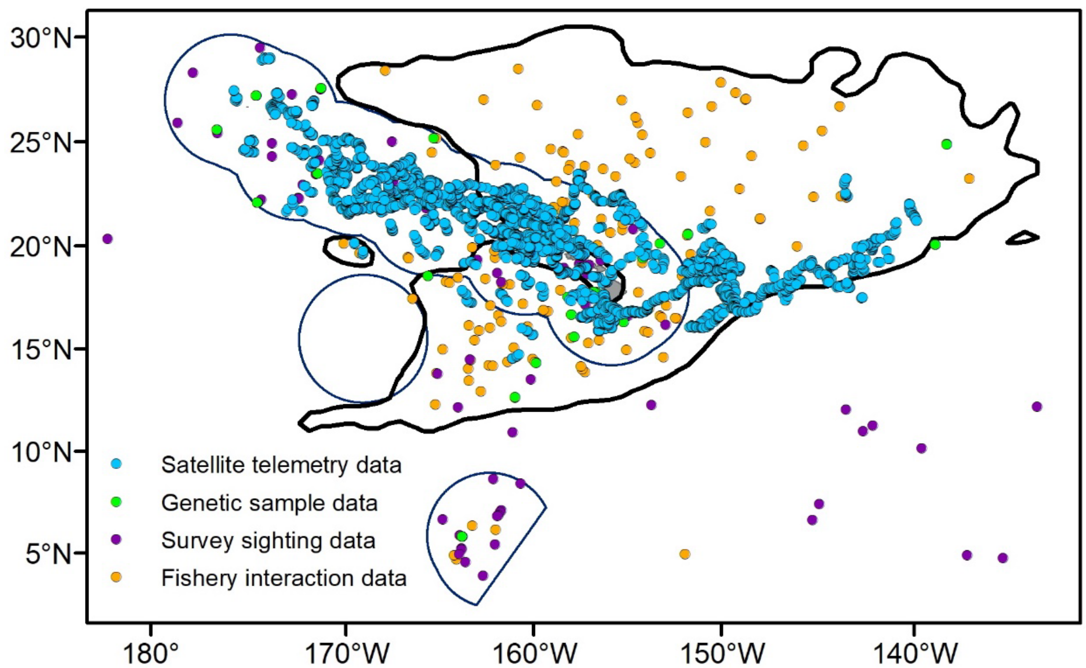

Figure 4. Alternative assessment approach considered (but not selected) that defines a management unit based on the fishery area as represented by the 95% kernel density estimate of fishing effort from 2017 to 2021 (thick black line). The U.S. EEZ around the Hawaiian Islands and Johnston Atoll is outlined in blue.

Define a management area encompassing the Hawaiian Islands EEZ and fishery area

Under this option, the management area was defined as a MCP around the Hawaiian Islands EEZ and the fishery area as represented by the 95% KDE of 2017-2021 fishing effort, thereby incorporating animals known to be part of the Hawaiʻi pelagic false killer whale stock (Figure 5). With this approach, the management area would be less likely to shift in the short term due to changes in fishing effort as much of the fishery area is buffered by the MCP; however, longer term shifts would still be likely. This area incorporates all telemetry and genetic data from the Hawaiʻi pelagic stock, which is an improvement over the fishery effort-based management unit. Also, through the explicit inclusion of the Hawaiian Islands EEZ, this management area does not divide the stock into two assessment units.

However, a management area derived using an MCP of these boundaries (the Hawaiian Islands EEZ and the fishery area) includes spaces that have not been surveyed (i.e., west of Johnston Atoll) and where there is little to no false killer whale biological data (i.e., within Johnston Atoll), contributing considerable uncertainty into the population identity of false killer whales using those areas. This area also includes more overlap with longline fishing by foreign fleets, injecting considerably more uncertainty related to foreign fleet impacts into the evaluation of overall bycatch within the management area, an expressed concern of the PSRG.

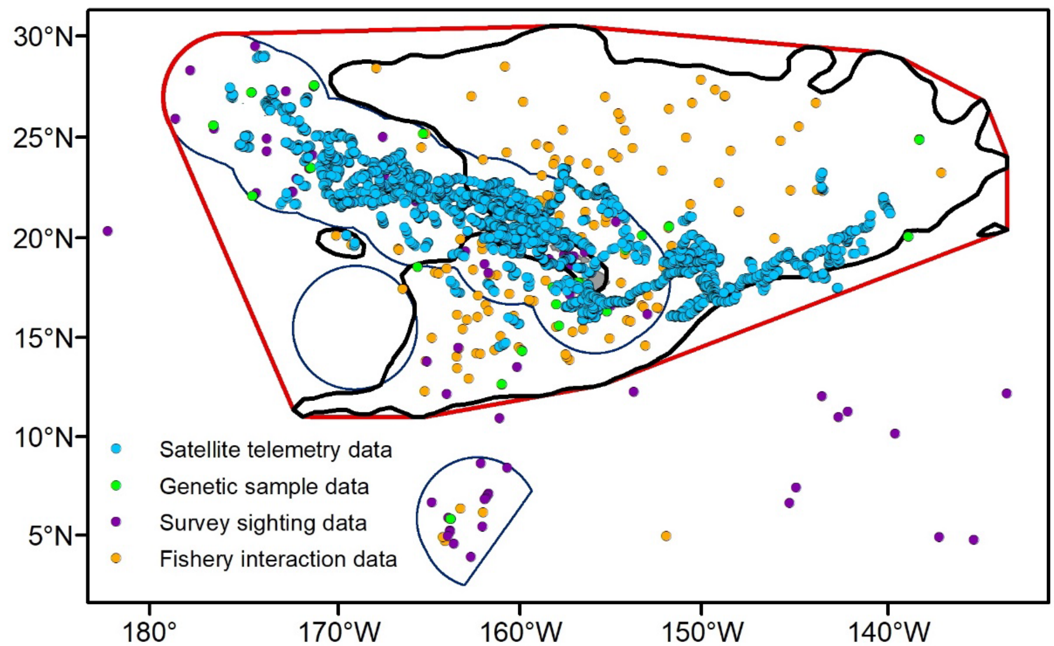

Figure 5. Alternative assessment approach considered (but not selected) that defines a management area based on a minimum convex hull (thick red line) around the U.S. Exclusive Economic Zone (EEZ), and around the Hawaiian Islands and the fishery area as represented by the 95% kernel density estimate of fishing effort from 2017 to 2021 (thick black line). The U.S. EEZ around the Hawaiian Islands and Johnston Atoll is outlined in blue.

Conclusions

Assessment of the Hawaiʻi pelagic stock of false killer whales based on the Hawaiian Islands EEZ area alone has led to a spatial mismatch between abundance and PBR estimates for the stock and the distribution and magnitude of the impact from bycatch in the Hawaiʻi-based deep-set longline fishery. This mismatch has complicated effective management of the stock. Using available biological datasets, a new management area was developed that allows for assessing abundance and human-caused MSI over the same area, as instructed by GAMMS. This new management area is an improvement over EEZ-based management, but it is still limited by relatively sparse survey and sample data outside of the EEZ. Although false killer whales are known to occur in waters immediately outside of this area, additional telemetry tracks linked to known Hawaiʻi pelagic animals, additional genetic samples, and new genetic analyses incorporating nuDNA datasets, will be required to refine our understanding of population structure within the tropical Pacific and improve the management area boundary for Hawaiʻi pelagic false killer whales.

Acknowledgments

The Hawaiʻi pelagic false killer whale management area was developed following consultation with the Pacific Islands Regional Office, the Office of Protected Resources, the Office of Science and Technology, and members of the False Killer Whale Take Reduction Team. The area was finalized following review by the Pacific Scientific Review Group. Robert Ahrens provided analysis and development of the deep-set longline fishery area and insights into foreign fleet fishing effort and bycatch as visualized through Global Fishing Watch.

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Appendix 1

Mortality and serious inury (MSI) estimates for Hawai‘i pelagic false killer whales inside and outside of the Hawaiian Islands EEZ. Estimates are derived from logbook and PIRO Observer Program datasets as described by McCracken et al. (2019). Estimates are corrected for observed interactions with unidentified blackfish (animals known based on the observer description to be either false killer whale or short-finned pilot whale) following the methods in McCracken (2010). MSI estimates inside the EEZ are prorated to stock as described in Oleson et al. (2021) and Carretta et al. (2023). Annual estimates are updated on a 5-year rolling basis, including incorporation of the most recent proration factor for the proportion of observed animals dead or seriously injured. Estimates reflected here are the most recently reported estimate for a given year.

Year	MSI Inside Hawai‘i EEZ (CV)	MSI Outside Hawai‘i EEZ (CV)
2008	16.2 (0.4)	0 (-)
2009	11.8 (0.9)	41.4 (0.3)
2010	13.5 (0.4)	6.0 (1.3)
2011	12.7 (0.4)	0 (-)
2012	12.1 (0.4)	0 (-)
2013	3.5 (1.4)	12.4 (0.8)
2014	8.5 (0.7)	36.3 (0.5)
2015	0 (-)	17.0 (0.4)
2016	4.0 (0.8)	27.9 (0.3)
2017	8.4 (0.7)	29.7 (0.4)
2018	12.3 (0.5)	27.9 (0.4
2019	26.0 (0.4)	35.5 (0.3)
2020	5.1 (0.9)	14.2 (0.5)
2021	32.1 (0.4)	37.0 (0.4)