Supplementary File C:
BIA Supplementary Descriptions

Biologically Important Areas II for cetaceans within U.S. and adjacent waters – Hawai‘i Region

Michaela A. Kratofil[1], Annette E. Harnish[1], Sabre D. Mahaffy[1], E. Elizabeth Henderson[2], Amanda L. Bradford[3], Stephen W. Martin[4], Barbara A. Lagerquist[5,6], Daniel M. Palacios[5,6], Erin M. Oleson[3], Robin W. Baird[1*]

[1]Cascadia Research Collective, Olympia, WA, USA
[2]Naval Information Warfare Center Pacific, San Diego, CA, USA
[3]Pacific Islands Fisheries Science Center, National Marine Fisheries Service, National Oceanic and Atmospheric Administration, Honolulu, HI, USA
[4]National Marine Mammal Foundation, San Diego, CA, USA
[5]Marine Mammal Institute, Oregon State University, Newport, OR, USA
[6]Department of Fisheries, Wildlife, and Conservation Sciences, Oregon State University, Corvallis, OR, USA

***Correspondence:** Robin W. Baird (rwbaird@cascadiaresearch.org)

6. Biologically Important Areas for Cetaceans Within U.S. Waters – Hawaii Region

Supplementary Descriptions

BIAs are sorted by species common name, BIA type, Importance Score and descriptive name. Child BIAs, if present, follow the parent BIA in the order of Importance Score and descriptive name.

Supplementary Description 6. 1. Blainville's beaked whale small and resident pop.

Species name: Blainville's beaked whale (*Mesoplodon densirostris*)

Descriptive name: O'ahu-Maui Nui-Hawai'i Island - Parent

BIA type: Small and Resident Pop.

BIA label: S-BIA1-s-b2-HI033-0a

Transboundary across: None

Hierarchy: Hierarchical BIA; Parent of children a

Importance score: 1 (Intensity: 1, Data support: 3)

Intensity matrix: Abundance: 2, Range: 1

Supporting notes for intensity score: There are no abundance estimates specific to the OMNHI population nor either of the island-associated communities (Hawaiʻi Island or Oʻahu) of Blainville's beaked whales in Hawaiian waters. The most recent estimate for the Hawaiian Islands-wide stock based on 2017 line-transect survey sighting data was 1,132 individuals, albeit with high uncertainty (CV=0.99; Bradford et al., 2021). Baird et al. (2009) reported an abundance estimate of 140 Blainville's beaked whales off Hawaiʻi Island using mark-recapture methods applied to photographic data from 2003 through 2006; however, this estimate is dated and included individuals known or suspected to be from a pelagic population. No abundance estimates specific to Oʻahu Blainville's beaked whales are available. As of July 2021, the photo-identification catalog for this species includes 229 slightly distinctive, distinctive, or very distinctive individuals (from fair-, good-, or excellent-quality photographs) encountered off Oʻahu and Hawaiʻi Island (CRC unpublished). The photo-identification catalog dates back to 1986 and likely includes individuals that have died or been born into the population, as well as individuals that are part of a pelagic population (Baird et al. 2009, 2012). For this assessment, we will assume the island-associated population is within the 126 to 500 individuals range of the BIA Intensity scoring criteria, although it is likely in the lower end of that range, given the Hawaiian Islands-wide estimate noted above (Bradford et al. 2021). The size of the modified MCP representing the BIA is 78,714 km2 (range size score = 1).

No current abundance estimate specific to these island-associated communities are available; however, based on long-term photo-identification data collected from extensive survey efforts and opportunistic sightings, we are confident that this (OMNHI) population is small (within 126-500 individuals, and likely at the lower end of that range) and resident to these insular waters. The true range size of this population remains unclear given recent photographic evidence of movement between Hawaiʻi Island and Oʻahu (Baird, 2019) and differing satellite tag-derived movement patterns exhibited by two individuals off Hawaiʻi Island (movements north of Maui Nui; offshore movements to several seamounts. In addition, only one individual has been tagged off Oʻahu and the transmission duration was only three days, so spatial use of Oʻahu resident Blainville's beaked whales remains poorly understood. Despite this, movements from the 10 remaining deployments generally displayed a consistent and similar use of leeward waters off Hawaiʻi Island.

Supporting notes for data support score: Data Support score = 3.

• This population has been studied for 20 years (2002-2021), primarily through dedicated small boat survey efforts. Additional photographic data supplied by other researchers and citizen science contributions spans a 36-year period.
• A total of 64 sightings from CRC effort, three sightings from NMFS effort, and 152 encounters from other researchers and community scientists since 1986, with re-sightings of individuals up to 29 years (1991-2019, 37 separate occasions) off Hawaiʻi Island and 12 years (2009-2021; nine separate occasions) off Oʻahu.
• 14 satellite tag deployments (4,969 filtered Argos locations) transmitting for up to ~159 days, the majority of which showed similar insular habitat use with one individual making a brief offshore excursion and spending time along north Maui Nui/east Oʻahu, another individual moving near Maui Nui for a brief period, and one Hawaiʻi Island resident making an offshore excursion to various seamounts.
• Tag positional uncertainty and irregularity accounted for through crawl model, and boundary encompasses nearly all of crawl standard error (68% confidence interval) ellipses

The existence of a small, resident, island-associated population off Hawaiʻi has long been acknowledged (Baird et al., 2009; Baird, 2016, 2019; Caretta et al., 2021; McSweeney et al., 2007; Oleson et al., 2013) and is supported by long-term, high resighting rates (up to 29 years) and information on movements through satellite tag deployments (Abecassis et al., 2015; Baird et al., 2010; Baird, 2016, 2019; CRC unpublished; Schorr et al., 2009). However, an understanding of associations between Blainville's beaked whales off Hawaiʻi Island and Oʻahu, and movements between these regions, is only recently beginning to emerge (Baird, 2019; CRC unpublished). In addition, one of the 13 satellite-tagged Hawaiʻi Island resident whales made extensive movements to offshore seamounts. As these data represent a snapshot of what is actually occurring in the population, such movements may occur more frequently than we currently know and have data to support in the BIA determination process. No recent abundance estimates specific to these island-associated communities are available, but the distinct individuals count from CRC's long-term photo-identification catalog and the maximum number of individuals documented in any one year (55, CRC unpublished) indicate the population is small. The BIA boundary includes a fair amount of space where no sightings occurred nor satellite tag locations transmitted, particularly in offshore waters south of Oʻahu and Maui Nui. However, the spatial extent of the boundary is supported by the data through the MCP method. Further, knowing that some movement occurs between Hawaiʻi and Oʻahu, and known residents have made offshore "excursions", these whales likely use these areas.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: This population is resident to this area year-round and no information (from available data) suggests the area is used dynamically or ephemerally.

Boundary certainty: 2

Supporting notes for boundary certainty: We have intermediate confidence in Boundary Certainty for the parent BIA for OMNHI Blainville's beaked whales. The boundary encompasses the entire population based on a long-term sighting dataset, curated from extensive survey effort, and available information from satellite tag deployments. However, there is a large amount of space with no documented use due to the offshore locations of the satellite tagged Hawaiʻi Island resident. It is unknown how often such offshore "excursions" occur in this population. This boundary is fairly broad given presumed primary habitat (depths within 2,000 m off Hawaiʻi Island; Abecassis et al., 2015; Baird et al., 2010, 2013; Schorr et al., 2009), but nevertheless encompasses all available spatial points on insular Blainville's beaked whales. Some satellite tagged animals used similar insular habitat off windward areas of the island where survey effort has been precluded (e.g., Maui Nui), and positional uncertainty was accounted for in satellite tag data. In addition, the boundary includes areas of known habitat that Blainville's beaked whales from this population likely use (waters within ~3,000 m deep), but where spatial data are lacking due to limited effort.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 14

# of years in which supporting tagging data collected: 7 (2006-2017)

Supporting information: Satellite tags were deployed on 13 Blainville's beaked whales during dedicated survey efforts off leeward Hawaiʻi Island in 2006 (n=3), 2008 (n=5), one each in 2009, 2011, and 2013, and two in 2012, and on one individual off Oʻahu in 2017 (Abecassis et al., 2015; Baird et al., 2010; Baird, 2016, 2019; Schorr et al., 2009). Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk model using the package crawl implemented in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 4-hour interval and locations on land were re-routed around a polygon representing the 300-m isobath using the pathroutr package (London, 2020). Crawl locations interpolated over periods spanning more than 1 day without any underlying Argos locations were removed.

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 67

# of years in which supporting visual data collected: 20 (2002-2021)

Supporting information: Sighting data used in this assessment were collected from both non-systematic, dedicated small boat surveys conducted by CRC off Oʻahu, Maui Nui, and Hawaiʻi Island in six, nine, and 20 years, respectively, spanning 2002-2021 (see Baird et al., 2013 for details on surveys) and ship-based line-transect surveys for cetaceans conducted by NMFS throughout the Hawaiian Archipelago in 11 years between 2002-2020 (see Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020 for details on surveys). CRC surveys off these three island areas combine to 121,088 km of effort with 64 sightings of Blainville's beaked whales as of May 2021, and NMFS surveys around Hawaiʻi Island (near and offshore) total to 16,607 km of effort with three sightings of Blainville's beaked whales, one each off Oʻahu, Maui, and Hawaiʻi Island. In addition, community science photographic and sightings contributions have added substantially to the information available on this population, yielding an additional 152 sightings off Hawaiʻi Island and Oʻahu combined over a period of 36 years (1986-2021), and comprising over 75% of all identifications in CRC's photo-identification catalog of Oʻahu Blainville's beaked whales and nearly 65% of CRC's catalog of Hawaiʻi Island Blainville's beaked whales (CRC unpublished). Individuals have been resighted off Hawaiʻi Island for timespans of up to 29 years (1991-2019) and Oʻahu up to 12 years (2009-2021). While community science contributions rarely come with associated latitude and longitude to include in the boundary delineation process (typically only general island or regional locality is provided), in this assessment we use the information on social structure and relative abundance that these photographic contributions have supported.

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 229

# of years of photo records to compare: 36 (1986-2021)

Maximum # of years same individual photographed in area: 29 (1991-2019) off Hawaiʻi Island; 12 (2009-2021) off Oʻahu

Supporting information: As of July 2021, the photo-identification catalog for this species includes 229 slightly distinctive, distinctive, or very distinctive individuals (from fair-, good-, or excellent-quality photographs) encountered off Oʻahu and Hawaiʻi Island (CRC unpublished). The photo-identification catalog dates back to 1986 and likely includes individuals that have died or been born into the population, as well as individuals that are part of a pelagic population (Baird et al. 2009, 2012). Re-sightings of individuals up to 29 years (1991-2019, 37 separate occasions) off Hawaiʻi Island and 12 years (2009-2021; nine separate occasions) off Oʻahu.

Genetic analyses conducted supporting designation (Y/N): N

What factors justify the boundary selection?: Baird et al. (2015) delineated a single BIA for Hawaiʻi Island Blainville's beaked whales based on sighting data from small boat survey efforts and spatial use from available satellite tag deployments. Additional sighting, photographic, and satellite tag data collected since the original 2015 assessment that provides recent evidence of movements between the areas were used to delineate a parent BIA that encompasses both Hawaiʻi Island and Oʻahu communities of Blainville's beaked whales. Although no resident Blainville's beaked whales have been encountered off Maui Nui (between Oʻahu and Hawaiʻi Island), this BIA encompasses Maui Nui due to known (satellite tag data) and presumed (photo-identification) movements through this area to Oʻahu (OMNHI population). A child BIA was delineated for the Hawaiʻi Island community based on primary habitat known from sightings and satellite tag data.

The basis for the parent BIA was a minimum convex polygon (MCP) encompassing all sighting and satellite-tag derived crawl locations; the BIA was established by adding a 3-km distance to the outer boundary of the MCP to account for positional uncertainty in the locations estimated by crawl. Although there is a large portion of the parent BIA that does not include any tag or sighting locations, individuals likely use these waters at least occasionally based on tag data showing occasional movements offshore and among islands and the one documented movement between Oʻahu and Hawaiʻi Island from photographic data (Baird, 2019). The inner (shoreward) boundary was defined as the 300-m isobath based on the shallowest sighting off these island areas from CRC dedicated survey efforts (shallowest sighting = 382 m deep). The resulting area of the parent BIA (i.e., population range size) is 78,714 km2.

Data sources: Cascadia Research Collective (unpub. data, 2002-2021); National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020; accessed 2021; Barlow 2006; Bradford et al., 2017; Yano et al., 2018, 2020); Abecassis et al., 2015; Baird et al., 2009, 2011, 2013, 2015; Baird 2019; Mahaffy et al., 2015; McSweeney et al., 2007; Schorr et al., 2009

Approximate % of population that uses this area for the designated purpose (if known): 100

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Abecassis, M., J. Polovina, R.W. Baird, A. Copeland, J.C. Drazen, R. Domokos, E. Oleson, Y. Jia, G.S. Schorr, D.L. Webster, and R.D. Andrews. 2015. Characterizing a foraging hotspot for short-finned pilot whales and Blainville's beaked whales located off the west side of Hawaiʻi Island by using tagging and oceanographic data. PLoS ONE 10(11):e0142628 doi:10.1371/journal.pone.0142628

Baird, R.W., D.J. McSweeney, G.S. Schorr, S.D. Mahaffy, D.L. Webster, J. Barlow, M.B. Hanson, J.P. Turner, and R.D. Andrews. 2009. Studies of beaked whales in Hawaiʻi: Population size, movements, trophic ecology, social organisation, and behaviour. ECS Special Publication 1:23-25

Baird, R.W., G.S. Schorr, D.L. Webster, S.D. Mahaffy, D.J. McSweeney, M.B. Hanson, and R.D. Andrews. 2011. Open-ocean movements of a satellite-tagged Blainville's beaked whale (Mesoplodon densirostris): Evidence for an offshore population in Hawaiʻi? Aquatic Mammals 37:506-511

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Baird, R.W. 2019. Behavior and ecology of not-so-social odontocetes: Cuvier's and Blainville's beaked whales. Pages 305-329 in: Ethology and Behavioral Ecology of Toothed Whales and Dolphins, the Odontocetes. Edited by B. Würsig. Springer.

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22(2):446-464

Bradford, A.L., K.A. Forney, E.M. Oleson, and J. Barlow. 2017. Abundance estimates of cetaceans from a line-transect survey within the U.S. Hawaiian Islands Exclusive Economic Zone. Fishery Bulletin 115:129-142

Bradford, A.L., E.M. Oleson, K.A. Forney, J.E. Moore, and J. Barlow. 2021. Line-transect abundance estimates of cetaceans in U.S. waters around the Hawaiian Islands in 2002, 2010, and 2017. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-PIFSC-115, 52 p. doi:10.25923/daz4-kw84

Caretta, J.V., E.M. Oleson, K.A. Forney, M.M. Muto, D.W. Weller, A.R. Lang, J. Baker, B. Hanson, A.J. Orr, J. Barlow, J.E. Moore, and R.L. Brownwell Jr. 2021. U.S. Pacific Marine Mammal Stock Assessments: 2020. U.S. Department of Commerce, NOAA.

Duong, T., and M.L. Hazelton. 2003. Plug-in bandwidth matrices for bivariate kernel density estimation. Journal of Nonparametric Statistics 15:17-30.

Duong, T., and M.L. Hazelton. 2005. Cross-validation bandwidth matrices for multivariate kernel density estimation. Scandinavian Journal of Statistics 32:485-506.

Duong, T. 2007. Ks: Kernel density estimation and kernel discriminant analysis for multivariate data in R. Journal of Statistical Software 21:1-16.

Duong, T. 2021. Ks: Kernel smoothing. R package version 1.12.0 https://CRAN.R-project.org/package=ks

Hauser, D.D.W., K.L. Laidre, R.S. Suydam, and P.R. Richard. 2014. Population-specific home ranges and migration timing of Pacific Arctic beluga whales (Delphinapterus leucas). Polar Biology 37:1171-1183

Hill, M.C., A.R. Bendlin, A.M. Van Cise, A. Milette-Winfree, A.D., Ligon, A.C. Ü, M.H. Deakos, and E.M. Oleson. 2019. Short-finned pilot whales (Globicephala macrorhynchus) of the Mariana Archipelago: individual affiliations, movements, and spatial use. Marine Mammal Science 35(3):797-824 doi:10.1111/mms.12567

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Mahaffy, S.D., R.W. Baird, D.J. McSweeney, D.L. Webster, and G.S. Schorr. 2015. Group structure and mating strategies of Cuvier’s (Ziphius cavirorstris) and Blainville’s (Mesoplodon densirostris) beaked whales off the island of Hawaiʻi. Poster presented at the 21st Biennial Conference on the Biology of Marine Mammals, San Francisco, California, December 14-18, 2015.

McSweeney, D.J., R.W. Baird, and S.D. Mahaffy. 2007. Site fidelity, associations, and movements of Cuvier’s (Ziphius cavirostris) and Blainville’s (Mesoplodon densirostris) beaked whales off the island of Hawaiʻi. Marine Mammal Science 23(3):666-687. Doi:10.1111/j.1748-7692.2007.00135.x

Schorr, G.S., R.W. Baird, M.B. Hanson, D.L. Webster, D.J. McSweeney, and R.D. Andrews. 2009. Movements of satellite-tagged Blainville’s beaked whales off the island of Hawaiʻi. Endangered Species Research 10:203-213

Yano, K.M., E.M. Oleson, J.L. Keating, L.T. Ballance, M.C. Hill, A.L. Bradford, A.N. Allen, T.W. Joyce, J.E. Moore, and A. Henry. 2018. Cetacean and seabird data collected during the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS), July-December 2017. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TM-NMFS-PIFSC-72, 110 p. doi:10.25923/7avn-gw82

Yano, K.M., E.M. Olesn, J.L.K. McCullough, M.C. Hill, and A.E. Henry. 2020. Cetacean and seabird data collected during the winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey (Winter HICEAS), January-March 2020. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-111, 72 p. doi:10.25923/ehfg-dp78

Worton, B.J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:164-168

Supplementary Description 6. 2. Blainville's beaked whale small and resident pop.

Species name: Blainville's beaked whale (*Mesoplodon densirostris*)

Descriptive name: O'ahu-Maui Nui-Hawai'i Island - Child (Hawai'i Island)

BIA type: Small and Resident Pop.

BIA label: S-BIA3-s-b3-HI033-a

Transboundary across: None

Hierarchy: Hierarchical BIA; Child a

Importance score: 3 (Intensity: 3, Data support: 3)

Intensity matrix: Abundance: 3, Range: 2

Supporting notes for intensity score: As noted for the parent BIA, recent abundance estimates are not available for Blainville's beaked whales resident to Hawaiʻi Island. Baird et al., (2009) estimated a total of 140 individuals off this island using photographic data collected from 2003 through 2006, but this estimate included animals thought to be from a pelagic population. As of July 2021, CRC's catalog includes 163 distinct individuals with fair-, good-, or excellent quality photographs. This includes all individuals documented since 1986, thus includes many born or that died during the study period. The catalog also includes some individuals belonging to a broader, pelagic population of Blainville's beaked whales that are occasionally encountered off Hawaiʻi Island (e.g., Baird et al. 2011). Thus we assume the Hawaiʻi Island community is comprised of 125 or fewer individuals. We assume that approximately 50% of the population within the parent BIA is contained within the core range (child BIA) identified for the Hawaii Island community, although we recognize that there is uncertainty associated with this value. It is important to note that all tagged individuals (with the exception of the one Oahu tagged whale) used the child BIA. Based on these lines of evidence, we assign an Intensity score of 3 to this child BIA. The area of child BIA: 4,214 km2.

Although no recent abundance estimate is available for this specific island-associated community of Blainville's beaked whales, the distinct individuals count from CRC's catalog, curated from photographic data collected over 36 years, suggests this community is fairly small. Nearly all of the tracks derived from satellite tag deployments further support a small range size off the leeward side of Hawaiʻi Island with both satellite tag locations and sighting locations concentrated in depths between 500 and 2,000 m. Whales off Hawaiʻi Island were tagged in six different years with data available from nine different months of the year, and transmission durations ranged from 15 to 159 days (Abecassis et al., 2015; Baird et al., 2010; Schorr et al., 2009).

Supporting notes for data support score: Data Support score = 3. The child BIA for Hawaiʻi Island Blainville's beaked whales was drawn based on known primary habitat from sightings collected over 20 years of small boat survey efforts (conducted every year by CRC; Baird et al., 2013), satellite tag data from 13 deployments during five separate years (Abecassis et al., 2015; Schorr et al., 2009), and information accrued over three decades from collaborating researchers and community scientists (CRC unpublished), which further supports the existence of a small and resident community associated with Hawaiʻi Island. Although Blainville's beaked whales are encountered relatively infrequently during CRC efforts (Baird et al., 2013), and in general due to their inconspicuous behavior, resighting rates of several individuals (up to 29 years, individual re-sightings up to 37 different occasions) also support high site fidelity to this island.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: There is no information to suggest spatiotemporal variability associated with this BIA.

Boundary certainty: 3

Supporting notes for boundary certainty: We have high certainty in the boundary for the Hawaiʻi Island child BIA. This boundary accurately describes the primary range of this island-associated community of Blainville's beaked whales considering the quantity, quality, and longevity of supporting data from all available sources of information (dedicated small boat and ship-based line-transect survey efforts, satellite tag data, photo-identification, etc.). Blainville's beaked whales off this island may use windward waters where small boat survey efforts have been precluded due to typically poor working conditions; however, there were no sightings off windward sides of the island from ship-based line-transect survey efforts and satellite-tagged individuals generally remained off the leeward side of the island.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 14

# of years in which supporting tagging data collected: 7 (2006-2017)

Supporting information: Satellite tags were deployed on 13 Blainville's beaked whales during dedicated survey efforts off leeward Hawaiʻi Island in 2006 (n=3), 2008 (n=5), one each in 2009, 2011, and 2013, and two in 2012, and on one individual off Oʻahu in 2017 (Abecassis et al., 2015; Baird et al., 2010; Baird, 2016, 2019; Schorr et al., 2009). Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk model using the package crawl implemented in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 4-hour interval and locations on land were re-routed around a polygon representing the 300-m isobath using the pathroutr package (London, 2020). Crawl locations interpolated over periods spanning more than 1 day without any underlying Argos locations were removed.

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 67

# of years in which supporting visual data collected: 20 (2002-2021)

Supporting information: Sighting data used in this assessment were collected from both non-systematic, dedicated small boat surveys conducted by CRC off Oʻahu, Maui Nui, and Hawaiʻi Island in six, nine, and 20 years, respectively, spanning 2002-2021 (see Baird et al., 2013 for details on surveys) and ship-based line-transect surveys for cetaceans conducted by NMFS throughout the Hawaiian Archipelago in 11 years between 2002-2020 (see Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020 for details on surveys). CRC surveys off these three island areas combine to 121,088 km of effort with 64 sightings of Blainville's beaked whales as of May 2021, and NMFS surveys around Hawaiʻi Island (near and offshore) total to 16,607 km of effort with three sightings of Blainville's beaked whales, one each off Oʻahu, Maui, and Hawaiʻi Island. In addition, community science photographic and sightings contributions have added substantially to the information available on this population, yielding an additional 152 sightings off Hawaiʻi Island and Oʻahu combined over a period of 36 years (1986-2021), and comprising over 75% of all identifications in CRC's photo-identification catalog of Oʻahu Blainville's beaked whales and nearly 65% of CRC's catalog of Hawaiʻi Island Blainville's beaked whales (CRC unpublished). Individuals have been resighted off Hawaiʻi Island for timespans of up to 29 years (1991-2019) and Oʻahu up to 12 years (2009-2021). While community science contributions rarely come with associated latitude and longitude to include in the boundary delineation process (typically only general island or regional locality is provided), in this assessment we use the information on social structure and relative abundance that these photographic contributions have supported.

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 229

# of years of photo records to compare: 36 (1986-2021)

Maximum # of years same individual photographed in area: 29 (1991-2019)

Supporting information: As of July 2021, the photo-identification catalog for this species includes 229 slightly distinctive, distinctive, or very distinctive individuals (from fair-, good-, or excellent-quality photographs) encountered off Oʻahu and Hawaiʻi Island (CRC unpublished). The photo-identification catalog dates back to 1986 and likely includes individuals that have died or been born into the population, as well as individuals that are part of a pelagic population (Baird et al. 2009, 2012). Re-sightings of individuals up to 29 years (1991-2019, 37 separate occasions) off Hawaiʻi Island and 12 years (2009-2021; nine separate occasions) off Oʻahu

Genetic analyses conducted supporting designation (Y/N): N

What factors justify the boundary selection?: Baird et al. (2015) delineated a single BIA for Hawaiʻi Island Blainville's beaked whales based on sighting data from small boat survey efforts and spatial use from available satellite tag deployments. Additional sighting, photographic, and satellite tag data collected since the original 2015 assessment that provides recent evidence of movements between the areas were used to delineate a parent BIA that encompasses both Hawaiʻi Island and Oʻahu communities of Blainville's beaked whales. Although no resident Blainville's beaked whales have been encountered off Maui Nui (between Oʻahu and Hawaiʻi Island), this BIA encompasses Maui Nui due to known (satellite tag data) and presumed (photo-identification) movements through this area to Oʻahu (OMNHI population). A child BIA was delineated for the Hawaiʻi Island community based on primary habitat known from sightings and satellite tag data.

Although there has been recent evidence for movements between Oʻahu and Hawaiʻi Island and in offshore waters (Baird, 2019), such movements have rarely been documented and long-term sighting histories and satellite tag data indicate that Hawaiʻi Island Blainville's beaked whales generally remain near the leeward slopes of the island. Therefore, we delineated a hierarchical BIA for Hawaiʻi Island Blainville's beaked whales with the intent to highlight the primary range of this community and acknowledge that a core range off Oʻahu may also exist, yet currently remains unknown due to limited information on the distribution and movements of individuals belonging to the Oʻahu community. The hierarchical BIA for Hawaiʻi Island Blainville's beaked whales was defined as the area between the 500 m and 2,000 m isobaths off the leeward side of the island based on both sighting rates in relation to bathymetric depths (Baird et al., 2013) and concentration of satellite tag locations (Abecassis et al., 2015; Baird et al., 2010; Schorr et al., 2009).

Data sources: Cascadia Research Collective (unpub. data, 2002-2021); National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020, accessed 2021; Barlow 2006; Bradford et al., 2017; Yano et al., 2018, 2020); Abecassis et al., 2015; Baird et al., 2009, 2011, 2013, 2015; Baird 2019; Mahaffy et al., 2015; McSweeney et al., 2007; Schorr et al., 2009

Approximate % of population that uses this area for the designated purpose (if known): 50

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Abecassis, M., J. Polovina, R.W. Baird, A. Copeland, J.C. Drazen, R. Domokos, E. Oleson, Y. Jia, G.S. Schorr, D.L. Webster, and R.D. Andrews. 2015. Characterizing a foraging hotspot for short-finned pilot whales and Blainville's beaked whales located off the west side of Hawaiʻi Island by using tagging and oceanographic data. PLoS ONE 10(11):e0142628 doi:10.1371/journal.pone.0142628

Baird, R.W., D.J. McSweeney, G.S. Schorr, S.D. Mahaffy, D.L. Webster, J. Barlow, M.B. Hanson, J.P. Turner, and R.D. Andrews. 2009. Studies of beaked whales in Hawaiʻi: Population size, movements, trophic ecology, social organisation, and behaviour. ECS Special Publication 1:23-25

Baird, R.W., G.S. Schorr, D.L. Webster, S.D. Mahaffy, D.J. McSweeney, M.B. Hanson, and R.D. Andrews. 2011. Open-ocean movements of a satellite-tagged Blainville's beaked whale (Mesoplodon densirostris): Evidence for an offshore population in

Hawaiʻi? Aquatic Mammals 37:506-511

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Baird, R.W. 2019. Behavior and ecology of not-so-social odontocetes: Cuvier's and Blainville's beaked whales. Pages 305-329 in: Ethology and Behavioral Ecology of Toothed Whales and Dolphins, the Odontocetes. Edited by B. Würsig. Springer.

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22(2):446-464

Bradford, A.L., K.A. Forney, E.M. Oleson, and J. Barlow. 2017. Abundance estimates of cetaceans from a line-transect survey within the U.S. Hawaiian Islands Exclusive Economic Zone. Fishery Bulletin 115:129-142

Bradford, A.L., E.M. Oleson, K.A. Forney, J.E. Moore, and J. Barlow. 2021. Line-transect abundance estimates of cetaceans in U.S. waters around the Hawaiian Islands in 2002, 2010, and 2017. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-PIFSC-115, 52 p. doi:10.25923/daz4-kw84

Caretta, J.V., E.M. Oleson, K.A. Forney, M.M. Muto, D.W. Weller, A.R. Lang, J. Baker, B. Hanson, A.J. Orr, J. Barlow, J.E. Moore, and R.L. Brownwell Jr. 2021. U.S. Pacific Marine Mammal Stock Assessments: 2020. U.S. Department of Commerce, NOAA.

Duong, T., and M.L. Hazelton. 2003. Plug-in bandwidth matrices for bivariate kernel density estimation. Journal of Nonparametric Statistics 15:17-30.

Duong, T., and M.L. Hazelton. 2005. Cross-validation bandwidth matrices for multivariate kernel density estimation. Scandinavian Journal of Statistics 32:485-506.

Duong, T. 2007. Ks: Kernel density estimation and kernel discriminant analysis for multivariate data in R. Journal of Statistical Software 21:1-16.

Duong, T. 2021. Ks: Kernel smoothing. R package version 1.12.0 https://CRAN.R-project.org/package=ks

Hauser, D.D.W., K.L. Laidre, R.S. Suydam, and P.R. Richard. 2014. Population-specific home ranges and migration timing of Pacific Arctic beluga whales (Delphinapterus leucas). Polar Biology 37:1171-1183

Hill, M.C., A.R. Bendlin, A.M. Van Cise, A. Milette-Winfree, A.D., Ligon, A.C. Ü, M.H. Deakos, and E.M. Oleson. 2019. Short-finned pilot whales (Globicephala macrorhynchus) of the Mariana Archipelago: individual affiliations, movements, and spatial use. Marine Mammal Science 35(3):797-824 doi:10.1111/mms.12567

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Mahaffy, S.D., R.W. Baird, D.J. McSweeney, D.L. Webster, and G.S. Schorr. 2015. Group structure and mating strategies of Cuvier's (Ziphius cavirorstris) and Blainville's (Mesoplodon densirostris) beaked whales off the island of Hawaiʻi. Poster presented at the 21st Biennial Conference on the Biology of Marine Mammals, San Francisco, California, December 14-18, 2015.

McSweeney, D.J., R.W. Baird, and S.D. Mahaffy. 2007. Site fidelity, associations, and movements of Cuvier's (Ziphius cavirostris) and Blainville's (Mesoplodon densirostris) beaked whales off the island of Hawaiʻi. Marine Mammal Science 23(3):666-687. Doi:10.1111/j.1748-7692.2007.00135.x

Schorr, G.S., R.W. Baird, M.B. Hanson, D.L. Webster, D.J. McSweeney, and R.D. Andrews. 2009. Movements of satellite-tagged Blainville's beaked whales off the island of Hawaiʻi. Endangered Species Research 10:203-213

Yano, K.M., E.M. Oleson, J.L. Keating, L.T. Ballance, M.C. Hill, A.L. Bradford, A.N. Allen, T.W. Joyce, J.E. Moore, and A. Henry. 2018. Cetacean and seabird data collected during the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS), July-December 2017. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TM-NMFS-PIFSC-72, 110 p. doi:10.25923/7avn-gw82

Yano, K.M., E.M. Olesn, J.L.K. McCullough, M.C. Hill, and A.E. Henry. 2020. Cetacean and seabird data collected during the winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey (Winter HICEAS), January-March 2020. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-111, 72 p. doi:10.25923/ehfg-dp78

Worton, B.J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:1

Supplementary Description 6. 3. Common bottlenose dolphin small and resident pop.

Species name: Common bottlenose dolphin (*Tursiops truncatus*)

Stock or population: Hawai'i island stock

Descriptive name: Hawai'i Island

BIA type: Small and Resident Pop.

BIA label: S-BIA2-s-b3-HI017-0

Transboundary across: None

Hierarchy: Non-hierarchical; single BIA

Importance score: 2 (Intensity: 2, Data support: 3)

Intensity matrix: Abundance: 2, Range: 2

Supporting notes for intensity score: Abundance estimates specific to each island-associated stock of bottlenose dolphins in Hawaiʻi were recently reported by Van Cise et al., (2021) based on long-term photo-identification data collected by CRC, other researchers, and community scientists. The abundance estimate for the Hawaiʻi Island stock was 136 individuals (SE=58) for the last year of the study (2018, estimated annually over the study period; Van Cise et al., 2021). Although an argument could be made to assign this stock's abundance the highest Intensity score of the BIA criteria (125 or fewer individuals) based on the uncertainty associated with the estimate, Van Cise et al., (2021) notes that because the abundance estimates for this stock were exclusively derived from encounters off the leeward side of the island, the reported values likely underestimate the true stock abundance. Based on this and knowing from satellite tag data that bottlenose dolphins use windward sides of the island where survey effort has been precluded, we assume the population is within the 126 to 500 range of the BIA Intensity scoring criteria (abundance score = 2). The resulting area of the BIA (i.e., population range size) is 8,299 km2 (range size score = 2).

The abundance estimate used to derive the intensity score is contemporary, specific to this island-associated stock, and based on long-term photo-identification data collected from extensive survey effort and opportunistic sightings; thus, we have high confidence that this stock's true abundance is within 126-500 individuals. Although the tag deployments used to help inform the BIA boundary were short, they were deployed during five different years and tagged individuals displayed similar use of nearshore habitat, with some individuals moving along windward sides of the island where survey effort has been precluded.

Supporting notes for data support score: Data Support score = 3.

• This stock has been studied for 20 years (2002-2021), although primarily through small boat surveys. Additional photographic data supplied by other researchers and community science contributions span a 34-year period.
• A total of 133 sightings from CRC effort, eight sightings from NMFS shipboard line-transect surveys, 148 encounters from other researchers and community scientists since 1987, with re-sightings of individuals up to 18 years (2003 to 2020)
• Five satellite tag deployments (1,749 filtered Argos locations) transmitting for up to ~30 days, all of which showed similar insular habitat use with some individuals moving along windward sides of the island
• Tag positional uncertainty and irregularity accounted for through crawl model, and boundary encompasses nearly all of crawl standard error (68% confidence interval) ellipses

The existence of this small, resident, island-associated stock has been recognized for over a decade (Baird et al., 2009; Baird, 2016; Caretta et al., 2019) and its differentiation from other island-associated and pelagic stocks is supported by genetic studies (Martien et al., 2011), long-term, high resighting rates (up to 18 years), (and information on movements through satellite tag deployments (Baird et al., 2009; Baird, 2016; CRC unpublished). Recent abundance estimates based on long-term photo-identification data further support the fact that this stock is both small and resident (Van Cise et al., 2021). The distribution of sighting and crawl-predicted locations is fairly consistent within the MCP boundary and current stock boundary (1,000 m isobath) with the exception of some areas off windward sides of the island where no sightings occurred (likely due to a lack of survey effort) and where no satellite tag locations were available. Despite this, the spatial extents of the boundary are supported by the MCP methods and objective estimates of uncertainty in tag locations.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: This population is resident to this area year-round and no information (from available data) suggests the area is used dynamically or ephemerally.

Boundary certainty: 3

Supporting notes for boundary certainty: We have high confidence in boundary certainty for the S-BIA for Hawaiʻi Island bottlenose dolphins. The boundary encompasses the entire stock based on a long-term sighting dataset, curated from extensive survey effort, and available information from satellite tag deployments. Some satellite tagged animals used similar insular habitat off windward areas of the island where survey effort has been precluded, and positional uncertainty was accounted for in satellite tag data. In addition, the boundary includes areas of known habitat that bottlenose dolphins from this stock likely use (waters within 1,000 m deep, stock boundary), but where spatial data are lacking due to limited effort.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 5

# of years in which supporting tagging data collected: 5 (2012-2021)

Supporting information: Satellite tags were deployed on five bottlenose dolphins off the west side of Hawaiʻi Island during dedicated survey efforts from 2012-2021. Briefly, location data were filtered following CRC's protocol and subsequently fit to a continuous-time correlated random walk using the package crawl implemented in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 1-hour interval and locations on land were re-routed around a polygon representing the islands with an added 50-m distance using the pathroutr package (London, 2020).

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 141 sightings

# of years in which supporting visual data collected: 20 (2002-2021)

Supporting information: Sighting data were collected from non-systematic, dedicated small boat surveys conducted off Hawaiʻi Island from 2002-2021 (see Baird et al., 2013b for details on surveys). Surveys off Hawaiʻi Island total 97,438 km of effort with 134 sightings of bottlenose dolphins. One of these sightings was in waters greater than 3,500 m deep and suspected to be part of a broader pelagic population; thus, this sighting was excluded from the BIA boundary delineation process. In addition, community science photographic and sightings contributions have added substantially to the information available on this stock, with 148 sightings off Hawaiʻi Island over a period of 34 years (1987-2020), comprising over 40% of all individuals in CRC's photo-identification catalog of Hawaiʻi Island bottlenose dolphins (CRC unpublished). Individuals have been resighted off this island for up to 18 years (2003-2020). While community science contributions rarely come with specific latitudes and longitudes to include in the boundary delineation process (typically only general locality is provided, e.g., off Hawaiʻi Island), in this assessment we use the information on social structure and associated movements that these photographic contributions have supported. Additional sighting data were available from NMFS ship-based line-transect surveys (Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020), and those with confirmed photographic assignment to the Hawaiʻi Island insular stock or within the known range of this stock were used in boundary determinations (n=8); effort from these surveys in the area shown in the respective figure total 4,906 km.

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 247

# of years of photo records to compare: 21 (1987-2020)

Maximum # of years same individual photographed in area: 18 (2003-2020)

Supporting information: Individuals have been resighted off this island for up to 18 years (2003-2020). While community science contributions rarely come with specific latitudes and longitudes to include in the boundary delineation process (typically only general locality is provided, e.g., off Hawaiʻi Island), in this assessment we use the information on social structure and associated movements that these photographic contributions have supported. Community science photographic contributions have added substantially to the information available on this population, with 148 sightings off Hawaiʻi Island over a period of 34 years (1987-2020), comprising over 40% of all individuals in CRC's photo-identification catalog of Hawaiʻi Island bottlenose dolphins (CRC unpublished).

Genetic analyses conducted supporting designation (Y/N): Y

Weak/moderate/strong support for genetic differentiation: Strong

Nature of supporting information: Strong

Supporting information: Genetic evidence suggests that there are four demographically isolated insular populations of bottlenose dolphins throughout the Hawaiian archipelago as well as a pelagic population (Martien et al., 2011). These five populations are recognized as distinct stocks by the National Marine Fisheries Service.

What factors justify the boundary selection?: Baird et al., (2015) delineated the BIA for Hawaiʻi Island bottlenose dolphins using its designated stock boundary (1,000-m isobath around the island). For this assessment, updated information from sightings and satellite tag data were used to evaluate the adequacy of the existing BIA for this stock in light of the new delineation protocols, and necessary revisions were made.

The basis for the BIA was a minimum convex polygon (MCP) encompassing all sighting and satellite-tag derived crawl locations. A 3-km distance band was added to the outer boundary of the MCP to account for positional uncertainty estimated by crawl; such a band captures nearly all of the positional uncertainty estimated by the model. The MCP (with band) was merged with the stock boundary (1,000-m isobath) to include areas that the MCP did not extend to due to limited survey effort in these areas, yet likely used by bottlenose dolphins based on similar habitat features. The inner (shoreward) boundary was defined as a 50-m distance band from shore such to include shallow waters used by bottlenose dolphins in this region (shallowest sighting off Hawaiʻi = 25-m). The resulting area of the BIA (i.e., population range size) is 8,299 km2.

Data sources: Cascadia Research, unpub. data, 2002-2021; National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020; accessed 2021); Baird et al., 2009, 2013a, 2013b, 2015; Martien et al., 2011; Van Cise et al., 2021

Approximate % of population that uses this area for the designated purpose (if known): 100

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Baird, R.W., A.M. Gorgone, D.J. McSweeney, A.D. Ligon, M.H. Deakos, D.L. Webster, G.S. Schorr, K.K. Martien, D.R. Salden, and S.D. Mahaffy. 2009. Population structure of island-associated dolphins: evidence from photo-identification of common bottlenose dolphins (Tursiops truncatus) in the main Hawaiian Islands. Marine Mammal Science 25(2):251-274 doi:10.1111/j.1748-7692.2008.00257.x

Baird, R.W., D.L. Webster, S.D. Mahaffy, G.S. Schorr, J.M Aschettino, and A.M. Gorgone. 2013a. Movements and spatial use of odontocetes in the western main Hawaiian Islands: results of a three-year study off Oʻahu and Kauaʻi. Final report under Grant No. N00244-10-1-0048 from the Naval Postgraduate School.

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013b. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Baird, R.W., C.J. Cornforth, S.M. Jarvis, N.A. DiMarzio, K. Dolan, E.E. Henderson, S.W. Martin, S.L. Watwood, S.D. Mahaffy, B.D. Guenther, J.K. Lerma, A.E. Harnish, and M.A. Kratofil. 2021. Odontocete studies on the Pacific Missile Range Facility in February 2020: satellite tagging, photo-identification, and passive acoustic monitoring. Prepared for Commander, Pacific Fleet, Environmental Readiness Division, Pearl Harbor, HI, under Contract No. N62470-15-D-8006 Task Order N6274219F0101 issued to HDR Inc., Honolulu, HI. February 2021.

Caretta, J.V., K.A. Forney, E.M. Oleson, D.W. Weller, A.R. Lang, J. Baker, M.M. Muto, B. Hanson, A.J. Orr, H. Huber, M.S. Lowry, J. Barlow, J.E. Moore, D. Lynch, L. Carswell, and R.L. Brownwell Jr. 2019. U.S. Pacific Marine Mammal Stock Assessments: 2018. U.S. Department of Commerce, NOAA.

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

Harnish, A.E. 2021. Population structure, residency, and inter-island movements of common bottlenose dolphins (Tursiops truncatus) off Oʻahu and Maui Nui. M.E.S. Thesis, The Evergreen State College, Olympia, WA, USA. 117pg.

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Martien, K.K., R.W. Baird, N.M. Hedrick, A.M. Gorgone, J.L. Thieleking, D.J. McSweeney, K.M. Robertson, and D.L. Webster. 2011. Population structure of island-associated dolphins: evidence from mitochondrial and microsatellite markers for common bottlenose dolphins (Tursiops truncatus) around the main Hawaiian Islands. Marine Mammal Science 28(3): E208-E232 doi:10.1111/j.1748-7692.2011.00506.x

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Van Cise, A.M., R.W. Baird, A.E. Harnish, J.J. Currie, S.H. Stack, T. Cullins, and A.M. Gorgone. 2021. Mark-recapture estimates suggest declines in abundance of common bottlenose dolphin stocks in the main Hawaiian Islands. Endangered Species Research 45:37-53 doi:10.3354/esr01117

Supplementary Description 6. 4. Common bottlenose dolphin small and resident pop.

Species name: Common bottlenose dolphin (*Tursiops truncatus*)

Stock or population: Kaua'i/Ni'ihau, O'ahu, and Maui Nui stocks

Descriptive name: Kaua'i/Ni'ihau-O'ahu-Maui Nui - Parent

BIA type: Small and Resident Pop.

BIA label: S-BIA1-s-b2-HI018-0abc

Transboundary across: None

Hierarchy: Hierarchical BIA; Parent of children abc

Importance score: 1 (Intensity: 1, Data support: 3)

Intensity matrix: Abundance: 2, Range: 1

Supporting notes for intensity score: Abundance estimates specific to each island-associated stock of bottlenose dolphins in Hawaiʻi were recently reported by Van Cise et al., (2021) based on long-term photo-identification data collected by CRC, other researchers, and community scientists. The abundance estimates for the Kauaʻi/Niʻihau, Oʻahu, and Maui Nui stocks were 112 (SE=27), 112 (SE=19), and 64 (SE=9.3), respectively, for the last year of the study (2018, estimated annually over the study period; Van Cise et al., 2021). Combined these estimates total to 288 individuals comprising these KNOMN population of bottlenose dolphins. Based on this, and in consideration of the uncertainty associated with the stock-specific estimates, we assume the abundance of the KNOMN population is within the 126 to 500 category of the BIA Intensity scoring criteria (abundance score =2). The resulting area of the parent BIA is 36,634 km2 (range size score = 1).

The abundance estimate used to derive the Intensity score is contemporary, specific to the island-associated stocks comprising the KNOMN population, and based on long-term photo-identification data collected from extensive survey effort and opportunistic sightings; thus, we have high confidence that the true abundance is within 126-500 individuals, although this is the combined abundance for three different stocks. Although the tag deployments used to help inform the BIA boundary were relatively short, they were deployed during different years and seasons and tagged individuals generally displayed similar habitat use, with some individuals moving between island areas.

Supporting notes for data support score: Data Support score = 3.

• This population has been studied for 22 years (2000-2021), although not surveyed every year and primarily through small boat surveys. Additional photographic data supplied by other researchers and community science contributions span a 24-year period.
• A total of 231 sightings from CRC effort, 20 sightings from NMFS ship-based line-transect effort, 696 encounters from other researchers and community scientists since 1996, with re-sightings of individuals up to 21 years (1997-2018)
• 21 satellite tag deployments (6,358 filtered Argos locations) transmitting for up to ~34 days, all of which generally showed similar habitat use around island areas (nearshore, shallower waters) with some individuals moving between island areas
• Tag positional uncertainty and irregularity accounted for through crawl model, and boundary encompasses nearly all of crawl standard error (68% confidence interval) ellipses

The existence of small, resident, island-associated stocks of bottlenose dolphins around Kauaʻi/Niʻihau, Oʻahu, and Maui Nui, respectively, has long been recognized (Baird et al., 2009; Baird, 2016; Caretta et al., 2019). Recent abundance estimates based on long-term photo-identification data further support the existence of these small and resident stocks (Van Cise et al., 2021). Movements between these island-associated populations are rare, but have occurred and thus support our delineation of a KNOM population-wide parent BIA (Baird, 2016; Baird et al., 2021; Harnish, 2021). Out of the 15 satellite tags deployed on bottlenose dolphins off Kauaʻi from 2011-2020, only one tagged individual left nearshore waters of Kauaʻi and moved to Oʻahu, and has not been documented associating with the Oʻahu resident population (Baird, 2016; Baird et al., 2021). This Kauaʻi/Niʻihau individual has only been encountered once (when it was tagged off Kauaʻi). As of May 2021 CRC's photo-identification catalog does not include any inter-island individuals sighted at both Kauaʻi/Niʻihau and other island areas (CRC unpublished).

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: This population is resident to this area year-round and no information (from available data) suggests the area is used dynamically or ephemerally.

Boundary certainty: 2

Supporting notes for boundary certainty: We have intermediate confidence in Boundary Certainty for the parent BIA for KNOMN bottlenose dolphins. The boundary encompasses the community comprised of three different stocks based on current designated stock boundaries, a long-term sighting dataset, and available information on satellite tag deployments. The boundary includes some areas farther offshore between Kauaʻi/Niʻihau and Oʻahu where there are no data points, primarily driven by the movement of a single individual between these island areas; however, the spatial extents of the boundary is supported by the MCP methods and objective estimates of uncertainty in tag locations.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 21

# of years in which supporting tagging data collected: 8 (2011-2020)

Supporting information: Satellite tags were deployed on 21 bottlenose dolphins during dedicated survey efforts off Kauaʻi/Niʻhau from 2011-2020 (n=15), Oʻahu in 2016 (n=1), and Maui Nui from 2012-2020 (n=5). Three of the tag deployments off Maui Nui were on individuals considered to be part of the Oʻahu stock (Harnish, 2021). Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk using the package crawl implemented in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 1-hour interval and locations on land were re-routed around a polygon representing the islands with an added 50-m distance using the pathroutr package (London, 2020).

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 251

# of years in which supporting visual data collected: 17 (2000-2021)

Supporting information: Sighting data were collected from non-systematic, dedicated small boat surveys conducted off Kauaʻi/Niʻihau, Oʻahu, and Maui Nui in 13, six, and nine years, respectively, spanning 2000-2021 (see Baird et al., 2011b, 2013, 2021 for details on surveys). Surveys off these islands combined total 50,642 km of effort with 234 sightings of bottlenose dolphins. Three of these sightings were off Kaʻula and not considered to be part of the Kauaʻi/Niʻihau stock (Carretta et al., 2021), and thus, were excluded from the BIA boundary delineation. In addition, community science photographic and sightings contributions (n = 696 encounters) have added substantially to the information available on the KNOMN population, comprising over 60% of the identifications in CRC's photo-identification catalog of KNOMN bottlenose dolphins, collected over a period of 24 years (1996-2019; CRC unpublished). While community science contributions rarely come with specific latitudes and longitudes to include in the boundary delineation process (only a general island or regional locality is typically provided), we used the information on social structure and relative abundance from these contributions in this assessment. Additional sighting data were available from NMFS ship-based line-transect surveys (Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020), and those with confirmed photographic assignment to the KNOMN insular population or within the known range of the KNOMN population were used in boundary determinations (n=20); effort from these surveys in the area total 12,732 km.

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 744

# of years of photo records to compare: 25 (1996-2020)

Maximum # of years same individual photographed in area: 15

Supporting information: A total of 231 sightings from CRC effort, 696 encounters from other researchers and community scientists since 1996, with re-sightings of individuals up to 21 years (1997-2018). The existence of a small, resident, island-associated stock of bottlenose dolphins around around Kauaʻi/Niʻihau, Oʻahu, and Maui Nui have long been recognized (Baird et al., 2009; Baird, 2016; Caretta et al., 2019). Recent abundance estimates based on long-term photo-identification data further support the existence of these small and resident populations (Van Cise et al., 2021).

Genetic analyses conducted supporting designation (Y/N): Y

Nature of supporting information: Strong

Supporting information: Genetic evidence suggests that there are four demographically isolated insular populations of bottlenose dolphins throughout the Hawaiian archipelago as well as a pelagic population (Martien et al., 2011). These five populations are recognized as distinct stocks by the National Marine Fisheries Service.

What factors justify the boundary selection?: Baird et al., (2015) delineated individual BIAs for each island-associated stock of bottlenose dolphins using its designated stock boundary (1,000-m isobath around the islands with the exception of a boundary in between Oʻahu and Maui Nui). In this assessment, a parent BIA boundary was delineated to encompass all three stocks among which there is documented evidence of inter-island movements (Kauaʻi/Niʻihau, Oʻahu and Maui Nui) and is hereafter referred as the "KNOMN population" (Harnish, 2021; Baird et al., 2021). Child BIAs were delineated for each of the three island-associated stocks. Therefore, each island-associated stock falls under the broader KNOMN population. Parent and child BIA boundaries were delineated based on sighting data, satellite tag data, and stock boundaries.

The basis for the parent BIA was a minimum convex polygon (MCP) encompassing all sighting and satellite-tag derived crawl locations. A 3-km distance was added to the outer boundary of the MCP to account for positional uncertainty estimated by crawl; this band captures nearly all of the positional uncertainty estimated by the model. The inner (shoreward) boundary was defined as 50-m distance band from shore such to include shallow waters used by bottlenose dolphins in these regions. The modified MCP was merged with the stock boundaries (1,000-m isobath) to include areas that the MCP did not extend to due to limited survey effort in these areas, yet likely used by bottlenose dolphins based on similar habitat features. The resulting area of the parent BIA is 36,634 km2.

Data sources: Cascadia Research Collective (unpub. data, 2000-2020); National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020; accessed 2021); Baird et al., 2009, 2013a, 2013b, 2015, 2021; Harnish 2021; Martien et al., 2011; Van Cise et al., 2021

Approximate % of population that uses this area for the designated purpose (if known): 100

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Baird, R.W., A.M. Gorgone, D.J. McSweeney, A.D. Ligon, M.H. Deakos, D.L. Webster, G.S. Schorr, K.K. Martien, D.R. Salden, and S.D. Mahaffy. 2009. Population structure of island-associated dolphins: evidence from photo-identification of common bottlenose dolphins (Tursiops truncatus) in the main Hawaiian Islands. Marine Mammal Science 25(2):251-274 doi:10.1111/j.1748-

7692.2008.00257.x

Baird, R.W., D.L. Webster, S.D. Mahaffy, G.S. Schorr, J.M Aschettino, and A.M. Gorgone. 2013a. Movements and spatial use of odontocetes in the western main Hawaiian Islands: results of a three-year study off Oʻahu and Kauaʻi. Final report under Grant No. N00244-10-1-0048 from the Naval Postgraduate School.

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013b. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Baird, R.W., C.J. Cornforth, S.M. Jarvis, N.A. DiMarzio, K. Dolan, E.E. Henderson, S.W. Martin, S.L. Watwood, S.D. Mahaffy, B.D. Guenther, J.K. Lerma, A.E. Harnish, and M.A. Kratofil. 2021. Odontocete studies on the Pacific Missile Range Facility in February 2020: satellite tagging, photo-identification, and passive acoustic monitoring. Prepared for Commander, Pacific Fleet, Environmental Readiness Division, Pearl Harbor, HI, under Contract No. N62470-15-D-8006 Task Order N6274219F0101 issued to HDR Inc., Honolulu, HI. February 2021.

Caretta, J.V., K.A. Forney, E.M. Oleson, D.W. Weller, A.R. Lang, J. Baker, M.M. Muto, B. Hanson, A.J. Orr, H. Huber, M.S. Lowry, J. Barlow, J.E. Moore, D. Lynch, L. Carswell, and R.L. Brownwell Jr. 2019. U.S. Pacific Marine Mammal Stock Assessments: 2018. U.S. Department of Commerce, NOAA.

Harnish, A.E. 2021. Population structure, residency, and inter-island movements of common bottlenose dolphins (Tursiops truncatus) off Oʻahu and Maui Nui. M.E.S. Thesis, The Evergreen State College, Olympia, WA, USA. 117pg.

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Martien, K.K., R.W. Baird, N.M. Hedrick, A.M. Gorgone, J.L. Thieleking, D.J. McSweeney, K.M. Robertson, and D.L. Webster. 2011. Population structure of island-associated dolphins: evidence from mitochondrial and microsatellite markers for common bottlenose dolphins (Tursiops truncatus) around the main Hawaiian Islands. Marine Mammal Science 28(3): E208-E232 doi:10.1111/j.1748-7692.2011.00506.x

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Van Cise, A.M., R.W. Baird, A.E. Harnish, J.J. Currie, S.H. Stack, T. Cullins, and A.M. Gorgone. 2021. Mark-recapture estimates suggest declines in abundance of common bottlenose dolphin stocks in the main Hawaiian Islands. Endangered Species Research 45:37-53 doi:10.3354/esr01117

Supplementary Description 6. 5. Common bottlenose dolphin small and resident pop.

Species name: Common bottlenose dolphin (*Tursiops truncatus*)

Stock or population: Kaua'i/Ni'ihau stock

Descriptive name: Kaua'i/Ni'ihau-O'ahu-Maui Nui - Child (Kaua'i/Ni'ihau)

BIA type: Small and Resident Pop.

BIA label: S-BIA3-s-b3-HI018-b

Transboundary across: None

Hierarchy: Hierarchical BIA; Child b

Importance score: 3 (Intensity: 3, Data support: 3)

Intensity matrix: Abundance: 3, Range: 2

Supporting notes for intensity score: Intensity score = 3; Stock-specific abundance estimates reported by Van Cise et al., (2021) are used to inform the Intensity score for each island-associated child BIA. The abundance estimates for the Kauaʻi/Niʻihau, Oʻahu, and Maui Nui stocks were 112 (SE=27), 112 (SE=19), and 64 (SE=9.3), respectively, for the last year of the study (2018, estimated annually over the study period; Van Cise et al., 2021). Based on this information on abundance specific to each child BIA here and the range sizes of the child BIAs (listed below), as well as the fact that these child BIAs represent intensified use relative to the parent BIA, we assigned Intensity scores of 3, 3, and 2 for the Kauaʻi/Niʻihau, Oʻahu, and Maui Nui child BIAs, respectively. Using these values, the approximate proportion of the KNOMN combined abundance contained within each child BIA is 39%, 39%, and 22%, for Kauaʻi/Niʻihau, Oʻahu, and Maui Nui BIAs, respectively. The area of this child BIA is 2,772 km2.

Similar to the Intensity score rationale for the parent BIA, abundance estimates used to inform the scores for these child BIAs were based on a recent analysis that generated stock-specific estimates, derived from long-term photo-identification data collected from extensive survey effort and opportunistic sightings (Van Cise et al., 2021); thus, we have high confidence in the small abundance of each stock with a child BIA. Despite the varying satellite tag deployment lengths and number of satellite tags deployed off different island areas, bottlenose dolphins that were satellite tagged rarely moved outside of delineated child BIAs.

Supporting notes for data support score: Score = 3; Each child BIA was drawn using current designated stock boundaries, representing known primary habitat (<1,000 m isobath), combined with satellite tag data, and information accrued over two decades from dedicated small boat survey efforts, shipboard line-transect surveys, and community scientists, which further supports the existence of these smaller, island-associated stocks. The latter sources of information also support the overlapping geographical ranges of the Oʻahu and Maui Nui bottlenose dolphins (CRC unpublished; Harnish, 2021). More satellite tags have been deployed on bottlenose dolphins off Kauaʻi compared to the other island areas. Therefore, the strength of the supporting data for the Kauaʻi/Niʻihau child BIA is greater than those for the Oʻahu and Maui Nui child BIAs. Despite this, what the Oʻahu and Maui Nui child BIAs lack in support from dedicated survey effort and satellite tag data is substantiated by the strength of contributed data from community scientists and collaborating researchers; of the 696 non-CRC sightings of bottlenose dolphins in the KNOM region, 675 (97%) occurred off Maui Nui and Oʻahu (CRC unpublished), spanning a period of 24 years (CRC unpublished; Harnish, 2021). Based on this, we assign the Kauaʻi/Niʻihau child BIA a Data Support score of three and the Oʻahu and Maui Nui child BIAs Data Support scores of two to reflect the differing biases and limitations associated with the primary sources of information used to inform each area.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: This population is resident to this area year-round and no information (from available data) suggests the area is used dynamically or ephemerally.

Boundary certainty: 3

Supporting notes for boundary certainty: We have high certainty in the boundary for the Kauaʻi/Niʻhau child BIA. Considering the quantity, quality, and longevity of supporting data from all available sources of information (dedicated small boat survey efforts, satellite tag data, re-sighting rates, etc.), we feel this boundary accurately reflects the primary range of this island-associated population.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 15

# of years in which supporting tagging data collected: 6 (2011-2020)

Supporting information: Satellite tags were deployed on 15 bottlenose dolphins during dedicated survey efforts off Kauaʻi/Niʻhau from 2011-2020. Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk using the package crawl implemented in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 1-hour interval and locations on land were re-routed around a polygon representing the islands with an added 50-m distance using the pathroutr package (London, 2020).

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 148

# of years in which supporting visual data collected: 13 (2003-2021)

Supporting information: Sighting numbers entered here reflect the number of sightings for this particular stock/region. General sighting information: Sighting data were collected from non-systematic, dedicated small boat surveys conducted off Kauaʻi/Niʻihau, Oʻahu, and Maui Nui in 13, six, and nine years, respectively, spanning 2000-2021 (see Baird et al., 2011b, 2013, 2021 for details on surveys). Surveys off these islands combined total 50,642 km of effort with 234 sightings of bottlenose dolphins. Three of these sightings were off Kaʻula and not considered to be part of the Kauaʻi/Niʻihau stock (Carretta et al., 2021), and thus, were excluded from the BIA boundary delineation. In addition, community science photographic and sightings contributions (n = 696 encounters) have added substantially to the information available on the KNOMN population, comprising over 60% of the identifications in CRC's photo-identification catalog of KNOMN bottlenose dolphins, collected over a period of 24 years (1996-2019; CRC unpublished). While community science contributions rarely come with specific latitudes and longitudes to include in the boundary delineation process (only a general island or regional locality is typically provided), we used the information on social structure and relative abundance from these contributions in this assessment. Additional sighting data were available from NMFS ship-based line-transect surveys (Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020), and those with confirmed photographic assignment to the KNOMN insular population or within the known range of the KNOMN population were used in boundary determinations (n=20); effort from these surveys in the area total 12,732 km.

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 208

# of years of photo records to compare: 14 (2003-2020)

Maximum # of years same individual photographed in area: 11

Supporting information: The existence of a small, resident, island-associated stock of bottlenose dolphins around Kauaʻi/Niʻihau has long been recognized (Baird et al., 2009; Baird, 2016; Caretta et al., 2019). Recent abundance estimates based on long-term photo-identification data further support the existence of these small and resident populations (Van Cise et al., 2021).

Genetic analyses conducted supporting designation (Y/N): Y

Nature of supporting information: Strong

Supporting information: Genetic evidence suggests that there are four demographically isolated insular populations of bottlenose dolphins throughout the Hawaiian archipelago as well as a pelagic population (Martien et al., 2011). These five populations are recognized as distinct stocks by the National Marine Fisheries Service.

What factors justify the boundary selection?: Baird et al., (2015) delineated individual BIAs for each island-associated stock of bottlenose dolphins using its designated stock boundary (1,000-m isobath around the islands with the exception of a boundary in between Oʻahu and Maui Nui). In this assessment, a parent BIA boundary was delineated to encompass all three stocks among which there is documented evidence of inter-island movements (Kauaʻi/Niʻihau, Oʻahu and Maui Nui) and is hereafter referred as the "KNOMN population" (Harnish, 2021; Baird et al., 2021). Child BIAs were delineated for each of the three island-associated stocks. Therefore, each island-associated stock falls under the broader KNOMN population. Parent and child BIA boundaries were delineated based on sighting data, satellite tag data, and stock boundaries.

Although it is known that some movement occurs between these island areas (Baird, 2016; Baird et al., 2021; Harnish, 2021), bottlenose dolphins generally remain near their island-associated regions. Rather than attempt to describe core ranges within each stock, we delineated child BIAs for each of the three stocks comprising the KNOMN population with the intent to highlight the primary ranges of each island-associated stock. Child BIA boundaries were drawn initially using each island-associated stock boundary as these boundaries capture the majority of satellite tag derived crawl locations (and their error ellipses) and sighting locations. The Kauaʻi/Niʻihau child BIA was drawn using current designated stock boundaries, representing known primary habitat (<1,000 m isobath).

Data sources: Cascadia Research Collective (unpub. data 2000-2020); National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020; accessed 2021); Baird et al., 2009, 2013a, 2013b, 2015, 2021; Martien et al., 2011, Van Cise et al., 2021

Approximate % of population that uses this area for the designated purpose (if known): 39

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Baird, R.W., A.M. Gorgone, D.J. McSweeney, A.D. Ligon, M.H. Deakos, D.L. Webster, G.S. Schorr, K.K. Martien, D.R. Salden, and S.D. Mahaffy. 2009. Population structure of island-associated dolphins: evidence from photo-identification of common bottlenose dolphins (Tursiops truncatus) in the main Hawaiian Islands. Marine Mammal Science 25(2):251-274 doi:10.1111/j.1748-7692.2008.00257.x

Baird, R.W., D.L. Webster, S.D. Mahaffy, G.S. Schorr, J.M Aschettino, and A.M. Gorgone. 2013a. Movements and spatial use of odontocetes in the western main Hawaiian Islands: results of a three-year study off Oʻahu and Kauaʻi. Final report under Grant No. N00244-10-1-0048 from the Naval Postgraduate School.

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013b. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Baird, R.W., C.J. Cornforth, S.M. Jarvis, N.A. DiMarzio, K. Dolan, E.E. Henderson, S.W. Martin, S.L. Watwood, S.D. Mahaffy, B.D. Guenther, J.K. Lerma, A.E. Harnish, and M.A. Kratofil. 2021. Odontocete studies on the Pacific Missile Range Facility in February 2020: satellite tagging, photo-identification, and passive acoustic monitoring. Prepared for Commander, Pacific Fleet, Environmental Readiness Division, Pearl Harbor, HI, under Contract No. N62470-15-D-8006 Task Order N6274219F0101 issued to HDR Inc., Honolulu, HI. February 2021.

Caretta, J.V., K.A. Forney, E.M. Oleson, D.W. Weller, A.R. Lang, J. Baker, M.M. Muto, B. Hanson, A.J. Orr, H. Huber, M.S. Lowry, J. Barlow, J.E. Moore, D. Lynch, L. Carswell, and R.L. Brownwell Jr. 2019. U.S. Pacific Marine Mammal Stock Assessments: 2018. U.S. Department of Commerce, NOAA.

Harnish, A.E. 2021. Population structure, residency, and inter-island movements of common bottlenose dolphins (Tursiops truncatus) off Oʻahu and Maui Nui. M.E.S. Thesis, The Evergreen State College, Olympia, WA, USA. 117pg.

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Martien, K.K., R.W. Baird, N.M. Hedrick, A.M. Gorgone, J.L. Thieleking, D.J. McSweeney, K.M. Robertson, and D.L. Webster. 2011. Population structure of island-associated dolphins: evidence from mitochondrial and microsatellite markers for common bottlenose dolphins (Tursiops truncatus) around the main Hawaiian Islands. Marine Mammal Science 28(3): E208-E232 doi:10.1111/j.1748-7692.2011.00506.x

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Van Cise, A.M., R.W. Baird, A.E. Harnish, J.J. Currie, S.H. Stack, T. Cullins, and A.M. Gorgone. 2021. Mark-recapture estimates suggest declines in abundance of common bottlenose dolphin stocks in the main Hawaiian Islands. Endangered Species Research 45:37-53 doi:10.3354/esr01117

Supplementary Description 6. 6. Common bottlenose dolphin small and resident pop.

Species name: Common bottlenose dolphin (*Tursiops truncatus*)

Stock or population: O'ahu stock

Descriptive name: Kaua'i/Ni'ihau-O'ahu-Maui Nui - Child (O'ahu)

BIA type: Small and Resident Pop.

BIA label: S-BIA3-s-b2-HI018-c

Transboundary across: None

Hierarchy: Hierarchical BIA; Child c

Importance score: 3 (Intensity: 3, Data support: 2)

Intensity matrix: Abundance: 3, Range: 2

Supporting notes for intensity score: Intensity = 3; Stock-specific abundance estimates reported by Van Cise et al., (2021) are used to inform the Intensity score for each island-associated child BIA. The abundance estimates for the Kauaʻi/Niʻihau, Oʻahu, and Maui Nui stocks were 112 (SE=27), 112 (SE=19), and 64 (SE=9.3), respectively, for the last year of the study (2018, estimated annually over the study period; Van Cise et al., 2021). Based on this information on abundance specific to each child BIA here and the range sizes of the child BIAs (listed below), as well as the fact that these child BIAs represent intensified use relative to the parent BIA, we assigned Intensity scores of 3, 3, and 2 for the Kauaʻi/Niʻihau, Oʻahu, and Maui Nui child BIAs, respectively. Using these values, the approximate proportion of the KNOMN combined abundance contained within each child BIA is 39%, 39%, and 22%, for Kauaʻi/Niʻihau, Oʻahu, and Maui Nui BIAs, respectively. The size of this child BIA is 8,487 km2.

Similar to the Intensity score rationale for the parent BIA, abundance estimates used to inform the scores for these child BIAs were based on a recent analysis that generated stock-specific estimates, derived from long-term photo-identification data collected from extensive survey effort and opportunistic sightings (Van Cise et al., 2021); thus, we have high confidence in the small abundance of each stock with a child BIA. Despite the varying satellite tag deployment lengths and number of satellite tags deployed off different island areas, bottlenose dolphins that were satellite tagged rarely moved outside of delineated child BIAs.

Supporting notes for data support score: Score = 2; Each child BIA was drawn using current designated stock boundaries, representing known primary habitat (<1,000 m isobath), combined with satellite tag data, and information accrued over two decades from dedicated small boat survey efforts, shipboard line-transect surveys, and community scientists, which further supports the existence of these smaller, island-associated stocks. The latter sources of information also support the overlapping geographical ranges of the Oʻahu and Maui Nui bottlenose dolphins (CRC unpublished; Harnish, 2021). More satellite tags have been deployed on bottlenose dolphins off Kauaʻi compared to the other island areas. Therefore, the strength of the supporting data for the Kauaʻi/Niʻihau child BIA is greater than those for the Oʻahu and Maui Nui child BIAs. Despite this, what the Oʻahu and Maui Nui child BIAs lack in support from dedicated survey effort and satellite tag data is substantiated by the strength of contributed data from community scientists and collaborating researchers; of the 696 non-CRC sightings of bottlenose dolphins in the KNOM region, 675 (97%) occurred off Maui Nui and Oʻahu (CRC unpublished), spanning a period of 24 years (CRC unpublished; Harnish, 2021). Based on this, we assign the Kauaʻi/Niʻihau child BIA a Data Support score of three and the Oʻahu and Maui Nui child BIAs Data Support scores of two to reflect the differing biases and limitations associated with the primary sources of information used to inform each area.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: This population is resident to this area year-round and no information (from available data) suggests the area is used dynamically or ephemerally.

Boundary certainty: 2

Supporting notes for boundary certainty: We have intermediate certainty in the Oʻahu and Maui Nui child BIA boundaries; only a limited number of satellite tags have been deployed on bottlenose dolphins from these stocks, all of which have shown varying spatial use within Oʻahu/Maui Nui region, with some individuals crossing stock boundaries. Having only recently recognized the geographical overlap of these two stocks from photo-identification analyses and satellite tag data (CRC unpublished; Harnish, 2021), the true primary range of each stock remains unclear. In addition, the Oʻahu and Maui Nui child BIAs include regions off the windward sides of the islands with little data to support due to limited survey effort.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 4

# of years in which supporting tagging data collected: 3 (2016-2020)

Supporting information: Satellite tags were deployed on 4 dolphins from the Oʻahu stock from 2016-2020. One tag was deployed off Oʻahu, and three off Maui Nui on individuals considered to be part of the Oʻahu stock (Harnish, 2021). Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk using the package crawl implemented in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 1-hour interval and locations on land were re-routed around a polygon representing the islands with an added 50-m distance using the pathroutr package (London, 2020).

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 28

# of years in which supporting visual data collected: 7 (2002-2020)

Supporting information: Sighting numbers entered here reflect the number of sightings for this particular stock/region. General sighting information: Sighting data were collected from non-systematic, dedicated small boat surveys conducted off Kauaʻi/Niʻihau, Oʻahu, and Maui Nui in 13, six, and nine years, respectively, spanning 2000-2021 (see Baird et al., 2011b, 2013, 2021 for details on surveys). Surveys off these islands combined total 50,642 km of effort with 234 sightings of bottlenose dolphins. Three of these sightings were off Kaʻula and not considered to be part of the Kauaʻi/Niʻihau stock (Carretta et al., 2021), and thus, were excluded from the BIA boundary delineation. In addition, community science photographic and sightings contributions (n = 696 encounters) have added substantially to the information available on the KNOM population, comprising over 60% of the identifications in CRC's photo-identification catalog of KNOM bottlenose dolphins, collected over a period of 24 years (1996-2019; CRC unpublished). While community science contributions rarely come with specific latitudes and longitudes to include in the boundary delineation process (only a general island or regional locality is typically provided), we used the information on social structure and relative abundance from these contributions in this assessment. Additional sighting data were available from NMFS ship-based line-transect surveys (Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020), and those with confirmed photographic assignment to the KNOMN insular population or within the known range of the KNOMN population were used in boundary determinations (n=20); effort from these surveys in the area total 12,732 km.

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 336

# of years of photo records to compare: 18 (2002-2019)

Maximum # of years same individual photographed in area: 14

Supporting information: The existence of a small, resident, island-associated stock of bottlenose dolphins around Oahʻu has long been recognized (Baird et al., 2009; Baird, 2016; Caretta et al., 2019). Recent abundance estimates based on long-term photo-identification data further support the existence of these small and resident populations (Van Cise et al., 2021).

Genetic analyses conducted supporting designation (Y/N): Y

Nature of supporting information: Strong

Supporting information: Genetic evidence suggests that there are four demographically isolated insular populations of bottlenose dolphins throughout the Hawaiian archipelago as well as a pelagic population (Martien et al., 2011). These five populations are recognized as distinct stocks by the National Marine Fisheries Service.

What factors justify the boundary selection?: Baird et al., (2015) delineated individual BIAs for each island-associated stock of bottlenose dolphins using its designated stock boundary (1,000-m isobath around the islands with the exception of a boundary in between Oʻahu and Maui Nui). In this assessment, a parent BIA boundary was delineated to encompass all three stocks among which there is documented evidence of inter-island movements (Kauaʻi/Niʻihau, Oʻahu and Maui Nui) and is hereafter referred as the "KNOMN population" (Harnish, 2021; Baird et al., 2021). Child BIAs were delineated for each of the three island-associated stocks. Therefore, each island-associated stock falls under the broader KNOMN population. Parent and child BIA boundaries were delineated based on sighting data, satellite tag data, and stock boundaries.

Although it is known that some movement occurs between these island areas (Baird, 2016; Baird et al., 2021; Harnish, 2021), bottlenose dolphins generally remain near their island-associated regions. Rather than attempt to describe core ranges within each stock, we delineated child BIAs for each of the three stocks comprising the KNOMN population with the intent to highlight the primary ranges of each island-associated stock. Child BIA boundaries were drawn initially using each island-associated stock boundary as these boundaries capture the majority of satellite tag derived crawl locations (and their error ellipses) and sighting locations. The Oʻahu child BIA was modified to include an area ranging from Penguin Bank to south Lānaʻi, meeting the southernmost boundary of the Maui Nui child BIA, as both satellite tag data and sighting data have shown use of these areas by Oʻahu bottlenose dolphins (termed "inter-island travelers"; CRC unpublished; Harnish, 2021). As a result, the Maui Nui and Oʻahu child BIAs share a common, overlapping region covering Penguin Bank to south Lānaʻi, reflecting the demographic independence of these two island-associated stocks while also highlighting their overlapping ranges based on available data.

Data sources: Cascadia Research Collective (unpub. data, 2002-2017); National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020; accessed 2021); Baird et al., 2009, 2013a, 2013b, 2015; Harnish 2021; Martien et al., 2011; Van Cise et al., 2021

Approximate % of population that uses this area for the designated purpose (if known): 39

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Baird, R.W., A.M. Gorgone, D.J. McSweeney, A.D. Ligon, M.H. Deakos, D.L. Webster, G.S. Schorr, K.K. Martien, D.R. Salden, and S.D. Mahaffy. 2009. Population structure of island-associated dolphins: evidence from photo-identification of common bottlenose dolphins (Tursiops truncatus) in the main Hawaiian Islands. Marine Mammal Science 25(2):251-274 doi:10.1111/j.1748-7692.2008.00257.x

Baird, R.W., D.L. Webster, S.D. Mahaffy, G.S. Schorr, J.M Aschettino, and A.M. Gorgone. 2013a. Movements and spatial use of odontocetes in the western main Hawaiian Islands: results of a three-year study off Oʻahu and Kauaʻi. Final report under Grant No. N00244-10-1-0048 from the Naval Postgraduate School.

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013b. Odontocete cetaceans around the main

Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Baird, R.W., C.J. Cornforth, S.M. Jarvis, N.A. DiMarzio, K. Dolan, E.E. Henderson, S.W. Martin, S.L. Watwood, S.D. Mahaffy, B.D. Guenther, J.K. Lerma, A.E. Harnish, and M.A. Kratofil. 2021. Odontocete studies on the Pacific Missile Range Facility in February 2020: satellite tagging, photo-identification, and passive acoustic monitoring. Prepared for Commander, Pacific Fleet, Environmental Readiness Division, Pearl Harbor, HI, under Contract No. N62470-15-D-8006 Task Order N6274219F0101 issued to HDR Inc., Honolulu, HI. February 2021.

Caretta, J.V., K.A. Forney, E.M. Oleson, D.W. Weller, A.R. Lang, J. Baker, M.M. Muto, B. Hanson, A.J. Orr, H. Huber, M.S. Lowry, J. Barlow, J.E. Moore, D. Lynch, L. Carswell, and R.L. Brownwell Jr. 2019. U.S. Pacific Marine Mammal Stock Assessments: 2018. U.S. Department of Commerce, NOAA.

Harnish, A.E. 2021. Population structure, residency, and inter-island movements of common bottlenose dolphins (Tursiops truncatus) off Oʻahu and Maui Nui. M.E.S. Thesis, The Evergreen State College, Olympia, WA, USA. 117pg.

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Martien, K.K., R.W. Baird, N.M. Hedrick, A.M. Gorgone, J.L. Thieleking, D.J. McSweeney, K.M. Robertson, and D.L. Webster. 2011. Population structure of island-associated dolphins: evidence from mitochondrial and microsatellite markers for common bottlenose dolphins (Tursiops truncatus) around the main Hawaiian Islands. Marine Mammal Science 28(3): E208-E232 doi:10.1111/j.1748-7692.2011.00506.x

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Van Cise, A.M., R.W. Baird, A.E. Harnish, J.J. Currie, S.H. Stack, T. Cullins, and A.M. Gorgone. 2021. Mark-recapture estimates suggest declines in abundance of common bottlenose dolphin stocks in the main Hawaiian Islands. Endangered Species Research 45:37-53 doi:10.3354/esr01117

Supplementary Description 6. 7. Common bottlenose dolphin small and resident pop.

Species name: Common bottlenose dolphin (*Tursiops truncatus*)

Stock or population: Maui Nui stock

Descriptive name: Kaua'i/Ni'ihau-O'ahu-Maui Nui - Child (Maui Nui)

BIA type: Small and Resident Pop.

BIA label: S-BIA2-s-b2-HI018-a

Transboundary across: None

Hierarchy: Hierarchical BIA; Child a

Importance score: 2 (Intensity: 2, Data support: 2)

Intensity matrix: Abundance: 3, Range: 1

Supporting notes for intensity score: Intensity = 2; Stock-specific abundance estimates reported by Van Cise et al., (2021) are used to inform the Intensity score for each island-associated child BIA. The abundance estimates for the Kauaʻi/Niʻihau, Oʻahu, and Maui Nui stocks were 112 (SE=27), 112 (SE=19), and 64 (SE=9.3), respectively, for the last year of the study (2018, estimated annually over the study period; Van Cise et al., 2021). Based on this information on abundance specific to each child BIA here and the range sizes of the child BIAs (listed below), as well as the fact that these child BIAs represent intensified use relative to the parent BIA, we assigned Intensity scores of 3, 3, and 2 for the Kauaʻi/Niʻihau, Oʻahu, and Maui Nui child BIAs, respectively. Using these values, the approximate proportion of the KNOMN combined abundance contained within each child BIA is 39%, 39%, and 22%, for Kauaʻi/Niʻihau, Oʻahu, and Maui Nui BIAs, respectively. The size of the Maui Nui child BIA is 10,622 km2.

Similar to the Intensity score rationale for the parent BIA, abundance estimates used to inform the scores for these child BIAs were based on a recent analysis that generated stock-specific estimates, derived from long-term photo-identification data collected from extensive survey effort and opportunistic sightings (Van Cise et al., 2021); thus, we have high confidence in the small abundance of each stock with a child BIA. Despite the varying satellite tag deployment lengths and number of satellite tags deployed off different island areas, bottlenose dolphins that were satellite tagged rarely moved outside of delineated child BIAs.

Supporting notes for data support score: Score = 2; Each child BIA was drawn using current designated stock boundaries, representing known primary habitat (<1,000 m isobath), combined with satellite tag data, and information accrued over two decades from dedicated small boat survey efforts, shipboard line-transect surveys, and community scientists, which further supports the existence of these smaller, island-associated stocks. The latter sources of information also support the overlapping geographical ranges of the Oʻahu and Maui Nui bottlenose dolphins (CRC unpublished; Harnish, 2021). More satellite tags have been deployed on bottlenose dolphins off Kauaʻi compared to the other island areas. Therefore, the strength of the supporting data for the Kauaʻi/Niʻihau child BIA is greater than those for the Oʻahu and Maui Nui child BIAs. Despite this, what the Oʻahu and Maui Nui child BIAs lack in support from dedicated survey effort and satellite tag data is substantiated by the strength of contributed data from community scientists and collaborating researchers; of the 696 non-CRC sightings of bottlenose dolphins in the KNOM region, 675 (97%) occurred off Maui Nui and Oʻahu (CRC unpublished), spanning a period of 24 years (CRC unpublished; Harnish, 2021). Based on this, we assign the Kauaʻi/Niʻihau child BIA a Data Support score of three and the Oʻahu and Maui Nui child BIAs Data Support scores of two to reflect the differing biases and limitations associated with the primary sources of information used to inform each area.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: This population is resident to this area year-round and no information (from available data) suggests the area is used dynamically or ephemerally.

Boundary certainty: 2

Supporting notes for boundary certainty: We have intermediate certainty in the Oʻahu and Maui Nui child BIA boundaries; only a limited number of satellite tags have been deployed on bottlenose dolphins from these stocks, all of which have shown varying spatial use within Oʻahu/Maui Nui region, with some individuals crossing stock boundaries. Having only recently recognized the geographical overlap of these two stocks from photo-identification analyses and satellite tag data (CRC unpublished; Harnish, 2021), the true primary range of each stock remains unclear. In addition, the Oʻahu and Maui Nui child BIAs include regions off the windward sides of the islands with little data to support due to limited survey effort.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 2

# of years in which supporting tagging data collected: 1 (2012)

Supporting information: Satellite tags were deployed on 5 bottlenose dolphins during dedicated survey efforts off Maui Nui from 2012-2020 (n=5). Three of the tag deployments off Maui Nui were on individuals considered to be part of the Oʻahu stock (Harnish, 2021). Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk using the package crawl implemented in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 1-hour interval and locations on land were re-routed around a polygon representing the islands with an added 50 m distance using the pathroutr package (London, 2020).

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 75

# of years in which supporting visual data collected: 8 (2000-2020)

Supporting information: Sighting numbers entered here reflect the number of sightings for this particular stock/region. General sighting information: Sighting data were collected from non-systematic, dedicated small boat surveys conducted off Kauaʻi/Niʻihau, Oʻahu, and Maui Nui in 13, six, and nine years, respectively, spanning 2000-2021 (see Baird et al., 2011b, 2013, 2021 for details on surveys). Surveys off these islands combined total 50,642 km of effort with 234 sightings of bottlenose dolphins. Three of these sightings were off Kaʻula and not considered to be part of the Kauaʻi/Niʻihau stock (Carretta et al., 2021), and thus, were excluded from the BIA boundary delineation. In addition, community science photographic and sightings contributions (n = 696 encounters) have added substantially to the information available on the KNOMN population, comprising over 60% of the identifications in CRC's photo-identification catalog of KNOMN bottlenose dolphins, collected over a period of 24 years (1996-2019; CRC unpublished). While community science contributions rarely come with specific latitudes and longitudes to include in the boundary delineation process (only a general island or regional locality is typically provided), we used the information on social structure and relative abundance from these contributions in this assessment. Additional sighting data were available from NMFS ship-based line-transect surveys (Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020), and those with confirmed photographic assignment to the KNOMN insular population or within the known range of the KNOMN population were used in boundary determinations (n=20); effort from these surveys in the area total 12,732 km.

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 200

# of years of photo records to compare: 24 (1996-2019)

Maximum # of years same individual photographed in area: 15

Supporting information: The existence of a small, resident, island-associated stock of bottlenose dolphins around Maui Nui has long been recognized (Baird et al., 2009; Baird, 2016; Caretta et al., 2019). Recent abundance estimates based on long-term photo-identification data further support the existence of these small and resident populations (Van Cise et al., 2021).

Genetic analyses conducted supporting designation (Y/N): Y

Nature of supporting information: Strong

Supporting information: Genetic evidence suggests that there are four demographically isolated insular populations of bottlenose dolphins throughout the Hawaiian archipelago as well as a pelagic population (Martien et al., 2011). These five populations are recognized as distinct stocks by the National Marine Fisheries Service.

What factors justify the boundary selection?: Baird et al., (2015) delineated individual BIAs for each island-associated stock of bottlenose dolphins using its designated stock boundary (1,000-m isobath around the islands with the exception of a boundary in between Oʻahu and Maui Nui). In this assessment, a parent BIA boundary was delineated to encompass all three stocks among which there is documented evidence of inter-island movements (Kauaʻi/Niʻihau, Oʻahu and Maui Nui) and is hereafter referred as the "KNOMN population" (Harnish, 2021; Baird et al., 2021). Child BIAs were delineated for each of the three island-associated stocks. Therefore, each island-associated stock falls under the broader KNOMN population. Parent and child BIA boundaries were delineated based on sighting data, satellite tag data, and stock boundaries.

Although it is known that some movement occurs between these island areas (Baird, 2016; Baird et al., 2021; Harnish, 2021), bottlenose dolphins generally remain near their island-associated regions. Rather than attempt to describe core ranges within each stock, we delineated child BIAs for each of the three stocks comprising the KNOM population with the intent to highlight the primary ranges of each island-associated stock. Child BIA boundaries were drawn initially using each island-associated stock boundary as these boundaries capture the majority of satellite tag derived crawl locations (and their error ellipses) and sighting locations. The Maui Nui child BIA was defined as the current recognized stock boundary for the stock (1000 m isobath). The Oʻahu child BIA was modified to include an area ranging from Penguin Bank to south Lānaʻi, meeting the southernmost boundary of the Maui Nui child BIA, as both satellite tag data and sighting data have shown use of these areas by Oʻahu bottlenose dolphins (termed "inter-island travelers"; CRC unpublished; Harnish, 2021). As a result, the Maui Nui and Oʻahu child BIAs share a common, overlapping region covering Penguin Bank to south Lānaʻi, reflecting the demographic independence of these two island-associated stocks while also highlighting their overlapping ranges based on available data.

Data sources: Cascadia Research Collective (unpub. data, 2000-2020); National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020; accessed 2021); Baird et al., 2009, 2013a, 2013b, 2015; Harnish 2021; Martien et al., 2011; Van Cise et al., 2021

Approximate % of population that uses this area for the designated purpose (if known): 22

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Baird, R.W., A.M. Gorgone, D.J. McSweeney, A.D. Ligon, M.H. Deakos, D.L. Webster, G.S. Schorr, K.K. Martien, D.R. Salden, and S.D. Mahaffy. 2009. Population structure of island-associated dolphins: evidence from photo-identification of common bottlenose dolphins (Tursiops truncatus) in the main Hawaiian Islands. Marine Mammal Science 25(2):251-274 doi:10.1111/j.1748-7692.2008.00257.x

Baird, R.W., D.L. Webster, S.D. Mahaffy, G.S. Schorr, J.M Aschettino, and A.M. Gorgone. 2013a. Movements and spatial use of odontocetes in the western main Hawaiian Islands: results of a three-year study off Oʻahu and Kauaʻi. Final report under Grant No. N00244-10-1-0048 from the Naval Postgraduate School.

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013b. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Baird, R.W., C.J. Cornforth, S.M. Jarvis, N.A. DiMarzio, K. Dolan, E.E. Henderson, S.W. Martin, S.L. Watwood, S.D. Mahaffy, B.D. Guenther, J.K. Lerma, A.E. Harnish, and M.A. Kratofil. 2021. Odontocete studies on the Pacific Missile Range Facility in February 2020: satellite tagging, photo-identification, and passive acoustic monitoring. Prepared for Commander, Pacific Fleet, Environmental Readiness Division, Pearl Harbor, HI, under Contract No. N62470-15-D-8006 Task Order N6274219F0101 issued to HDR Inc., Honolulu, HI. February 2021.

Caretta, J.V., K.A. Forney, E.M. Oleson, D.W. Weller, A.R. Lang, J. Baker, M.M. Muto, B. Hanson, A.J. Orr, H. Huber, M.S. Lowry, J. Barlow, J.E. Moore, D. Lynch, L. Carswell, and R.L. Brownwell Jr. 2019. U.S. Pacific Marine Mammal Stock Assessments: 2018. U.S. Department of Commerce, NOAA.

Harnish, A.E. 2021. Population structure, residency, and inter-island movements of common bottlenose dolphins (Tursiops truncatus) off Oʻahu and Maui Nui. M.E.S. Thesis, The Evergreen State College, Olympia, WA, USA. 117pg.

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Martien, K.K., R.W. Baird, N.M. Hedrick, A.M. Gorgone, J.L. Thieleking, D.J. McSweeney, K.M. Robertson, and D.L. Webster. 2011. Population structure of island-associated dolphins: evidence from mitochondrial and microsatellite markers for common bottlenose dolphins (Tursiops truncatus) around the main Hawaiian Islands. Marine Mammal Science 28(3): E208-E232 doi:10.1111/j.1748-7692.2011.00506.x

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Van Cise, A.M., R.W. Baird, A.E. Harnish, J.J. Currie, S.H. Stack, T. Cullins, and A.M. Gorgone. 2021. Mark-recapture estimates suggest declines in abundance of common bottlenose dolphin stocks in the main Hawaiian Islands. Endangered Species Research 45:37-53 doi:10.3354/esr01117

Supplementary Description 6. 8. Cuvier's beaked whale small and resident pop.

Species name: Cuvier's beaked whale (*Ziphius cavirostris*)

Descriptive name: Hawai'i Island - Parent

BIA type: Small and Resident Pop.

BIA label: S-BIA2-s-b2-HI021-0a

Transboundary across: None

Hierarchy: Hierarchical BIA; Parent of children a

Importance score: 2 (Intensity: 2, Data support: 3)

Intensity matrix: Abundance: 3, Range: 1

Supporting notes for intensity score: Baird et al. (2009) estimated abundance of Cuvier's beaked whales off Hawaiʻi Island using mark-recapture analyses of photo-identified individuals from 2003 through 2006. The estimate of marked individuals was 55 (CV=0.26), and 98.5% of the individuals (CV=0.07) were estimated to be marked. While the estimate is dated, photo-identification of this species since then has continued to suggest the population is small: between 2002 and 2020, just 83 individuals that were at least slightly distinctive were photo-identified off Hawaiʻi Island with fair- or better-quality photos (CRC unpublished). With contributed encounters from community scientists dating back to 1990, the photo-ID catalog includes 97 individuals that were at least slightly distinctive with fair- or better- quality photos (CRC unpublished). Given the time span of photos, this number likely includes a number of individuals that were born or died during the study period. Therefore, we assign an abundance score of 3 corresponding to 125 or fewer individuals. The resulting area of the parent BIA (i.e., population range size) is 37,157 km2 (range size score = 1).

No contemporary abundance estimate for this island-associated population is available; however, considering the abundance estimate reported by Baird et al., (2009) and the distinct number of identified individuals in CRC's photo-ID catalog – curated from extensive survey efforts and opportunistic sightings – we are confident that this population is small (within 125 or fewer individuals) and resident to these insular waters. The true range size of this population remains unclear given observed movements to offshore areas and among other island areas. Despite this, the majority of satellite tagged Cuvier's beaked whales displayed similar habitat use and spent much of their time along the leeward side of Hawaiʻi Island.

Supporting notes for data support score: Data Support score = 3

• This population has been studied for 20 years (2002-2021), primarily through dedicated small boat survey efforts. Additional photographic data supplied by other researchers and citizen science contributions spans a 31-year period.
• A total of 92 sightings from CRC effort, seven sightings from NMFS ship-based line-transect surveys, and 41 encounters from other researchers and community scientists since 1990, with re-sightings of individuals up to 25 years off Hawaiʻi Island (on eight separate occasions) and up to 15 times (over 16 year span)
• 10 satellite tag deployments (1,667 filtered Argos locations) transmitting for up to ~50 days, the majority of which showed similar insular habitat use along slopes of Hawaiʻi Island, with some individuals moving along windward sides of the island and along north Maui Nui where survey effort has been precluded
• Tag positional uncertainty and irregularity accounted for through crawl model, and boundary encompasses nearly all of crawl standard error (68% confidence interval) ellipses

The existence of a small, resident, island-associated population of Cuvier's beaked whales off Hawaiʻi Island has long been acknowledged (Baird et al., 2009; Baird, 2016, 2019; Caretta et al., 2021; McSweeney et al., 2007; Oleson et al., 2013). Long-term resighting rates (up to 25-year span, up to 15 separate times) and movements from satellite tagged whales further support long-term fidelity to this island (Baird et al., 2009, 2010; Baird, 2016, 2019; CRC unpublished). Some satellite-tagged Cuvier's beaked whales moved to offshore waters for brief periods of time and one individual moved northwest along the windward side of Maui Nui and north of Molokaʻi, adding some uncertainty in our understanding of the full extent of their range. No recent abundance estimates specific to this island-associated population are available, but the distinct individuals count from CRC's long-term photo-identification catalog and previously published estimates based on a subset of the data presented here (Baird et al., 2009) indicate the population is small. There are some portions of the parent BIA boundary that include a fair amount of space where no sightings occurred nor satellite tag locations transmitted, particularly in offshore waters south of Maui Nui and north of Hawaiʻi Island, but the extent of the boundary is supported by the MCP methods. However, knowing that some offshore and inter-island movements occur based on available satellite tag data, these whales may use these areas more frequently than we've been able to document.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: This population is resident to this area year-round and no information (from available data) suggests the area is used dynamically or ephemerally.

Boundary certainty: 2

Supporting notes for boundary certainty: We have intermediate confidence in Boundary Certainty for the parent BIA for Hawaiʻi Island Cuvier's beaked whales. The boundary encompasses the entire population based on a long-term sighting dataset, curated from extensive survey effort, and available information on movements from satellite tag deployments. Concentrations of sighting locations generally agree with those from satellite-tagged Cuvier's beaked whales. There are some portions of the parent BIA boundary that include a fair amount of space where no sightings occurred nor satellite tag locations transmitted, particularly in offshore waters south of Maui Nui and north of Hawaiʻi Island, but the extent of the boundary is supported by the MCP methods and objective estimates of uncertainty in tag positions. It is unknown how frequently such offshore excursions occur in this population. Several satellite-tagged animals used similar insular habitat off windward areas of the island where survey effort has been precluded (e.g., Maui Nui, Hawaiʻi Island), and positional uncertainty was accounted for in satellite tag data. In addition, the boundary includes areas of known habitat that Cuvier's beaked whales from this population likely use (waters within ~3,500 m deep), but where spatial data are lacking due to limited effort.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 10

# of years in which supporting tagging data collected: 6 (2008-2015)

Supporting information: Satellite tags were deployed on 10 Cuvier's beaked whales during dedicated survey efforts off leeward Hawaiʻi Island from 2008 through 2015 (Baird, 2016, 2019). Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk model using the package crawl implemented in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 4-hour interval and locations on land were re-routed around a polygon representing the 800-m isobath using the pathroutr package (London, 2020). Crawl positions during periods of large transmission gaps (with a 1-day gap threshold) were removed from each individual's track (where applicable) such to limit locations characterized by large positional uncertainty resulting from interpolation over long periods without any original Argos data.

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 99

# of years in which supporting visual data collected: 17 (2002-2021)

Supporting information: Sighting data were collected from non-systematic, dedicated small boat surveys conducted off Hawaiʻi Island from 2002 through 2021 (see Baird et al., 2013 for details on surveys). Surveys off Hawaiʻi Island total 97,438 km of effort with 92 Cuvier's beaked whale sightings. In addition, community science contributions have added substantially to the available information on this population, with 41 encounters over a 31-year span (1990-2020) providing over 30% of the Cuvier's beaked whale identifications in CRC's photo-identification catalog (CRC unpublished). While community science contributions rarely come with associated latitude and longitude to include in the boundary delineation process (typically only general island or regional locality is provided), in this assessment we use the information on social structure and relative abundance that these photographic contributions have supported. Additional sighting data were available from NMFS ship-based line-transect surveys (Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020), and those with confirmed photographic assignment to the insular population or within the known range of this population were included in boundary determinations (n=7); effort from these surveys in the area total 4,906 km.

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 83

# of years of photo records to compare: 16 (2002-2020)

Maximum # of years same individual photographed in area: 24.5

Supporting information: Photo-identification of this species has continued to suggest the population is small: between 2002 and 2020, just 83 individuals that were at least slightly distinctive were photo-identified off Hawaiʻi Island with fair or better quality photos (CRC unpublished). Given the time span of photos, this number likely includes a number of individuals that were born or died during the study period. Re-sightings of individuals extended up to 24.5 years off Hawaiʻi Island.

Genetic analyses conducted supporting designation (Y/N): N

What factors justify the boundary selection?: Using data available through 2013, Baird et al. (2015) delineated a single BIA for Hawaiʻi Island Cuvier's beaked whales based on sighting data from small boat survey efforts and spatial use from available satellite tag deployments. Additional sighting, photographic, and satellite tag data collected since the original 2015 study were used to revise the BIA boundary in this assessment. A child BIA was delineated for the Hawaiʻi Island population based on primary habitat known from sightings and satellite tag data.

The basis for the parent BIA was a minimum convex polygon (MCP) encompassing all sighting and satellite-tag derived crawl locations; the BIA was established by adding a 3-km distance band to the outer boundary of the MCP to account for positional uncertainty in the locations estimated by crawl. The inner (shoreward) boundary was defined as the 800-m isobath based on the shallowest sighting off these island areas from CRC dedicated survey efforts (shallowest sighting = 825 m deep). The resulting area of the parent BIA (i.e., population range size) is 37,157 km2.

Data sources: Cascadia Research Collective (unpub. data, 2002-2020); National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020, accessed 2021; Barlow 2006; Bradford et al., 2017, 2021); Yano et al., 2018, 2020); Baird et al., 2009, 2013, 2015; Baird 2019; Mahaffy et al., 2019; McSweeney et al., 2007; Schorr et al., 2009

Approximate % of population that uses this area for the designated purpose (if known): 100

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Baird, R.W., D.J. McSweeney, G.S. Schorr, S.D. Mahaffy, D.L. Webster, J. Barlow, M.B. Hanson, J.P. Turner, and R.D. Andrews. 2009. Studies of beaked whales in Hawaiʻi: Population size, movements, trophic ecology, social organisation, and behaviour. ECS Special Publication 1:23-25

Baird, R.W., G.S. Schorr, D.L. Webster, D.J. McSweeney, M.B. Hanson, and R.D. Andrews. 2010. Movements and habitat use of

Cuvier's and Blainville's beaked whales in Hawaiʻi: Results from satellite tagging in 2009/2010. Report prepared under Order No. AB133F09SE4843 from the Southwest Fisheries Science Center, La Jolla, CA

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Baird, R.W. 2019. Behavior and ecology of not-so-social odontocetes: Cuvier's and Blainville's beaked whales. Pages 305-329 in: Ethology and Behavioral Ecology of Toothed Whales and Dolphins, the Odontocetes. Edited by B. Würsig. Springer.

Bradford, A.L., E.M. Oleson, K.A. Forney, J.E. Moore, and J. Barlow. 2021. Line-transect abundance estimates of cetaceans in U.S. waters around the Hawaiian Islands in 2002, 2010, and 2017. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-PIFSC-115, 52 p. doi:10.25923/daz4-kw84

Caretta, J.V., E.M. Oleson, K.A. Forney, M.M. Muto, D.W. Weller, A.R. Lang, J. Baker, B. Hanson, A.J. Orr, J. Barlow, J.E. Moore, and R.L. Brownwell Jr. 2021. U.S. Pacific Marine Mammal Stock Assessments: 2020. U.S. Department of Commerce, NOAA.

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Mahaffy, S.D., R.W. Baird, D.J. McSweeney, D.L. Webster, and G.S. Schorr. 2015. Group structure and mating strategies of Cuvier's (Ziphius cavirorstris) and Blainville's (Mesoplodon densirostris) beaked whales off the island of Hawaiʻi. Poster presented at the 21st Biennial Conference on the Biology of Marine Mammals, San Francisco, California, December 14-18, 2015.

McSweeney, D.J., R.W. Baird, and S.D. Mahaffy. 2007. Site fidelity, associations, and movements of Cuvier's (Ziphius cavirostris) and Blainville's (Mesoplodon densirostris) beaked whales off the island of Hawaiʻi. Marine Mammal Science 23(3):666-687. Doi:10.1111/j.1748-7692.2007.00135.x

Oleson, E.M., R.W. Baird, K.K. Martien, and B.L. Taylor. 2013. Island-associated stocks of odontocetes in the main Hawaiian Islands: a synthesis of available information to facilitate evaluation of stock structure. Document PSRG-2013-16 presented to the Pacific Scientific Review Group, Del Mar, April 2013.

Supplementary Description 6. 9. Cuvier's beaked whale small and resident pop.

Species name: Cuvier's beaked whale (*Ziphius cavirostris*)

Descriptive name: Hawai'i Island - Child

BIA type: Small and Resident Pop.

BIA label: S-BIA3-s-b3-HI021-a

Transboundary across: None

Hierarchy: Hierarchical BIA; Child a

Importance score: 3 (Intensity: 3, Data support: 3)

Intensity matrix: Abundance: 3, Range: 2

Supporting notes for intensity score: The child BIA for Hawaiʻi Island Cuvier's beaked whales described here represents intensified use relative to the broader parent BIA. As such, it is appropriate here to score the child BIA the highest intensity score. We deem this reasonable considering that the population is likely already fewer than 125 individuals. We assume that the child BIA contains approximately 50% of the population, recognizing there are several sources of uncertainty associated with this estimate related to biases from survey effort and challenges in studying this particular species.

Although the abundance estimate for this population is dated, the number of distinct individuals from CRC's long-term photo-identification catalog indicate that the population is small. Nearly all of the tracks derived from satellite tag deployments further support a small range size off the leeward side of Hawaiʻi Island with both satellite tag locations and sighting locations concentrated in depths between 2,000 and 3,500 m. Whales off Hawaiʻi Island were tagged in six different years and transmission durations ranged from 7 to 49 days (Baird et al., 2010).

Supporting notes for data support score: Score = 3; The child BIA for Hawaiʻi Island Cuvier's beaked whales was drawn based on known primary habitat from sightings collected over 20 years of small boat survey efforts (conducted every year by CRC; Baird et al., 2013), satellite tag data from 10 deployments during six separate years (Baird et al., 2010), and information accrued over three decades from collaborating researchers and community scientists (CRC unpublished), which further supports the existence of a small and resident population associated with Hawaiʻi Island. Although Cuvier's beaked whales are encountered relatively infrequently during CRC efforts (Baird et al., 2013), and in general due to their inconspicuous behavior, resighting rates of several individuals (up to 25 years, individual re-sightings up to 15 different occasions) also support high site fidelity to this island.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: This population is resident to this area year-round and no information (from available data) suggests the area is used dynamically or ephemerally.

Boundary certainty: 3

Supporting notes for boundary certainty: We have high certainty in the boundary for the Hawaiʻi Island child BIA. We feel this boundary accurately describes the primary range of this island-associated community of Cuvier's beaked whales considering the quantity, quality, and longevity of supporting data from all available sources of information (dedicated small boat survey efforts, satellite tag data, re-sighting rates, etc.). Cuvier's beaked whales off this island have used windward waters where small boat survey efforts have been precluded due to typically poor working conditions, and where some shipboard line-transect surveys have covered; however the majority of satellite-tagged beaked whales spent their time off the leeward side of the island.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 10

# of years in which supporting tagging data collected: 6 (2008-2015)

Supporting information: Satellite tags were deployed on 10 Cuvier's beaked whales during dedicated survey efforts off leeward Hawaiʻi Island from 2008 through 2015 (Baird, 2016, 2019). Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk model using the package crawl implemented in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 4-hour interval and locations on land were re-routed around a polygon representing the 800-m isobath using the pathroutr package (London, 2020).

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 99

# of years in which supporting visual data collected: 17 (2002-2021)

Supporting information: Sighting data were collected from non-systematic, dedicated small boat surveys conducted off Hawaiʻi Island from 2002 through 2021 (see Baird et al., 2013 for details on surveys). Surveys off Hawaiʻi Island total 97,438 km of effort with 92 Cuvier's beaked whale sightings. In addition, community science contributions have added substantially to the available information on this population, with 41 encounters over a 31-year span (1990-2020) providing over 30% of the Cuvier's beaked whale identifications in CRC's photo-identification catalog (CRC unpublished). While community science contributions rarely come with associated latitude and longitude to include in the boundary delineation process (typically only general island or regional locality is provided), in this assessment we use the information on social structure and relative abundance that these photographic contributions have supported. Additional sighting data were available from NMFS ship-based line-transect surveys (Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020), and those with confirmed photographic assignment to the insular population or within the known range of this population were included in boundary determinations (n=7); effort from these surveys total 4,906 km.

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 97

# of years of photo records to compare: 30 (1990-2020)

Maximum # of years same individual photographed in area: 25

Supporting information: Photo-identification of this species has continued to suggest the population is small: between 1990 and 2020, just 97 individuals that were at least slightly distinctive were photo-identified off Hawaiʻi Island with fair or better quality photos (CRC unpublished). Given the time span of photos, this number likely includes a number of individuals that were born or died during the study period.

Genetic analyses conducted supporting designation (Y/N): N

What factors justify the boundary selection?: Although a few satellite-tagged Cuvier's beaked whales have moved away from Hawaiʻi Island, either to offshore waters or along slopes of Maui Nui, movements from the remaining satellite-tagged whales indicate that Hawaiʻi Island Cuvier's beaked whales generally reside in deep waters near the leeward slopes of the island. Therefore, we delineated a child BIA for Hawaiʻi Island Cuvier's beaked whales with the intent to highlight the primary range of this population while acknowledging the broader, population-wide range reflected by the parent BIA. The child BIA for Hawaiʻi Island Cuvier's beaked whales was defined as the area between the 2,000 m and 3,500 m isobaths off the leeward side of Hawaiʻi Island based on both sighting rates in relation to bathymetric depths (Baird et al., 2013) and concentration of satellite tag locations (Baird, 2016, 2019).

Data sources: Cascadia Research Collective (unpub. data, 2002-2020); National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020, accessed 2021; Barlow 2006; Bradford et al., 2017, 2021); Yano et al., 2018, 2020); Baird et al., 2009, 2013, 2015; Baird 2019; Mahaffy et al., 2019; McSweeney et al., 2007; Schorr et al., 2009

Approximate % of population that uses this area for the designated purpose (if known): 50

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Baird, R.W., D.J. McSweeney, G.S. Schorr, S.D. Mahaffy, D.L. Webster, J. Barlow, M.B. Hanson, J.P. Turner, and R.D. Andrews. 2009. Studies of beaked whales in Hawaiʻi: Population size, movements, trophic ecology, social organisation, and behaviour. ECS Special Publication 1:23-25

Baird, R.W., G.S. Schorr, D.L. Webster, D.J. McSweeney, M.B. Hanson, and R.D. Andrews. 2010. Movements and habitat use of Cuvier's and Blainville's beaked whales in Hawaiʻi: Results from satellite tagging in 2009/2010. Report prepared under Order No. AB133F09SE4843 from the Southwest Fisheries Science Center, La Jolla, CA

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Baird, R.W. 2019. Behavior and ecology of not-so-social odontocetes: Cuvier's and Blainville's beaked whales. Pages 305-329 in: Ethology and Behavioral Ecology of Toothed Whales and Dolphins, the Odontocetes. Edited by B. Würsig. Springer.

Bradford, A.L., E.M. Oleson, K.A. Forney, J.E. Moore, and J. Barlow. 2021. Line-transect abundance estimates of cetaceans in U.S. waters around the Hawaiian Islands in 2002, 2010, and 2017. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-PIFSC-115, 52 p. doi:10.25923/daz4-kw84

Caretta, J.V., E.M. Oleson, K.A. Forney, M.M. Muto, D.W. Weller, A.R. Lang, J. Baker, B. Hanson, A.J. Orr, J. Barlow, J.E. Moore, and R.L. Brownwell Jr. 2021. U.S. Pacific Marine Mammal Stock Assessments: 2020. U.S. Department of Commerce, NOAA.

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Mahaffy, S.D., R.W. Baird, D.J. McSweeney, D.L. Webster, and G.S. Schorr. 2015. Group structure and mating strategies of Cuvier's (Ziphius cavirorstris) and Blainville's (Mesoplodon densirostris) beaked whales off the island of Hawaiʻi. Poster presented at the 21st Biennial Conference on the Biology of Marine Mammals, San Francisco, California, December 14-18, 2015.

McSweeney, D.J., R.W. Baird, and S.D. Mahaffy. 2007. Site fidelity, associations, and movements of Cuvier's (Ziphius cavirostris) and Blainville's (Mesoplodon densirostris) beaked whales off the island of Hawaiʻi. Marine Mammal Science 23(3):666-687. Doi:10.1111/j.1748-7692.2007.00135.x

Oleson, E.M., R.W. Baird, K.K. Martien, and B.L. Taylor. 2013. Island-associated stocks of odontocetes in the main Hawaiian Islands: a synthesis of available information to facilitate evaluation of stock structure. Document PSRG-2013-16 presented to the Pacific Scientific Review Group, Del Mar, April 2013.

Supplementary Description 6. 10. Dwarf sperm whale small and resident pop.

Species name: Dwarf sperm whale (*Kogia sima*)

Descriptive name: Hawai'i Island - Parent

BIA type: Small and Resident Pop.

BIA label: S-BIA3-s-b2-HI003-0a

Transboundary across: None

Hierarchy: Hierarchical BIA; Parent of children a

Importance score: 3 (Intensity: 3, Data support: 2)

Intensity matrix: Abundance: 3, Range: 3

Supporting notes for intensity score: This island-associated population is not formally recognized, and no abundance estimate specific to this small, resident population is available. The most recent abundance estimate for the broader main Hawaiian Islands stock, derived from a line-transect survey within the U.S. Hawaiian EEZ conducted in 2002, was 37,440 (CV=0.78) (Bradford et al., 2021). As of January 2021, CRC's photo-identification catalog for the Hawaiʻi Island population of dwarf sperm whales (sighted in waters < 2,000 m deep) includes a total of 84 individuals with slightly distinctive, distinctive, or very distinctive markings (from fair-, good-, or excellent-quality photographs; CRC unpublished). This number includes individuals with re-sighting rates up to 15 years (2004 to 2019) and analyses of distances between re-sightings indicates their range is relatively small (Baird et al., 2021). Photos from dedicated survey effort span an 18-year period (2003-2020), and thus it is likely that the catalog includes individuals that have died or been born into the population during this period, as well as individuals from a putative pelagic population (Baird et al., 2021). Combined these supporting lines of evidence suggest that the population is small, and therefore, we assume the population is comprised of 125 or fewer individuals for the BIA scoring process. The size of the MCP representing the parent BIA is 1,341 km2 (range size score = 3).

Despite the fact that there is no abundance estimate specific to this island-associated population of dwarf sperm whales, the high resighting rates of photo-identified individuals suggests that the population is small. Analyses of resighting locations indicate that photo-identified individuals appear to have a small range off the west coast of Hawaiʻi Island (Baird et al., 2021).

Supporting notes for data support score: We assigned this BIA a Data Support score of 2.

- This population has been studied for 20 years (2002-2021). Additional photographic data supplied by other researchers and community science contributions span a 16-year period.
- A total of 83 sightings from CRC effort in waters < 2,000 m deep, 26 encounters from other researchers and community scientists since 2004, with re-sightings of individuals up to 15 years (2004 to 2019)
- No satellite tag data available; movements outside of study area unknown

Despite the fact that this population has not been formally recognized as a stock by NMFS, its probable existence has long been acknowledged and is supported by long-term studies on photo-identified individuals off Hawaiʻi Island (Baird, 2005, 2016; Baird et al., 2021; Mahaffy et al., 2009; Oleson et al., 2013). Although no abundance estimates specific to this population are available, long-term photo-identification analyses, based on data collected from both dedicated and opportunistic efforts, provide evidence that this population is small and resident (Baird, 2005, 2016; Mahaffy et al., 2009; Baird et al., 2021). No satellite tag data are available for this species in this particular region or worldwide; consequently, their movements outside of the study area are unknown. It is also suspected that dwarf sperm whales encountered in deeper waters are part of a broader pelagic population and simply overlap with the range of insular, resident dwarf sperm whales. Thus, the resident, insular population's range is much smaller than the entire geographical range in which all dwarf sperm whales (including pelagic) have been encountered, further supporting the biological importance of nearshore waters to this specific small and resident population (Baird et al., 2021). Over 60% of all insular dwarf sperm whale sightings off this island (excluding sightings in water > 2,000 m deep) are contained within the estimated core range, although we recognize that bias in both survey effort and the ability to detect this elusive species makes it challenging to estimate their true geographic range. For example, their range may extend to waters off windward regions of the island where survey effort has been precluded. Based on available lines of data support and associated biases, we have intermediate confidence in the data support for the parent BIA and for the child BIA.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: This population is resident to this area year-round and no information (from available data) suggests the area is used dynamically or ephemerally.

Boundary certainty: 2

Supporting notes for boundary certainty: We have intermediate confidence in Boundary Certainty for both the parent and child BIA for Hawaiʻi Island dwarf sperm whales, based on the best available data. The parent BIA boundary encompasses the entire population based on a long-term sighting dataset curated from extensive survey effort and community scientists, although the parent BIA includes some areas without any sighting locations as a result of the MCP methods. Resident dwarf sperm whales may use windward areas of the island where survey effort has been precluded; however, we have no evidence to address this. The northern portion of the child BIA (core range) includes gaps of areas with no sightings, reflecting reduced survey effort in this area. Based on known primary habitat in areas with higher survey coverage, it is likely that Hawaiʻi Island dwarf sperm whales use this area.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 83

# of years in which supporting visual data collected: 17 (2003-2021)

Supporting information: Sighting data were collected from non-systematic, dedicated small boat surveys conducted off Hawaiʻi Island from April 2002 to November 2021 (see Baird et al., 2013 for details on surveys). Surveys off Hawaiʻi Island total 97,438 km of effort with 89 sightings of dwarf sperm whales as of November 2021. Six of these sightings were in waters greater than 2,000 m deep and suspected to be part of a broader pelagic population (Baird et al., 2021) and thus excluded from the boundary delineation process. Community science photographic and sightings contributions have also supplemented information on this population, with 26 sightings off Hawaiʻi Island spanning a period of 16 years (2004-2019), comprising approximately 20% of all individuals in Cascadia Research Collective (CRC)'s photo-identification catalog of Hawaiʻi Island dwarf sperm whales (CRC unpublished). Re-sightings of individuals photo-identified off this island range up to 15 years (Baird et al., 2021). While community science contributions rarely come with specific latitudes and longitudes to include in the boundary delineation process (typically only general locality is provided, e.g., off Hawaiʻi Island), we used the information on social structure and associated movements from these photographic contributions in this assessment. There were no dwarf sperm whale sightings from NMFS's ship-based line-transect surveys around the main Hawaiian Islands (Bradford et al., 2021).

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 84

# of years of photo records to compare: 18 (2003-2020)

Maximum # of years same individual photographed in area: 15 (2004-2019)

Supporting information: Re-sighting rates of individuals photo-identified off this island range up to 15 years (Baird et al., 2021). Community science photographic and sightings contributions have also supplemented information on this population, with 26 sightings off Hawaiʻi Island spanning a period of 16 years (2004-2019), comprising approximately 20% of all individuals in CRC 's photo-identification catalog of Hawaiʻi Island dwarf sperm whales (CRC unpublished). While community science contributions rarely come with specific latitudes and longitudes to include in the boundary delineation process (typically only general locality is provided, e.g., off Hawaiʻi Island), in this assessment we used the information on social structure and associated movements that from these photographic contributions have supported in this assessment.

As of January 2021, CRC's photo-identification catalog for the Hawaiʻi Island population of dwarf sperm whales (sighted in waters < 2,000 m deep) includes a total of 84 individuals with slightly distinctive, distinctive, or very distinctive markings (from fair-, good-, or excellent-quality photographs; CRC unpublished). This number includes individuals with re-sighting rates up to 15 years (2004 to 2019) and analyses of distances between re-sightings indicates their range is relatively small (Baird et al., 2021). Photos from dedicated survey effort span an 18-year period (2003-2020), and thus it is likely that the catalog includes individuals that have died or been born into the population during this period, as well as individuals from a putative pelagic population (Baird et al., 2021).

Genetic analyses conducted supporting designation (Y/N): N

What factors justify the boundary selection?: Following Baird et al. (2015), we delineated the parent BIA boundary for Hawaiʻi Island dwarf sperm whales based on sighting data, using additional sighting locations obtained since the 2015 assessment. We excluded deep-water (> 2,000 m) areas where there were sightings of dwarf sperm whales, based on evidence that these offshore groups may be part of a pelagic population (Baird et al., 2021). No satellite tag data were available for use in this process as this species has never been satellite tagged. In this assessment, we also estimated this population's core range based on bathymetric depths with the greatest dwarf sperm whale sighting rates (500-1,000 m; Baird et al., 2013; Baird et al., 2021).

The basis of the parent BIA was a minimum convex polygon (MCP) encompassing all sighting locations in less than 2,000 m depth. The inner boundary was defined as the 300-m isobath based on the shallowest sighting of dwarf sperm whales off this island (352 m).

Data sources: Cascadia Research Collective (unpub. data, 2003-2021); National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020; accessed 2021); Baird et al., 2005, 2013, 2015, 2021; Mahaffy et al., 2009

Approximate % of population that uses this area for the designated purpose (if known): 100

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Baird, R.W. 2005. Sightings of dwarf (Kogia sima) and pygmy (K. breviceps) sperm whales from the Main Hawaiian Islands. Pacific Science 59(3):461-466

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Baird, R.W., S.D. Mahaffy, and J.K. Lerma. 2021. Site fidelity, spatial use, and behavior of dwarf sperm whales in Hawaiian waters: using small-boat surveys, photo-identification, and unmanned aerial systems to study a difficult-to-study species. Marine Mammal Science 38(1):326-348 doi:10.1111/mms.12861

Bradford, A.L., E.M. Oleson, K.A. Forney, J.E. Moore, and J. Barlow. 2021. Line-transect abundance estimates of cetaceans in U.S. waters around the Hawaiian Islands in 2002, 2010, and 2017. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-PIFSC-115, 52 p. doi:10.25923/daz4-kw84

Caretta, J.V., K.A. Forney, E.M. Oleson, D.W. Weller, A.R. Lang, J. Baker, M.M. Muto, B. Hanson, A.J. Orr, H. Huber, M.S. Lowry, J. Barlow, J.E. Moore, D. Lynch, L. Carswell, and R.L. Brownwell Jr. 2019. U.S. Pacific Marine Mammal Stock Assessments: 2018. U.S. Department of Commerce, NOAA.

Mahaffy, S.D., R.W. Baird, D.J. McSweeney, D.L. Webster, and G.S. Schorr. 2009. Individual photo-identification of dwarf sperm whales off the island of Hawaiʻi: evidence of site fidelity and a small population size. Poster presented at the 18th Biennial Conference on the Biology of Marine Mammals, Quebec, October 2009.

Oleson, E.M., R.W. Baird, K.K. Martien, and B.L. Taylor. 2013. Island-associated stocks of odontocetes in the main Hawaiian Islands: a synthesis of available information to facilitate evaluation of stock structure. Document PSRG-2013-16 presented to the Pacific Scientific Review Group, Del Mar, April 2013.

Supplementary Description 6. 11. Dwarf sperm whale small and resident pop.

Species name: Dwarf sperm whale (*Kogia sima*)

Descriptive name: Hawai'i Island - Child

BIA type: Small and Resident Pop.

BIA label: S-BIA3-s-b2-HI003-a

Transboundary across: None

Hierarchy: Hierarchical BIA; Child a

Importance score: 3 (Intensity: 3, Data support: 2)

Intensity matrix: Abundance: 3, Range: 3

Supporting notes for intensity score: We assume the child BIA (core range) contains approximately 50% of the population, recognizing there are several sources of uncertainty associated with this estimate related to biases from survey effort and challenges in studying this particular species. The size of the area between the 500 m and 1,000 m isobaths within the MCP representing the child BIA is 457 km2. Because the child BIA represents intensified use relative to the broader parent BIA, we assigned an Intensity score of 3 for the child BIA.

Despite the fact that there is no abundance estimate specific to this island-associated population of dwarf sperm whales, the high resighting rates of photo-identified individuals suggests that the population is small. Analyses of resighting locations indicate that photo-identified individuals appear to have a small range off the west coast of Hawaiʻi Island (Baird et al., 2021).

Supporting notes for data support score: Data Support score = 2.

- This population has been studied for 20 years (2002-2021). Additional photographic data supplied by other researchers and community science contributions span a 16-year period.
- A total of 83 sightings from CRC effort in waters < 2,000 m deep, 26 encounters from other researchers and community scientists since 2004, with re-sightings of individuals up to 15 years (2004 to 2019)
- No satellite tag data available; movements outside of study area unknown

Despite the fact that this population has not been formally recognized as a stock by NMFS, its probable existence has long been acknowledged and is supported by long-term studies on photo-identified individuals off Hawaiʻi Island (Baird, 2005, 2016; Baird et al., 2021; Mahaffy et al., 2009; Oleson et al., 2013). Although no abundance estimates specific to this population are available, long-term photo-identification analyses, based on data collected from both dedicated and opportunistic efforts, provide evidence that this population is small and resident (Baird, 2005, 2016; Mahaffy et al., 2009; Baird et al., 2021). No satellite tag data are available for this species in this particular region or worldwide; consequently, their movements outside of the study area are unknown. It is also suspected that dwarf sperm whales encountered in deeper waters are part of a broader pelagic population and simply overlap with the range of insular, resident dwarf sperm whales. Thus, the resident, insular population's range is much smaller than the entire geographical range in which all dwarf sperm whales (including pelagic) have been encountered, further supporting the biological importance of nearshore waters to this specific small and resident population (Baird et al., 2021). Over 60% of all insular dwarf sperm whale sightings off this island (excluding sightings in water > 2,000 m deep) are contained within the estimated child BIA, although we recognize that bias in both survey effort and the ability to detect this elusive species makes it challenging to estimate their true geographic range. For example, their range may extend to waters off windward regions of the island where survey effort has been precluded. Based on available lines of data support and associated biases, we have intermediate confidence in the data support for the parent BIA and for the child BIA.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: This population is resident to this area year-round and no information (from available data) suggests the area is used dynamically or ephemerally.

Boundary certainty: 2

Supporting notes for boundary certainty: We have intermediate confidence in Boundary Certainty for both the parent and child BIA for Hawaiʻi Island dwarf sperm whales, based on the best available data. The parent BIA boundary encompasses the entire population based on a long-term sighting dataset curated from extensive survey effort and community scientists, although the parent BIA includes some areas without any sighting locations as a result of the MCP methods. Resident dwarf sperm whales may use windward areas of the island where survey effort has been precluded; however, we have no evidence to address this. The northern portion of the child BIA (core range) includes gaps of areas with no sightings, reflecting reduced survey effort in this area. Based on known primary habitat in areas with higher survey coverage, it is likely that Hawaiʻi Island dwarf sperm whales use this area.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): N

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 55

# of years in which supporting visual data collected: 17 (2003-2021)

Supporting information: A total of 55 sightings (66% of all sightings at < 2,000 m depth) were within the estimated core range, and this estimated proportion contained within the core range still supports an abundance score of 125 or fewer individuals. General sighting information: Sighting data were collected from non-systematic, dedicated small boat surveys conducted off Hawaiʻi Island from April 2002 to November 2021 (see Baird et al., 2013 for details on surveys). Surveys off Hawaiʻi Island total 97,438 km of effort with 89 sightings of dwarf sperm whales as of November 2021. Six of these sightings were in waters greater than 2,000 m deep and suspected to be part of a broader pelagic population (Figure 1; Baird et al., 2021) and thus excluded from the boundary delineation process. Community science photographic and sightings contributions have also supplemented information on this population, with 26 sightings off Hawaiʻi Island spanning a period of 16 years (2004-2019), comprising approximately 20% of all individuals in Cascadia Research Collective (CRC)'s photo-identification catalog of Hawaiʻi Island dwarf sperm whales (CRC unpublished). Re-sightings of individuals photo-identified off this island range up to 15 years (Baird et al., 2021). While community science contributions rarely come with specific latitudes and longitudes to include in the boundary delineation process (typically only general locality is provided, e.g., off Hawaiʻi Island), we used the information on social structure and associated movements from these photographic contributions in this assessment. There were no dwarf sperm whale sightings from NMFS's ship-based line-transect surveys around the main Hawaiian Islands (Bradford et al., 2021).

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 84

# of years of photo records to compare: 17 (2003-2021)

Maximum # of years same individual photographed in area: 15 (2004-2019)

Supporting information: As of January 2021, CRC's photo-identification catalog for the Hawaiʻi Island population of dwarf sperm whales (sighted in waters < 2,000 m deep) includes a total of 84 individuals with slightly distinctive, distinctive, or very distinctive markings (from fair-, good-, or excellent-quality photographs; CRC unpublished). This number includes individuals with re-sighting rates up to 15 years (2004 to 2019) and analyses of distances between re-sightings indicates their range is relatively small (Baird et al., In Review). Photos from dedicated survey effort span an 18-year period (2003-2020), and thus it is likely that the catalog includes individuals that have died or been born into the population during this period, as well as individuals from a putative pelagic population (Baird et al., 2021).

Genetic analyses conducted supporting designation (Y/N): N

What factors justify the boundary selection?: Following Baird et al. (2015), we delineated the parent BIA boundary for Hawaiʻi Island dwarf sperm whales based on sighting data, using additional sighting locations obtained since the 2015 assessment. We excluded deep-water (> 2,000 m) areas where there were sightings of dwarf sperm whales, based on evidence that these offshore groups may be part of a pelagic population (Baird et al., 2021). No satellite tag data were available for use in this process as this species has never been satellite tagged. In this assessment, we also estimated this population's core range based on bathymetric depths with the greatest dwarf sperm whale sighting rates (500-1,000 m; Baird et al., 2013; Baird et al., 2021).

Based on sighting rates in relation to bathymetric depths (Baird et al., 2013, 2021), we designated the area between the 500 m and 1,000 m isobaths within the MCP as the child BIA of the population. The resulting area of the child BIA (i.e., population core range size) is 457 km2.

Data sources: Cascadia Research Collective (unpub. data, 2003-2021); National Marie Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020; accessed 2021); Baird et al., 2005, 2013, 2015, 2021; Mahafffy et al., 2009; Oleson et al., 2013

Approximate % of population that uses this area for the designated purpose (if known): 50

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Baird, R.W. 2005. Sightings of dwarf (Kogia sima) and pygmy (K. breviceps) sperm whales from the Main Hawaiian Islands. Pacific Science 59(3):461-466

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Baird, R.W., S.D. Mahaffy, and J.K. Lerma. 2021. Site fidelity, spatial use, and behavior of dwarf sperm whales in Hawaiian waters: using small-boat surveys, photo-identification, and unmanned aerial systems to study a difficult-to-study species. Marine Mammal Science 38(1):326-348 doi:10.1111/mms.12861

Bradford, A.L., E.M. Oleson, K.A. Forney, J.E. Moore, and J. Barlow. 2021. Line-transect abundance estimates of cetaceans in U.S. waters around the Hawaiian Islands in 2002, 2010, and 2017. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-PIFSC-115, 52 p. doi:10.25923/daz4-kw84

Caretta, J.V., K.A. Forney, E.M. Oleson, D.W. Weller, A.R. Lang, J. Baker, M.M. Muto, B. Hanson, A.J. Orr, H. Huber, M.S. Lowry, J. Barlow, J.E. Moore, D. Lynch, L. Carswell, and R.L. Brownwell Jr. 2019. U.S. Pacific Marine Mammal Stock

Assessments: 2018. U.S. Department of Commerce, NOAA.

Mahaffy, S.D., R.W. Baird, D.J. McSweeney, D.L. Webster, and G.S. Schorr. 2009. Individual photo-identification of dwarf sperm whales off the island of Hawaiʻi: evidence of site fidelity and a small population size. Poster presented at the 18th Biennial Conference on the Biology of Marine Mammals, Quebec, October 2009.

Oleson, E.M., R.W. Baird, K.K. Martien, and B.L. Taylor. 2013. Island-associated stocks of odontocetes in the main Hawaiian Islands: a synthesis of available information to facilitate evaluation of stock structure. Document PSRG-2013-16 presented to the Pacific Scientific Review Group, Del Mar, April 2013.

Supplementary Description 6. 12. False Killer whale small and resident pop.

Species name: False Killer whale (*Pseudorca crassidens*)

Stock or population: Main Hawaiian Islands Insular Stock

Descriptive name: Main Hawaiian Islands Insular Stock - Parent

BIA type: Small and Resident Pop.

BIA label: S-BIA1-s-b3-HI035-0a

Transboundary across: None

Hierarchy: Hierarchical BIA; Parent of children a

Importance score: 1 (Intensity: 1, Data support: 3)

Intensity matrix: Abundance: 2, Range: 1

Supporting notes for intensity score: The most recent abundance estimate for this population is from 2015 of 167 individuals (95% CI 128-218; abundance score = 2) and was based on long-term photo-identification data collected by CRC, other researchers, and community scientists (Bradford et al., 2018). The size of the modified MCP representing the parent BIA is 94,217 km2 (range size score = 1).

The abundance estimate used to derive the intensity score is contemporary, specific to this island-associated stock, and based on long-term photo-identification data collected from extensive survey effort and opportunistic sightings; thus, we have high confidence that the true abundance is within 126-500 individuals. Most satellite tag deployments used to inform the parent BIA boundary transmitted for at least a month, and they were deployed during different years and seasons and tagged individuals generally displayed similar habitat use (shelf/slope waters) with frequent inter-island movements, all within the range of Kauaʻi/Niʻihau to Hawaiʻi Island.

Supporting notes for data support score: We assigned a Data Support score of 3 based on the following:

• This stock has been studied for 22 years (2000-2021), although not surveyed every year. Additional photographic data supplied by other researchers and community science contributions span a 36-year period (1986-2021).
• A total of 92 sightings from CRC effort, nine sightings from NMFS ship-based line-transect surveys, 361 encounters from other researchers and community scientists since 1986, with re-sightings of individuals up to 33 years (1986-2019, on 9 separate occasions) and up to 58 separate times (over a 17-year span)
• Genetic differentiation from NWHI and pelagic false killer whale stocks in the Hawaiian archipelago (Chivers et al., 2010; Martien et al., 2014).
• Contemporary abundance estimate derived from the best available data on this stock (Bradford et al., 2018)
• 65 satellite tag deployments (38,286 filtered Argos locations) transmitting for up to ~200 days (median = 40 days), all of which generally showed similar habitat use around island areas (nearshore, shelf/slope waters) with several individuals moving frequently between island areas, ranging between Kauaʻi/Niʻihau and Hawaiʻi Island
• Tag positional uncertainty and irregularity accounted for through crawl model, and boundary encompasses nearly all of crawl standard error (68% confidence interval) ellipses

The existence of this demographically distinct, small, and resident stock of false killer whales associated with the main Hawaiian Islands has long been recognized (Baird et al., 2008, 2010, 2012, 2021; Caretta et al., 2021), and is supported by long-term, high resighting rates (up to 33 years), genetic studies (Chivers et al., 2010; Martien et al., 2014), and information on movements through satellite tag deployments (Baird et al., 2012, 2019). Abundance estimates used to inform the intensity score for this parent BIA are contemporary and robust, and were derived from the best available data on this stock (long-term photo-ID; Bradford et al., 2018). The boundary includes some areas where no sightings occurred nor satellite tag locations transmitted (e.g., south of Kauaʻi/Niʻihau); however, the data support the spatial extents of the boundary through the MCP method. Further, given the frequency of inter-island movements undertaken by these false killer whales, it is likely that these areas are used more often than we currently have data to explicitly support.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: No information to suggest the area is used dynamically or ephemerally.

Boundary certainty: 3

Supporting notes for boundary certainty: We have high confidence in the Boundary Certainty for the MHI insular false killer whale parent BIA. This boundary encompasses their entire known range based on movements collected from 65 satellite tag deployments (55 individuals, 2007-2021), the majority of which transmitted for at least a month. Positional uncertainty was accounted for in satellite tag data through the use of state-space models (crawl).

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 65 tags (48 groups)

# of years in which supporting tagging data collected: 13 (2007-2021)

Supporting information: Location data from satellite tags were available for 65 deployments on MHI insular false killer whales from 2007-2021 (Baird et al. 2012, 2021; Baird, 2016). Detailed methods on satellite tag data processing methods are provided as supplementary material (see corresponding manuscript). Briefly, location data were filtered following CRC's protocol (see manuscript supplementary material) and subsequently fit to a continuous-time correlated random walk model using the package crawl implemented in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl-fitted models were used to predict locations at 4-hour intervals and locations on land were re-routed around a polygon representing the islands with a 50-m distance band added pathroutr package (London, 2020). Crawl locations interpolated over periods spanning one or more days without any underlying Argos locations were removed.

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 101

# of years in which supporting visual data collected: 20 (2000-2021)

Supporting information: Sighting and photographic data were collected from CRC non-systematic, dedicated small boat surveys conducted throughout the main Hawaiian Islands from 2000-2021 (see Baird et al., 2013a for details on surveys). Surveys off these islands combined total 148,080 km of effort with 93 MHI insular false killer whale sightings. In addition, photos taken by other researchers during localized research efforts (e.g., Pacific Whale Foundation off Maui Nui, Dan McSweeney off Hawaiʻi Island) or during large-scale ship surveys (e.g., by the National Marine Fisheries Service (NMFS)), as well as community science contributions, were incorporated into analyses of residency, social organization, and abundance (e.g., Baird et al. 2008, 2019; Bradford et al., 2018). Collectively, there have been over 400 encounters with individuals from this stock since 1986 (35-year span), with individuals re-sighted over spans of up to 33 years (on 9 separate occasions) and with a maximum of 58 encounters (over 17 years; CRC unpublished). Contributed encounters comprise over 60% of all MHI insular false killer whale identifications in CRC's photo-identification catalog. Ship-based line-transect surveys throughout the Hawaiian Archipelago have been undertaken by NMFS in 11 years between 2002 and 2020 (see Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020 for details on surveys). Out of the 34 false killer whale sightings documented in the MHI region during these shipboard line-transect surveys, nine sightings were confirmed matches to the insular MHI stock (23,830 km of effort).

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 327

# of years of photo records to compare: 36 (1986-2021)

Maximum # of years same individual photographed in area: 33

Supporting information: Combined there have been over 400 encounters with individuals from this population since 1986 (35-year span), with individuals re-sighted over spans of up to 33 years (on 9 separate occasions) and during up to 58 encounters (over 17 years; CRC unpublished). Contributed encounters comprise over 60% of all MHI insular false killer whale identifications in CRC's photo-identification catalog.

Genetic analyses conducted supporting designation (Y/N): Y

Nature of supporting information: Strong

Supporting information: MHI false killer whales are genetically differentiated from NWHI false killer whales and pelagic false killer whales (Chivers et al. 2010; Martien et al. 2014).

What factors justify the boundary selection?: Baird et al. (2015) delineated a single BIA for MHI insular false killer whales based on high density areas identified from available satellite tag deployments (see Baird et al., 2012). Additional sighting, photographic, and satellite tag data collected since the original 2015 study were used to revise the BIA boundary in this assessment, extending the boundary to encompass not just their high-use areas but their entire known range. A child BIA was delineated for this population based on primary habitat identified through satellite tag data.

The basis for the parent BIA was a minimum convex polygon (MCP) encompassing all satellite-tag derived crawl locations; the BIA was established by adding a 3 km distance to the outer boundary of the MCP to account for positional uncertainty in the locations estimated by crawl. The inner (shoreward) boundary was defined as a 50-m distance from shore based on the shallowest sighting off these island areas from CRC dedicated survey efforts (shallowest sighting = 60 m deep). All sighting locations were encompassed by the modified MCP. The resulting area of the parent BIA (i.e., population range size) is 94,217 km2.

Data sources: Cascadia Research Collective (unpub. data, 2000-2021); National Marine Fisheries Service (2002-2020; accessed 2021); Baird et al., 2008, 2012, 2013, 2015, 2019, 2021; Bradford et al., 2018; Martien et al., 2014

Approximate % of population that uses this area for the designated purpose (if known): 100

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Baird, R.W., A.M. Gorgone, D.J. McSweeney, D.L. Webster, D.R. Salden, M.H. Deakos, A.D. Ligon, G.S. Schorr, J. Barlow, and S.D. Mahaffy. 2008. False killer whales (Pseudorca crassidens) around the main Hawaiian Islands: long-term site fidelity, inter-island movements, and association patterns. Marine Mammal Science 24:591-612 doi:10.1111/j.1748-7692.2008.00200.x.

Baird, R.W. 2009. A review of false killer whales in Hawaiian waters: biology, status, and risk factors. Report prepared for the U.S. Marine Mammal Commission under Order No. E40475499 December 23, 2009

Baird, R.W., G.S. Schorr, D.L. Webster, D.J. McSweeney, M.B. Hanson, and R.D. Andrews. 2010. Movements and habitat use of satellite-tagged false killer whales around the main Hawaiian Islands. Endangered Species Research 10:107-121 doi:10.3354/esr00258

Baird, R.W., M.B. Hanson, G.S. Schorr, D.L. Webster, D.J. McSweeney, A.M. Gorgone, S.D. Mahaffy, D. Holzer, E.M. Oleson, and R.D. Andrews. 2012. Range and primary habitats of Hawaiian insular false killer whales: informing determination of critical habitat. Endangered Species Research 18:47-61 doi:10.3354.esr00435

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013a. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., E.M. Oleson, J. Barlow, A.D. Ligon, A.M. Gorgone, and S.D. Mahaffy. 2013b. Evidence of an island-associated population of false killer whales (Pseudorca crassidens) in the Northwestern Hawaiian Islands. Pacific Science 67(4):513-521.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Baird, R.W., D.B. Anderson, M.A. Kratofil, D.L. Webster, and S.D. Mahaffy. 2019. Cooperative conservation and long-term management of false killer whales in Hawaiʻi: geospatial analyses of fisheries and satellite tag data to understand fishery interactions. Report to the State of Hawaiʻi Board of Land and Natural Resources under contract No. 67703. Cascadia Research Collective

Baird, R.W., D.B. Anderson, M.A. Kratofil, and D.L. Webster. 2021. Bringing the right fishermen to the table: Indices of overlap between endangered false killer whales and nearshore fisheries in Hawaii. Biological Conservation 255:108975

Bradford, A.L., E.M. Oleson, R.W. Baird, C.H. Boggs, K.A. Forney, and N.C. Young. 2015. Revised stock boundaries for false killer whales (Pseudorca crassidens) in Hawaiian waters. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-47, 20p. doi:10.7289/V5DF6P6J

Bradford, A.L., R.W. Baird, S.D. Mahaffy, A.M. Gorgone, D.J. McSweeney, T. Cullins, D.L. Webster, and A.N. Zerbini. 2018. Abundance estimates for management of endangered false killer whales in the main Hawaiian Islands. Endangered Species Research 36:297-313 doi:10.3354/esr00903

Bradford, A.L., E.M. Oleson, K.A. Forney, J.E. Moore, and J. Barlow. 2021. Line-transect abundance estimates of cetaceans in U.S. waters around the Hawaiian Islands in 2002, 2010, and 2017. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-PIFSC-115, 52 p. doi:10.25923/daz4-kw84

Caretta, J.V., E.M. Oleson, K.A. Forney, M.M. Muto, D.W. Weller, A.R. Lang, J. Baker, B. Hanson, A.J. Orr, J. Barlow, J.E. Moore, and R.L. Brownell Jr. 2021. U.S. Pacific Marine Mammal Stock Assessments: 2020. U.S. Department of Commerce, NOAA.

Chivers, S.J., R.W. Baird, K.M. Martien, B.L. Taylor, E. Archer, A.M. Gorgone, B.L. Hancock, N.M. Hedrick, D. Matilla, D.J. McSweeney, E.M. Oleson, C.L. Palmer, V. Pease, K.M. Robertson, J. Robbins, J.C. Salinas, G.S. Schorr, J.L. Schultz, J.L. Theileking, and D.L. Webster. 2010. Evidence of genetic differentiation for Hawaiʻi insular false killer whales (Pseudorca crassidens). NOAA Technical Memorandum NMFS-SWFSC-458, 46 pp.

Duong, T., and M.L. Hazelton. 2003. Plug-in bandwidth matrices for bivariate kernel density estimation. Journal of Nonparametric Statistics 15:17-30.

Duong, T., and M.L. Hazelton. 2005. Cross-validation bandwidth matrices for multivariate kernel density estimation. Scandinavian Journal of Statistics 32:485-506.

Duong, T. 2007. Ks: Kernel density estimation and kernel discriminant analysis for multivariate data in R. Journal of Statistical Software 21:1-16.

Duong, T. 2021. Ks: Kernel smoothing. R package version 1.12.0 https://CRAN.R-project.org/package=ks

Hauser, D.D.W., K.L. Laidre, R.S. Suydam, and P.R. Richard. 2014. Population-specific home ranges and migration timing of Pacific Arctic beluga whales (Delphinapterus leucas). Polar Biology 37:1171-1183

Hill, M.C., A.R. Bendlin, A.M. Van Cise, A. Milette-Winfree, A.D., Ligon, A.C. Ü, M.H. Deakos, and E.M. Oleson. 2019. Short-finned pilot whales (Globicephala macrorhynchus) of the Mariana Archipelago: individual affiliations, movements, and spatial use. Marine Mammal Science 35(3):797-824 doi:10.1111/mms.12567

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Martien, K.K., S.J. Chivers, R.W. Baird, F.I. Archer, A.M. Gorgone, B.L. Hancock-Hanser, D. Mattila, D.J. McSweeney, E.M. Oleson, C. Palmer, V.L. Pease, K.M. Robertson, G.S. Schorr, M.B. Schultz, D.L. Webster, and B.L. Taylor. 2014. Nuclear and mitochondrial patterns of population structure in North Pacific false killer whales (Pseudorca crassidens). Journal of Heredity 105:611-626 doi:10.1093/jhered/esu029

Oleson, E.M., C.H. Boggs, K.A. Forney, M.B. Hanson, D.R. Kobayashi, B.L. Taylor, P.R. Wade, and G.M. Ylitalo. 2010. Status review of Hawaiian insular false killer whales (Pseudorca crassidens) under the Endangered Species Act. U.S. Dep. Commerce. NOAA Tech Memo. NOAA-TM-NMFS-PIFSC-22 140pp.

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Shaff, J.F., M.A. Kratofil, and R.W. Baird. 2021. Beneath the surface: Diving behavior of false killer whales from two populations across diel and lunar cycles in Hawaiian waters. Poster presented at the 7th International Bio-logging Symposium, Honolulu, HI, October 2021.

Worton, B.J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:164-168

Supplementary Description 6. 13. False Killer whale small and resident pop.

Species name: False Killer whale (*Pseudorca crassidens*)

Stock or population: Main Hawaiian Islands Insular Stock

Descriptive name: Main Hawaiian Islands Insular Stock - Child

BIA type: Small and Resident Pop.

BIA label: S-BIA3-s-b3-HI035-a

Transboundary across: None

Hierarchy: Hierarchical BIA; Child a

Importance score: 3 (Intensity: 3, Data support: 3)

Intensity matrix: Abundance: 3, Range: 3

Supporting notes for intensity score: The most recent abundance estimate for this stock is from 2015 of 167 individuals (95% CI 128-218) and was based on long-term photo-identification data collected by CRC, other researchers, and community scientists (Bradford et al., 2018). The child BIA for MHI false killer whales described here represents intensified use relative to the broader parent BIA. As such, it is appropriate here to score the core BIA the highest intensity score (abundance = 125 or fewer, and size of core area much smaller than the geographic range described by BIA). Area of child BIA (all polygons combined): 7,775 km2

Supporting notes for data support score: We assigned this BIA a Data Support score of 3. The child BIA described here was drawn using satellite tag data from 48 groups of tagged false killer whales (see KDE methods above), accounting for bias associated with varying deployment durations and pseudoreplication (i.e., pairs of animals tagged together and acting in concert) using a widely used approach for estimating core range (KDEs). Location data were collected over a period of 15 years and extend to areas where small boat survey efforts have been precluded due to typically poor working conditions. Group movements represented by the 48 satellite tag deployments consists of information from all four social clusters, although sample size varies by cluster (greatest sample size for cluster 1). The child BIA characterized here is similar to the established BIA described by Baird et al. (2015), with additional areas highlighted off Oʻahu and between Oʻahu and Maui Nui.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: No information to suggest the area is used dynamically or ephemerally.

Boundary certainty: 3

Supporting notes for boundary certainty: We have high certainty in the boundary for the MHI insular false killer whale child BIA. This boundary accurately describes the core range and highest intensity areas of this stock, considering the quantity, quality, and longevity of supporting data from all available sources of information (dedicated small boat survey efforts, satellite tag data, photo-identification, etc.). These core areas cover regions where survey effort has been precluded due to typically poor working conditions (e.g., windward sides of the islands), yet is still highlighted by independent satellite tagged individuals. Positional uncertainty was accounted for in satellite tag data through the use of state-space models (crawl) and several measures were made to mediate biases with the kernel density estimation (e.g., coarser time step to mediate spatial autocorrelation, weighted approach to mediate tag deployment locality bias and varying deployment durations).

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 65 tags (48 groups)

# of years in which supporting tagging data collected: 13 (2007-2021)

Supporting information: Location data from satellite tags were available for 65 deployments on MHI insular false killer whales from 2007-2021 (Baird et al. 2012, 2021; Baird, 2016). Detailed methods on satellite tag data processing methods are provided as supplementary material (see corresponding manuscript). Briefly, location data were filtered following CRC's protocol (see supplementary material with corresponding manuscript) and subsequently fit to a continuous-time correlated random walk model using the package crawl implemented in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl-fitted models were used to predict locations at 4-hour intervals and locations on land were re-routed around a polygon representing the islands with a 50-m distance band added pathroutr package (London, 2020). Crawl locations interpolated over periods spanning one or more days without any underlying Argos locations were removed.

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 101

# of years in which supporting visual data collected: 20 (2000-2021)

Supporting information: Sighting and photographic data were collected from CRC non-systematic, dedicated small boat surveys conducted throughout the main Hawaiian Islands from 2000-2021 (see Baird et al., 2013a for details on surveys). Surveys off these islands combined total 148,080 km of effort with 93 MHI insular false killer whale sightings. In addition, photos taken by other researchers during localized research efforts (e.g., Pacific Whale Foundation off Maui Nui, Dan McSweeney off Hawaiʻi Island) or during large-scale ship surveys (e.g., by the National Marine Fisheries Service (NMFS)), as well as community science contributions, were incorporated into analyses of residency, social organization, and abundance (e.g., Baird et al. 2008, 2019; Bradford et al., 2018). Collectively, there have been over 400 encounters with individuals from this stock since 1986 (35-year span), with individuals re-sighted over spans of up to 33 years (on 9 separate occasions) and with a maximum of 58 encounters (over 17 years; CRC unpublished). Contributed encounters comprise over 60% of all MHI insular false killer whale identifications in CRC's photo-identification catalog. Ship-based line-transect surveys throughout the Hawaiian Archipelago have been undertaken by NMFS in 11 years between 2002 and 2020 (see Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020 for details on surveys). Out of the 34 false killer whale sightings documented in the MHI region during these shipboard line-transect surveys, nine sightings were confirmed matches to the insular MHI stock (23,830 km of effort).

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 327

# of years of photo records to compare: 36 (1986-2021)

Maximum # of years same individual photographed in area: 33

Supporting information: Combined there have been over 400 encounters with individuals from this population since 1986 (35 year span), with individuals re-sighted over spans of up to 33 years (on 9 separate occasions) and on up to 58 encounters (over 17 years; CRC unpublished). Contributed encounters comprise over 60% of all MHI insular false killer whale identifications in CRC's photo-identification catalog.

Genetic analyses conducted supporting designation (Y/N): Y

Nature of supporting information: Strong

Supporting information: MHI false killer whales are genetically differentiated from NWHI false killer whales and pelagic false killer whales (Chivers et al. 2010; Martien et al. 2014).

What factors justify the boundary selection?: Analyses of satellite tag data have highlighted particular areas of intensified use within the MHI insular false killer whales' range (Baird et al., 2012, 2019; Baird, 2016). Analyses have also indicated varying spatial use by social cluster (Baird et al. 2012, 2019). Therefore, rather than attempt to describe the primary range of each social cluster, we delineated a child BIA with the intent to represent the core range (i.e., high-intensity areas) for the entire stock. We used the same KDE approach as was applied for the parent BIA to generate a UD of the sample population, and used a 50% isopleth of the UD to represent the core range of the stock. Combined area of child BIA: 7,775 km2

Kernel density analysis
We used kernel density estimation (KDE) to generate a utility distribution (UD) of the sample population (Worton, 1989) and used a 50% isopleth of the UD to represent the core range of the population. Prior to kernel density analyses, crawl positions during periods of large transmission gaps were removed from each individual's track (where applicable) to avoid generating artificially "dense" areas resulting from interpolation over long periods without any original Argos data; a 1-day gap threshold was used (i.e., interpolated crawl points removed during periods where Argos locations did not transmit for 1 or more days apart). Further, one of each pair of tagged individuals that acted in concert was removed to reduce pseudoreplication (final analytical sample size = 48 tags with 15,794 4-hour crawl locations). All tag locations were pooled together. The contribution of each tag's location was weighted to the overall kernel density based on deployment length, and the KDE was re-scaled so it integrated to one (Hauser et al., 2014; Hill et al., 2019), such that locations from shorter deployments would have less weight than those with longer deployments. Kernel densities were estimated using the bivariate plug-in bandwidth (or smoothing parameter) matrix (Duong & Hazelton, 2003, 2005; Duong, 2007) accessed through the ks package for R (Duong, 2021). The location weighting was completed using the weights argument within the ks package (Duong, 2021).

Data sources: Cascadia Research Collective (unpub. data, 2000-2021); National Marine Fisheries Service (2002-2020; accessed 2021); Baird et al., 2008, 2012, 2013, 2015, 2019, 2021; Bradford et al., 2018; Martien et al., 2014

Approximate % of population that uses this area for the designated purpose (if known): 50

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Baird, R.W., A.M. Gorgone, D.J. McSweeney, D.L. Webster, D.R. Salden, M.H. Deakos, A.D. Ligon, G.S. Schorr, J. Barlow, and S.D. Mahaffy. 2008. False killer whales (Pseudorca crassidens) around the main Hawaiian Islands: long-term site fidelity, inter-island movements, and association patterns. Marine Mammal Science 24:591-612 doi:10.1111/j.1748-7692.2008.00200.x.

Baird, R.W. 2009. A review of false killer whales in Hawaiian waters: biology, status, and risk factors. Report prepared for the U.S. Marine Mammal Commission under Order No. E40475499 December 23, 2009

Baird, R.W., G.S. Schorr, D.L. Webster, D.J. McSweeney, M.B. Hanson, and R.D. Andrews. 2010. Movements and habitat use of satellite-tagged false killer whales around the main Hawaiian Islands. Endangered Species Research 10:107-121 doi:10.3354/esr00258

Baird, R.W., M.B. Hanson, G.S. Schorr, D.L. Webster, D.J. McSweeney, A.M. Gorgone, S.D. Mahaffy, D. Holzer, E.M. Oleson, and R.D. Andrews. 2012. Range and primary habitats of Hawaiian insular false killer whales: informing determination of critical habitat. Endangered Species Research 18:47-61 doi:10.3354.esr00435

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013a. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., E.M. Oleson, J. Barlow, A.D. Ligon, A.M. Gorgone, and S.D. Mahaffy. 2013b. Evidence of an island-associated population of false killer whales (Pseudorca crassidens) in the Northwestern Hawaiian Islands. Pacific Science 67(4):513-521.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Baird, R.W., D.B. Anderson, M.A. Kratofil, D.L. Webster, and S.D. Mahaffy. 2019. Cooperative conservation and long-term management of false killer whales in Hawaiʻi: geospatial analyses of fisheries and satellite tag data to understand fishery interactions. Report to the State of Hawaiʻi Board of Land and Natural Resources under contract No. 67703. Cascadia Research Collective

Baird, R.W., D.B. Anderson, M.A. Kratofil, and D.L. Webster. 2021. Bringing the right fishermen to the table: Indices of overlap between endangered false killer whales and nearshore fisheries in Hawaii. Biological Conservation 255:108975

Bradford, A.L., E.M. Oleson, R.W. Baird, C.H. Boggs, K.A. Forney, and N.C. Young. 2015. Revised stock boundaries for false killer whales (Pseudorca crassidens) in Hawaiian waters. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-47, 20p. doi:10.7289/V5DF6P6J

Bradford, A.L., R.W. Baird, S.D. Mahaffy, A.M. Gorgone, D.J. McSweeney, T. Cullins, D.L. Webster, and A.N. Zerbini. 2018. Abundance estimates for management of endangered false killer whales in the main Hawaiian Islands. Endangered Species Research 36:297-313 doi:10.3354/esr00903

Bradford, A.L., E.M. Oleson, K.A. Forney, J.E. Moore, and J. Barlow. 2021. Line-transect abundance estimates of cetaceans in U.S. waters around the Hawaiian Islands in 2002, 2010, and 2017. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-PIFSC-115, 52 p. doi:10.25923/daz4-kw84

Caretta, J.V., E.M. Oleson, K.A. Forney, M.M. Muto, D.W. Weller, A.R. Lang, J. Baker, B. Hanson, A.J. Orr, J. Barlow, J.E. Moore, and R.L. Brownell Jr. 2021. U.S. Pacific Marine Mammal Stock Assessments: 2020. U.S. Department of Commerce, NOAA.

Chivers, S.J., R.W. Baird, K.M. Martien, B.L. Taylor, E. Archer, A.M. Gorgone, B.L. Hancock, N.M. Hedrick, D. Matilla, D.J. McSweeney, E.M. Oleson, C.L. Palmer, V. Pease, K.M. Robertson, J. Robbins, J.C. Salinas, G.S. Schorr, J.L. Schultz, J.L. Theileking, and D.L. Webster. 2010. Evidence of genetic differentiation for Hawaiʻi insular false killer whales (Pseudorca crassidens). NOAA Technical Memorandum NMFS-SWFSC-458, 46 pp.

Duong, T., and M.L. Hazelton. 2003. Plug-in bandwidth matrices for bivariate kernel density estimation. Journal of Nonparametric Statistics 15:17-30.

Duong, T., and M.L. Hazelton. 2005. Cross-validation bandwidth matrices for multivariate kernel density estimation. Scandinavian Journal of Statistics 32:485-506.

Duong, T. 2007. Ks: Kernel density estimation and kernel discriminant analysis for multivariate data in R. Journal of Statistical Software 21:1-16.

Duong, T. 2021. Ks: Kernel smoothing. R package version 1.12.0 https://CRAN.R-project.org/package=ks

Hauser, D.D.W., K.L. Laidre, R.S. Suydam, and P.R. Richard. 2014. Population-specific home ranges and migration timing of Pacific Arctic beluga whales (Delphinapterus leucas). Polar Biology 37:1171-1183

Hill, M.C., A.R. Bendlin, A.M. Van Cise, A. Milette-Winfree, A.D., Ligon, A.C. Ü, M.H. Deakos, and E.M. Oleson. 2019. Short-finned pilot whales (Globicephala macrorhynchus) of the Mariana Archipelago: individual affiliations, movements, and spatial use. Marine Mammal Science 35(3):797-824 doi:10.1111/mms.12567

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Martien, K.K., S.J. Chivers, R.W. Baird, F.I. Archer, A.M. Gorgone, B.L. Hancock-Hanser, D. Mattila, D.J. McSweeney, E.M. Oleson, C. Palmer, V.L. Pease, K.M. Robertson, G.S. Schorr, M.B. Schultz, D.L. Webster, and B.L. Taylor. 2014. Nuclear and mitochondrial patterns of population structure in North Pacific false killer whales (Pseudorca crassidens). Journal of Heredity 105:611-626 doi:10.1093/jhered/esu029

Oleson, E.M., C.H. Boggs, K.A. Forney, M.B. Hanson, D.R. Kobayashi, B.L. Taylor, P.R. Wade, and G.M. Ylitalo. 2010. Status review of Hawaiian insular false killer whales (Pseudorca crassidens) under the Endangered Species Act. U.S. Dep. Commerce.

NOAA Tech Memo. NOAA-TM-NMFS-PIFSC-22 140pp.

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Shaff, J.F., M.A. Kratofil, and R.W. Baird. 2021. Beneath the surface: Diving behavior of false killer whales from two populations across diel and lunar cycles in Hawaiian waters. Poster presented at the 7th International Bio-logging Symposium, Honolulu, HI, October 2021.

Worton, B.J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:164-168

Supplementary Description 6. 14. False Killer whale small and resident pop.

Species name: False Killer whale (*Pseudorca crassidens*)

Stock or population: Northwestern Hawaiian Islands Insular Stock

Descriptive name: Northwestern Hawaiian Islands Insular Stock

BIA type: Small and Resident Pop.

BIA label: S-BIA1-s-b2-HI034-0

Transboundary across: None

Hierarchy: Non-hierarchical; single BIA

Importance score: 1 (Intensity: 1, Data support: 2)

Intensity matrix: Abundance: 2, Range: 1

Supporting notes for intensity score: The most recent abundance estimate for this stock is 477 individuals (95% CI 48-4,712) and was based on visual encounter data from a shipboard line-transect survey conducted in 2017 by NMFS (Bradford et al., 2020). As of August 2021, CRC's photo-identification catalog for NWHI false killer whales includes 97 slightly distinctive, distinctive, or very distinctive individuals (from fair-, good-, or excellent-quality photographs; CRC unpublished). For the purposes of this assessment, we assumed an abundance within the 126 to 500 category of the BIA Intensity scoring criteria (score = 2) but recognize there is uncertainty in this estimate due to limited survey coverage on this stock. The size of the modified MCP representing the BIA is 138,001 km2 (range size score = 1)

The abundance estimate used to inform the intensity score is contemporary and specific to this population, however the associated confidence interval indicates a high degree of uncertainty (Bradford et al., 2020). The distinct individuals total from CRC's photo-identification catalog suggests the population is small but, similar to the abundance estimate, limited survey and sighting data on this population preclude a better understanding of their true abundance. Despite this, from available sighting, genetic, and movement data, we are confident that this is a small and resident population.

Supporting notes for data support score: We assigned a Data Support score of 2 based on the following:

• This stock has been studied for 11 years (2010-2021), although not surveyed often within their currently understood range. Additional photographic data supplied by other researchers and community science contributions span a 19-year period (2003-2021).
• A total of 5 sightings from CRC effort and 4 from NMFS effort, 10 encounters from other researchers and community scientists since 2003, with re-sightings of individuals up to 12.8 years (three separate years, on three separate occasions) and up to 5 separate times (over 7.7-year span)
• Genetic differentiation from pelagic and MHI false killer whale stocks (Martien et al., 2014)
• 7 satellite tag deployments (2,059 filtered Argos locations) transmitting for up to ~53 days (median = 21 days), all of which generally showed similar habitat use around the archipelago (nearshore, shelf/slope waters), with some spending more time around Kauaʻi/Niʻihau and others primarily between the Gardner Pinnacles and Middle Bank
• Tag positional uncertainty and irregularity accounted for through crawl model, and boundary encompasses nearly all of crawl standard error (68% confidence interval) ellipses

This demographically distinct stock of false killer whales is supported by several lines of evidence, notably genetics (Martien et al., 2014), movements from satellite tag data (Baird et al., 2013b; Baird, 2016), and photo-identification studies (Baird et al., 2013b). The abundance estimate used to inform the Intensity score for this BIA is contemporary and based on data collected from a systematic ship-based line-transect survey (Bradford et al., 2020), and is further supported by a long-term photo-identification catalog maintained for this stock (CRC unpublished). Despite the strengths of available supporting information, there remains uncertainty in the true range and abundance of this stock. This uncertainty is largely due to limited survey effort in this stock's primary range (Northwestern Hawaiian Islands) and low frequency of occurrence in portions of their range that are surveyed more often (e.g., Kauaʻi/Niʻihau).

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: No information to suggest the area is used dynamically or ephemerally.

Boundary certainty: 2

Supporting notes for boundary certainty: We have intermediate confidence in the Boundary Certainty for the NWHI insular false killer whale S-BIA. This boundary encompasses their entire range based on movements collected from 7 satellite tag deployments, but tags were deployed only in the eastern portion of the range of the stock. Positional uncertainty was accounted for in satellite tag data through the use of state-space models (crawl). Although the opportunistic sightings of NWHI false killer whales off Oʻahu and Hawaiʻi Island are deemed rare, they do present a degree of uncertainty to our understanding of this stock's true range. Limited survey coverage in the NWHI precludes a better understanding of their range within that portion of the archipelago (aside from satellite tag data). Despite this, small boat survey efforts have been conducted off Kauaʻi in 12 years since 2003 (albeit with limited coverage in most years due to typically poor working conditions), and the small proportion of NWHI false killer whale encounters during those efforts could indicate limited use of that region relative to the rest of the NWHI.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 7

# of years in which supporting tagging data collected: 4 (2010-2015)

Supporting information: Location data from satellite tags were available for 7 deployments on NWHI false killer whales from 2010-2015, tagged either off Nihoa (n=2) or Kauaʻi (n=5) (Baird et al. 2013b, Baird, 2016). Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk model using the package crawl implemented in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 4-hour interval and locations on land were re-routed around a polygon representing the islands with a 50 m distance added using the pathroutr package (London, 2020). Crawl locations interpolated over periods spanning 1 or more days without any underlying Argos locations were removed.

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 9

# of years in which supporting visual data collected: 6 (2006-2020)

Supporting information: Sighting and photographic data for individuals from the NWHI stock come from three different sources: CRC surveys, NMFS ship-based line-transect surveys (PIFSC and SWFSC), and citizen science contributions. CRC has conducted non-systematic, dedicated small boat surveys throughout the main Hawaiian Islands from 2000-2021 (see Baird et al., 2013a for details on surveys). CRC surveys off these islands combined total 148,080 km of effort with a total of 5 NWHI false killer whale sightings in four different years (2012, 2013, 2015, 2020), all of which were off Kauaʻi/Niʻihau. NMFS conducted ship-based line-transect surveys in 11 years from 2002 through 2020 totaling 46,455 km of effort throughout the Hawaiian Archipelago (as mapped in respective figure; see Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020 for details on surveys). False killer whales from this population were documented once during NMFS surveys in 2006 off Niʻihau (during monk seal dedicated effort, Marie Hill pers. comm.) and three times in 2010 off Nihoa (Baird et al. 2013b; Bradford et al., 2017). Community science encounters with photographic documentation of individuals from this population are from Kauaʻi (in 2006, 2008, 2012, 2019), off Waiʻanae, Oʻahu (in 2013 and 2015), and off Hawaiʻi Island (one individual documented in 2003). All individuals from these encounters are linked by association in the same social network (CRC unpublished).

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 97

# of years of photo records to compare: 19 (2003-2021)

Maximum # of years same individual photographed in area: 12.8

Supporting information: As of August 2021, CRC's photo-identification catalog for NWHI false killer whales includes 97 slightly distinctive, distinctive, or very distinctive individuals (from fair-, good-, or excellent-quality photographs; CRC unpublished).

Genetic analyses conducted supporting designation (Y/N): Y

Nature of supporting information: Strong

Supporting information: NWHI false killer whales are genetically differentiated from MHI false killer whales and pelagic false killer whales (Chivers et al. 2010; Martien et al. 2014).

What factors justify the boundary selection?: Baird et al. (2015) only delineated a S-BIA for MHI insular false killer whales. With a more comprehensive understanding of the stock structure of NWHI false killer whales and revised BIA delineation protocols, we deem it reasonable to delineate a S-BIA for this island-associated stock.

The basis for the parent BIA was a minimum convex polygon (MCP) encompassing all satellite-tag derived crawl locations; the BIA was established by adding a 3 km distance to the outer boundary of the MCP to account for positional uncertainty in the locations estimated by crawl. Although there are two sightings of individuals from this population off Waiʻanae, Oʻahu, and one of off Kona, Hawaiʻi, these areas are not considered to be part of the regular range of this stock, given they represent less than 2% of all false killer whale encounters off Oʻahu, and less than 0.4% of false killer whale encounters to the islands to the east of Oʻahu (CRC unpublished). The inner (shoreward) boundary was defined as a 50-m distance from shore, based on the shallowest sighting of false killer whales based on CRC dedicated survey efforts (shallowest sighting = 50 m). The resulting area of the parent BIA (i.e., population range size) is 138,001 km2.

Data sources: Cascadia Research Collective (2012-2020, unpublished) accessed 2021; National Marine Fisheries Service (2002-2020) accessed 2021; Shaff, Kratofil, and Baird (2021); Baird et al. (2013b); Baird, (2016).

Approximate % of population that uses this area for the designated purpose (if known): 100

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Baird, R.W., A.M. Gorgone, D.J. McSweeney, D.L. Webster, D.R. Salden, M.H. Deakos, A.D. Ligon, G.S. Schorr, J. Barlow, and S.D. Mahaffy. 2008. False killer whales (Pseudorca crassidens) around the main Hawaiian Islands: long-term site fidelity, inter-island movements, and association patterns. Marine Mammal Science 24:591-612 doi:10.1111/j.1748-7692.2008.00200.x.

Baird, R.W., G.S. Schorr, D.L. Webster, D.J. McSweeney, M.B. Hanson, and R.D. Andrews. 2010. Movements and habitat use of satellite-tagged false killer whales around the main Hawaiian Islands. Endangered Species Research 10:107-121 doi:10.3354/esr00258

Baird, R.W., M.B. Hanson, G.S. Schorr, D.L. Webster, D.J. McSweeney, A.M. Gorgone, S.D. Mahaffy, D. Holzer, E.M. Oleson, and R.D. Andrews. 2012. Range and primary habitats of Hawaiian insular false killer whales: informing determination of critical habitat. Endangered Species Research 18:47-61 doi:10.3354.esr00435

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013a. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269

Baird, R.W., E.M. Oleson, J. Barlow, A.D. Ligon, A.M. Gorgone, and S.D. Mahaffy. 2013b. Evidence of an island-associated population of false killer whales (Pseudorca crassidens) in the Northwestern Hawaiian Islands. Pacific Science 67(4):513-521 doi:10.2984/67.4.2

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Baird, R.W., D.B. Anderson, M.A. Kratofil, D.L. Webster, and S.D. Mahaffy. 2019. Cooperative conservation and long-term management of false killer whales in Hawaiʻi: geospatial analyses of fisheries and satellite tag data to understand fishery interactions. Report to the State of Hawaiʻi Board of Land and Natural Resources under contract No. 67703. Cascadia Research Collective

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22(2):446-464

Bradford, A.L., E.M. Oleson, R.W. Baird, C.H. Boggs, K.A. Forney, and N.C. Young. 2015. Revised stock boundaries for false killer whales (Pseudorca crassidens) in Hawaiian waters. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-47, 20p. doi:10.7289/V5DF6P6J

Bradford, A.L., K.A. Forney, E.M. Oleson, and J. Barlow. 2017. Abundance estimates of cetaceans from a line-transect survey within the U.S. Hawaiian Islands Exclusive Economic Zone. Fishery Bulletin 115:129-142

Bradford, A.L., R.W. Baird, S.D. Mahaffy, A.M. Gorgone, D.J. McSweeney, T. Cullins, D.L. Webster, and A.N. Zerbini. 2018. Abundance estimates for management of endangered false killer whales in the main Hawaiian Islands. Endangered Species Research 36:297-313 doi:10.3354/esr00903

Bradford, A.L., E.A. Becker, E.M. Oleson, K.A. Forney, J.E. Moore, and J. Barlow. 2020. Abundance estimates of false killer whales in Hawaiian waters and the broader central Pacific. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-104, 78pp. doi:10.259232/2jjg-p807

Caretta, J.V., E.M. Oleson, K.A. Forney, M.M. Muto, D.W. Weller, A.R. Lang, J. Baker, B. Hanson, A.J. Orr, J. Barlow, J.E. Moore, and R.L. Brownell Jr. 2021. U.S. Pacific Marine Mammal Stock Assessments: 2020. U.S. Department of Commerce, NOAA.

Chivers, S.J., R.W. Baird, K.M. Martien, B.L. Taylor, E. Archer, A.M. Gorgone, B.L. Hancock, N.M. Hedrick, D. Matilla, D.J. McSweeney, E.M. Oleson, C.L. Palmer, V. Pease, K.M. Robertson, J. Robbins, J.C. Salinas, G.S. Schorr, J.L. Schultz, J.L. Theileking, and D.L. Webster. 2010. Evidence of genetic differentiation for Hawaiʻi insular false killer whales (Pseudorca crassidens). NOAA Technical Memorandum NMFS-SWFSC-458, 46 pp.

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Martien, K.K., S.J. Chivers, R.W. Baird, F.I. Archer, A.M. Gorgone, B.L. Hancock-Hanser, D. Mattila, D.J. McSweeney, E.M. Oleson, C. Palmer, V.L. Pease, K.M. Robertson, G.S. Schorr, M.B. Schultz, D.L. Webster, and B.L. Taylor. 2014. Nuclear and mitochondrial patterns of population structure in North Pacific false killer whales (Pseudorca crassidens). Journal of Heredity 105:611-626 doi:10.1093/jhered/esu029

Martien, K.K., B.L. Taylor, S.J. Chivers, S.D. Mahaffy, A.M. Gorgone, and R.W. Baird. 2019. Fidelity to natal social groups and mating within and between social groups in an endangered false killer whale population. Endangered Species Research 40:219-230 doi:10.3354.esr00995

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Shaff, J.F., M.A. Kratofil, and R.W. Baird. 2021. Beneath the surface: Diving behavior of false killer whales from two populations across diel and lunar cycles in Hawaiian waters. Poster presented at the 7th International Bio-logging Symposium, Honolulu, HI, October 2021.

Yano, K.M., E.M. Oleson, J.L. Keating, L.T. Ballance, M.C. Hill, A.L. Bradford, A.N. Allen, T.W. Joyce, J.E. Moore, and A. Henry. 2018. Cetacean and seabird data collected during the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS), July-December 2017. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TM-NMFS-PIFSC-72, 110 p. doi:10.25923/7avn-gw82

Yano, K.M., E.M. Olesn, J.L.K. McCullough, M.C. Hill, and A.E. Henry. 2020. Cetacean and seabird data collected during the winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey (Winter HICEAS), January-March 2020. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-111, 72 p. doi:10.25923/ehfg-dp78

Supplementary Description 6. 15. Humpback whale reproductive area

Species name: Humpback whale (*Megaptera novaeangliae*)

Descriptive name: Main Hawaiian Islands - Parent

BIA type: Reproductive Area

BIA label: R-BIA2-s-b2-HI024-0a

Transboundary across: None

Hierarchy: Hierarchical BIA; Parent of children a

Importance score: 2 (Intensity: 2, Data support: 2)

Supporting notes for intensity score: Score = 2; Humpback whales make extensive movements from high-latitude feeding grounds to the tropical, shallow waters of the Hawaiian archipelago for breeding during winter months. Humpback whales can be found in Hawaiʻi from late fall through spring, although they typically use Hawaiian waters from December through May (months captured by the revised BIA), with the highest concentration of whales occurring between February through March. It has been estimated that over 50% of North Pacific humpback whales use Hawaiian waters as breeding grounds; the most recent estimated abundance for the Hawaiʻi region is 10,103 (no CV estimated) individuals (Calambokidis et al., 2008). More recent model-based methods estimated an abundance of 11,278 humpback whales (CV=0.56) in the U.S. Hawaiian Islands EEZ during peak abundance (mid-February to mid-March) in 2020; however, this may be an underestimate of all whales that overwinter in Hawaiian waters as it does not consider individuals outside of this peak period (Becker et al., 2022). Further, this estimate extends to both NWHI and MHI regions but was derived from survey data exclusively within the MHI region, so there remains uncertainty in the true EEZ-wide abundance during this period (Becker et al., 2022). Adult females with calves are known to preferentially use shallow waters of the Auʻau Channel (Craig and Herman, 2000; Craig et al., 2014; Cartwright et al., 2012; Pack et al., 2018), and this important nursery region is captured by the child BIA. High-density areas identified by satellite tag data (leeward Maui Nui, Penguin Bank) agree with findings from previous photo-identification studies and aerial surveys (Mobley et al., 2001, 2004), and additional areas (e.g., Kauaʻi/Niʻihau, Middle Bank) have been highlighted with the inclusion of more recent data (Henderson et al., 2019, 2022; Palacios et al., 2020; Yano et al., 2020). Movements between island areas within the MHI occur frequently (Calambokidis et al., 2008; Cerchio et al., 1998; Palacios et al., 2020; Henderson et al., 2021, 2022). Thus, some deeper water habitat/channels between islands are important for this species. No other reproductive BIA within U.S. waters were delineated for North Pacific humpback whales, emphasizing the importance of this R-BIA in this basin (Harrison et al., this issue). Considering the above, we assign intensity scores of 2 and 3 for parent and child BIAs, respectively. We estimate that approximately 75% of the population of breeding humpback whales in the MHI is contained within the child BIA (representing the core range). All tagged whales included in this assessment used the child BIA and the greatest weighted occupancy values occurred within the portion of the child BIA encompassing Penguin Bank and inner Maui Nui. Additionally, 66% of the sightings (1,922 out of 2,911) were contained within the child BIA boundary, that highlights humpback whales' known association with shallow waters for breeding. However, we acknowledge that there is uncertainty in this estimate.

Supporting notes for data support score: Score = 2; The revised humpback whale BIAs presented here were informed by data on movements from 71 satellite tag deployments during nine unique years spanning 1995 to 2019. The maximum number of days transmitted within the MHI breeding area perimeter was 42 days. The area within which reproductive behavior is assumed (i.e., MHI breeding area perimeter) was informed by movement-model estimated behaviors on satellite tag tracks, identified as the switch from area restricted search to directed travel behavior (Palacios et al., 2019, 2020; Henderson et al., 2022). The child BIA (core range) was supported by satellite tag data and all four sources of sighting data (CRC and NIWC Pacific/HDR, Inc. small boat surveys, NMFS ship-based line-transect surveys, and MMRC aerial surveys). The revised boundaries are supported by satellite tagged whale occupancy patterns and concentrations of sightings from both earlier (1990s to 2000s) and recent (2010s) survey efforts. Concentrations of sighting locations from all available efforts conducted throughout the MHI from 1993-2020 generally agree with revised BIA boundaries. Although there remains uncertainty in the most recent abundance estimate (Becker et al., 2022), it was derived from more recent data than the earlier estimate from Calambokidis et al. (2008), which can be considered a valid minimum estimate given recent evidence that the population has continued to increase in localized foraging regions (e.g., Alaska; Muto et al., 2019). Considering these lines of evidence and their strengths and weaknesses, we assigned data support scores of 2 for the parent BIA and 3 for the child BIA.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: No information to suggest either area is used dynamically or ephemerally; boundaries based on static (bathymetric) features.

Boundary certainty: 2

Supporting notes for boundary certainty: We have intermediate confidence in Boundary Certainty for the parent BIA and high confidence in the boundary certainty for the child BIA. While the parent BIA boundary (1,000-m isobath) generally conforms to primary-use areas based on satellite tag data and sightings, the majority of satellite tags used in this assessment were deployed off Maui Nui and the majority of sighting locations were collected over two decades ago (aerial surveys). In addition, only a small number of adult females with calves were satellite tagged (n=6) and thus the movements from available satellite tag data are biased towards adult males or adults without calves. We have high confidence in the child BIA boundary based on both supporting data used in this assessment and from previous studies.

Months of year designation is applicable: January, February, March, April, May, December

Tagging data supporting designation (Y/N): Y

# of tags: 71

# of years in which supporting tagging data collected: 9 (1995-2019)

Supporting information: Data from 84 satellite tags deployed on humpback whales off Maui (n=61) and Kauaʻi/Niʻihau (n=23) during dedicated efforts by Oregon State University (OSU; 1995-2019; Mate et al., 1998; Palacios et al., 2019, 2020) and Naval Information Warfare Center Pacific (NIWCP; 2017-2019; Henderson et al., 2019, 2022) were used for this assessment. Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered according to CRC and OSU's protocols (see supplementary material) and subsequently fit to a continuous-time correlated random walk model via the package crawl (Johnson et al. 2008; Johnson and London, 2018). Crawl fitted models were used to predict locations at a fine temporal interval for residence time calculations (10 minutes) and locations were re-routed around a polygon representing the islands with an added 50 m distance using the pathroutr package (London, 2020). Location data from satellite tags that had less than five days of data within the MHI breeding area perimeter were excluded from analyses to limit spatial bias associated with tag deployment locality; the resulting final sample size for this assessment was 71 satellite tags.

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 2911

# of years in which supporting visual data collected: 21 (1993-2021)

Supporting information: Sighting data during the December-May humpback whale breeding season used for this assessment were collected from four separate sources and in different manners: (1) opportunistically from non-systematic, small boat surveys focusing on odontocetes conducted by CRC throughout the main Hawaiian Islands 2000-2020 (see Baird et al., 2013 for details on surveys); (2) ship-based line-transect surveys for cetaceans conducted by NMFS throughout the main Hawaiian Islands and Northwestern Hawaiian Islands from 2002-2020, with sightings in 2009, 2019 and 2010 (see Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020 for details on surveys); (3) dedicated small boat survey efforts conducted by HDR Inc. off Kauaʻi/Niʻihau from 2017-2019; and (4) aerial surveys conducted throughout the main Hawaiian Islands during February through April by Marine Mammal Research Consultants Ltd. (MMRC) from 1993-2003, collected by J. Mobley (MMRC; Mobley et al., 2001; Mobley, 2004) and provided by PacIOOS (Pacific Islands Ocean Observing System). Although there are NMFS survey and sighting data available off the northwestern Hawaiian Islands and areas outside of the breeding area perimeter, the focus of this BIA is on the main Hawaiian Islands; therefore, northwestern Hawaiian Islands sightings were not considered in this assessment and 11 NMFS sightings outside of the breeding area perimeter off the main Hawaiian Islands were excluded from the BIA revision process. Vessel tracklines during the humpback whale breeding season and within the main Hawaiian Islands breeding area perimeter considered in this BIA (December-May) from all four sources combine to a total of 123,117 km of effort in the main Hawaiian Islands, with a total of 2,911 humpback whale sightings (1993-2020).

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

Supporting information: Calambokidis et al. (2008)

Genetic analyses conducted supporting designation (Y/N): N

What factors justify the boundary selection?: Baird et al. (2015) delineated an R-BIA for humpback whales in the main Hawaiian Islands based on areas with high densities of visual sightings. In this revised assessment, we used information from a large collection of satellite tag deployments to examine the proportion of time that individual whales spend inside the established BIA boundaries (i.e., residence time) compared to outside the boundaries and use this to inform the adequacy of the 2015 boundaries. Sighting locations from several sources were also mapped to compare with the spatial distribution of satellite-tagged whales. We restricted this revised assessment to the area around the Hawaiian Archipelago extending from the coastline to 50 km offshore, as described in Palacios et al. (2019, 2020) and Henderson et al. (2022), which is hereafter considered the "breeding area perimeter". This breeding area perimeter was informed by the relative distance from the islands wherein satellite-tagged humpback whale movement behavior switched from area-restricted search (ARS; indicative of residence while in the breeding area) to directed travel (i.e., start of migration), as estimated by state-space models (Palacios et al., 2019, 2020; Henderson et al., 2022). This particular R-BIA concerns important breeding areas within the MHI; therefore, we focused our assessment on the portion of the breeding area perimeter ranging from Middle Bank Seamount to Hawaiʻi Island (i.e., excluding the MHI), which is also where most data are available. From here on, this area will be referred to as the MHI breeding area perimeter.

Based on the spatial distribution of sightings and occupancy pattern of satellite-tagged whales, we revised the BIA from 2015 by extending the boundary to the 1,000-m isobath around all MHI, including Middle Bank and Kaʻula. In contrast to the 2015 BIA boundary, the revised boundary encompasses a broader area used by humpback whales during the breeding season. The updated boundary also extends farther west to include areas of importance (e.g., Middle Bank) as indicated by both satellite tag and recent sighting data. The revised BIA is hereafter referred as the 'parent' BIA. In addition, we delineated a child BIA representing the 'core range' for this species based on notably high intensity of use within the broader updated boundary (1,000-m isobath); we designated this area as the 200-m isobath as this isobath generally agreed with increased occupancy levels relative to the entire MHI breeding area perimeter and parent BIA, based on the distribution of all data sources. For both parent and child BIA boundaries, the inner (shoreward) boundary was defined as a 50-m distance band from shore. The area of the parent BIA is 23,042 km2 and the area of the child BIA is 6,679 km2. Satellite tag and sighting data used to inform revised BIA boundaries spanned the months of December through May (with locations occurring within the breeding area perimeter). Thus, these boundaries likely encompass the most important reproductive areas for North Pacific humpback whales in the MHI from December through May.

Data sources: Marine Mammal Research Consultants (Mobley et al., 2001; Mobley, 2004 accessed 2021 through PacIOOS Voyager; Cascadia Research Collective, unpublished 2000-2020 (accessed 2021), Baird et al., (2013); HDR Inc., (2017-2019) accessed 2021; National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2009-2020) accessed 2021, Barlow, (2006), Bradford et al., (2017), Yano et al., (2018, 2020); Oregon State University (1995-2019), Mate et al., (1998), Palacios et al., (2019, 2020) accessed 2021; Naval Information Warfare Center Pacific (2017-2019), accessed 2021, Henderson et al., (2019, 2022).

Approximate % of population that uses this area for the designated purpose (if known): 100

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Allen, A.N., Harvey, M., Harrell, L., Jansen, A., Merkens, K.P., Wall. C.C., Cattiau, J., and Oleson, E.M. (2021). A convolutional neural network for automated detection of humpback whale song in a diverse, long-term passive acoustic dataset. Front. Mar. Sci. 8, 607321. Doi: 10.3389/fmars.2021.607321

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22(2):446-464

Barlow, J., Calambokidis, J., Falcone, E.A., Baker, C.S., Burdin, A.M., Clapham, P.J., et al. (2011). Humpback whale abundance in the North Pacific estimated by photographic capture-recapture with bias correction from simulation studies. Mar. Mamm. Sci. 27(4), 793-818. doi: 10.1111/j.1748-7692.2010.00444.x

Becker, E.A., K.A. Forney, E.M. Oleson, A.L. Bradford, R. Hoopes, J.E. Moore, and J. Barlow. 2022. Abundance, distribution, and seasonality of cetaceans within the U.S. Exclusive Economic Zone around the Hawaiian Archipelago based on species distribution models. U.S. Dept. of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-131, 45 p. doi:10.25923/9e50-d280

Calambokidis, J.C., E.A. Falcone, T.J. Quinn, A.M. Burdin, P.J. Clapham, J.K.B. Ford, C.M. Gabriele, R. LeDuc, D. Mattila, L. Rojas-Bracho, J.M. Straley, B.L. Taylor, J. Urbán-R., D. Weller, B.H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K. Flynn, A. Havron, J. Huggins, and N. Maloney. 2008. SPLASH: Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific. Final report for Contract AB133F-03-RP-00078, U.S. Dept of Commerce, Western Administrative Center, Seattle, Washington, USA.

Caretta, J.V., K.A. Forney, E.M. Oleson, D.W. Weller, A.R. Lang, J. Baker, M.M. Muto, B. Hanson, A.J. Orr, H. Huber, M.S. Lowry, J. Barlow, J.E. Moore, D. Lynch, L. Carswell, and R.L. Brownell Jr. 2019. U.S. Pacific Marine Mammal Stock Assessments: 2018. U.S. Department of Commerce, NOAA.

Cartwright, R., and Sullivan, M. (2009). Behavioral ontogeny in humpback whale (Megaptera novaeangliae) calves during their residence in Hawaiian waters. Mar. Mamm. Sci. 25(3), 659-680. doi: 10.1111/j.1748-7692.2009.00286.x

Cartwright, R., B. Gillespie, K. LaBonte, T. Mangold, A. Venema, K. Eden, and M. Sullivan. 2012. Between a rock and a hard place: habitat selection in female-calf humpback whale (Megaptera novaeangliae) pairs on the Hawaiian breeding grounds. PLOS ONE 7(5):e38004

Cerchio. S., C.M. Gabriele, T.F. Norris, and L.M. Herman. 1998. Movements of humpback whales between Kauai and Hawaii: Implications for population structure and abundance estimation in the Hawaiian Islands. Marine Ecology Progress Series 175:13-22

Craig, A.S., and L.M. Herman. 2000. Habitat preferences of female humpback whales Megaptera novaeangliae in the Hawaiian Islands are associated with reproductive status. Marine Ecology Progress Series 193:209-216

Craig, A.S., Herman, L.M., and Pack, A.A. (2002). Male mate choice and male-male competition coexist in the humpback whale (Megaptera novaeangliae). Can. J. Zool. 80, 745-755. Doi: 10.1139/z02-050

Craig, A.S., L.M. Herman, A.A. Pack, and J.O. Waterman. 2014. Habitat segregation by female humpback whales in Hawaiian waters: Avoidance of males? Behaviour 151:613-631

Henderson, E.E., Aschettino, J., Deakos, M., Alongi, G., and Leota, T. (2019). Quantifying the behavior of humpback whales (Megaptera novaeangliae) and potential responses to sonar. Aquat. Mamm. 45(6), 612-631. doi: 10.1578/am.45.6.2019.612

Henderson, E.E., Aschettino, J., and Engelhaupt, D. (2021). Dive and movement behavior of humpback whale competitive group and a multiday association between a primary escort and female in Hawaiʻi. Mar. Mamm. Sci. 38(2), 835-846. doi: 10.1111/mms.12891

Henderson, E.E., Deakos, M., Aschettino, J., Engelhaupt, D., and Alongi, G. (2022). Behavior and inter-island movements of satellite-tagged humpback whales in Hawaiʻi, USA. Mar. Ecol. Prog. Ser. 685, 197-213. doi:10.3354/meps13976

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

Johnston, D.W., Chapla, M.E., Williams, L.E., and Mattila, D.K. (2007). Identification of humpback whale Megaptera novaeangliae wintering habitat in the Northwestern Hawaiian Islands using spatial habitat modeling. Endanger. Species Res. 3, 249-257. Doi:10.3354/esr00049

Lammers, M.O., Fisher-Pool, P.I., Au, W.W.L., Meyer, C.G., Wong, K.B., an Brainard, R.E. 2011. Humpback whale Megaptera novaeangliae song reveals wintering activity in the Northwestern Hawaiian Islands. Mar. Ecol. Prog. Ser. 423, 261-268. Doi: 10.3354/meps08959

London, J.M. 2021. Pathroutr: an R package for (re-)routing paths around barriers (version v0.2.1). Zenodo http://doi.org/10.5281/zenodo.4321827

Mate, B.R., R. Gisiner, and J. Mobley. 1998. Local and migratory movements of Hawaiian humpback whales tracked by satellite telemetry. Canadian Journal of Zoology 76:863-868

Mobley, J.R., Jr., G.B. Bauer, and L.M. Herman. 1999. Changes over a ten-year interval in the distribution and relative abundance of humpback whales (Megaptera novaeangliae) wintering in Hawaiian waters. Aquatic Mammals 25(2):63-72

Mobley, J.R., Jr., S. Spitz, and R. Grotefendt. 2001. Abundance of humpback whales in Hawaiian waters: Results of 1993-2000 aerial surveys. Report prepared for the Hawaiian Islands Humpback Whale National Marine Sanctuary.

Mobley, J.R. 2004. Results of marine mammal surveys on U.S. Navy underwater ranges in Hawaii and Bahamas. Final report submitted to Office of Naval Research, Marine Mammal Program, under award number #N000140210841. March 22, 2004

Möller, L.M., C.R.M. Attard, K. Bilgmann, V. Andrews-Goff, I. Jonsen, D. Paton, and M.C. Double. 2020. Movements and behaviour of blue whales satellite tagged in an Australian upwelling system. Scientific Reports 10:21165 doi:10.1038/s41598-020-78143-2

Muto, M.M., V.T. Helker, G.J. Delean, R.P. Angliss, P.L. Boveng, J.M. Breiwick, G.M. Brost, M.F. Cameron, P.J. Clapham, S.P. Dahle, M.E. Dahlheim, B.S. Fadely, M.C. Ferguson, L.W. Fritz, R.C. Hobbs, Y.V. Ivashchenko, A.S. Kennedy, J.M. London, S.A. Mizroch, R.R. Ream, E.L. Richmond, K.E.W. Shelden, K.L. Sweeney, R.G. Towell, P.R. Wade, J.M. Waite, and A.N. Zerbini. 2019. Alaska marine mammal stock assessments, 2019. U.S. Dep. Commer., NOAA. Tech Memo. NMFS-AFSC-404, 395 p.

Pack, A.A., L.M. Herman, A.S. Craig, S.S. Spitz, J.O. Waterman, E.Y.K. Herman, M.H. Deakos, S. Hakala, and C. Lowe. 2018. Comparing depth and seabed terrain preferences of individually identified female humpback whales (Megaptera novaeangliae), with and without calf, off Maui, Hawaii. Marine Mammal Science 34(5) doi: 10.1111/mms.12495

Palacios, D.M., B.R. Mate, C.S. Baker, C.E. Hayslip, T.M. Follett, D. Steel, B.A. Lagerquist, L.M. Irvine, and M.H. Winsor. 2019. Tracking North Pacific humpback whales to unravel their basin-wide movements. Final technical report prepared for Pacific Life Foundation. Marine Mammal Institute, Oregon State University, Newport, Oregon, USA. 30 June 2019. 58 pp. doi:10.5399/osu/1117 https://ir.library.oregonstate.edu/concern/technical_reports/z890s0924

Palacios, D.M., B.R. Mate, C.S. Baker, B.A. Lagerquist, L.M. Irvine, T.M. Follett, D. Steel, and C.E. Hayslip. 2020. Humpback whale tagging in support of marine mammal monitoring across multiple navy training areas in the Pacific Ocean: Final report for the Hawaiian breeding area in Spring 2019, including historical data from previous tagging efforts. Prepared for Commander, US Pacific Fleet, and Commander, Naval Sea Systems Command. Submitted to Naval Facilities Engineering Command Southwest, San Diego, California, under Cooperative Ecosystem Studies Unit, Department of the Navy Cooperative Agreement No. N62473-19-2-0002. 15 May 2020. 122 pp.

Patton, D., and Lawless, S. (2021). Surface and underwater observation of a humpback whale (Megaptera novaeangliae) birth in progress off Lahaina, Maui, and subsequent encounter of the female with a healthy calf. Aquat. Mamm. 47(6), 550-558. doi: 10.1578/AM.47.6.2021.550

Ransome, N., Bejder, L., Jenner, M., Penfold, G., Brosig, V.J., Kitson, C., et al. (2022). Observations of parturition in humpback whales (Megaptera novaeangliae) and occurrence of escorting and competitive behavior around birthing females. Mar. Mamm. Sci. 38(2), 408-432. doi:10.1111/mms.12864

Yano, K.M., E.M. Oleson, J.L. Keating, L.T. Ballance, M.C. Hill, A.L. Bradford, A.N. Allen, T.W. Joyce, J.E. Moore, and A. Henry. 2018. Cetacean and seabird data collected during the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS), July-December 2017. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TM-NMFS-PIFSC-72, 110 p. doi:10.25923/7avn-gw82

Yano, K.M., Oleson, E.M., Hill, M.C., Keating-McCullough, J.L., and Lammers, M.O. (2019). Spring survey reveals large numbers of humpback whales in the Northwestern Hawaiian Islands. Poster presented at the World Marine Mammal Conference, Barcelona, Spain, 2019.

Yano, K.M., E.M. Oleson, J.L.K. McCullough, M.C. Hill, and A.E. Henry. 2020. Cetacean and seabird data collected during the winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey (Winter HICEAS), January-March 2020. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-111, 72 p. doi:10.25923/ehfg-dp78

Supplementary Description 6. 16. Humpback whale reproductive area

Species name: Humpback whale (*Megaptera novaeangliae*)

Descriptive name: Main Hawaiian Islands - Child

BIA type: Reproductive Area

BIA label: R-BIA3-s-b3-HI024-a

Transboundary across: None

Hierarchy: Hierarchical BIA; Child a

Importance score: 3 (Intensity: 3, Data support: 3)

Supporting notes for intensity score: Score = 3; Humpback whales make extensive movements from high-latitude feeding grounds to the tropical, shallow waters of the Hawaiian archipelago for breeding during winter months. Humpback whales can be found in Hawaiʻi from late fall through spring, although they typically use Hawaiian waters from December through May (months captured by the revised BIA), with the highest concentration of whales occurring between February through March. It has been estimated that over 50% of North Pacific humpback whales use Hawaiian waters as breeding grounds; the most recent estimated abundance for the Hawaiʻi region is 10,103 (no CV estimated) individuals (Calambokidis et al., 2008). More recent model-based methods estimated an abundance of 11,278 humpback whales (CV=0.56) in the U.S. Hawaiian Islands EEZ during peak abundance (mid-February to mid-March) in 2020; however, this may be an underestimate of all whales that overwinter in Hawaiian waters as it does not consider individuals outside of this peak period (Becker et al., 2022). Further, this estimate extends to both NWHI and MHI regions but was derived from survey data exclusively within the MHI region, so there remains uncertainty in the true EEZ-wide abundance during this period (Becker et al., 2022). Adult females with calves are known to preferentially use shallow waters of the Auʻau Channel (Craig and Herman, 2000; Craig et al., 2014; Cartwright et al., 2012; Pack et al., 2018), and this important nursery region is captured by the child BIA. High-density areas identified by satellite tag data (leeward Maui Nui, Penguin Bank) agree with findings from previous photo-identification studies and aerial surveys (Mobley et al., 2001, 2004), and additional areas (e.g., Kauaʻi/Niʻihau, Middle Bank) have been highlighted with the inclusion of more recent data (Henderson et al., 2019, 2022; Palacios et al., 2020; Yano et al., 2020). Movements between island areas within the MHI occur frequently (Calambokidis et al., 2008; Cerchio et al., 1998; Palacios et al., 2020; Henderson et al., 2021, 2022). Thus, some deeper water habitat/channels between islands are important for this species. No other reproductive BIA within U.S. waters were delineated for North Pacific humpback whales, emphasizing the importance of this R-BIA in this basin (Harrison et al., this issue). Considering the above, we assign intensity scores of 2 and 3 for parent and child BIAs, respectively. We estimate that approximately 75% of the population of breeding humpback whales in the MHI is contained within the child BIA (representing the core range). All tagged whales included in this assessment used the child BIA and the greatest weighted occupancy values occurred within the portion of the child BIA encompassing Penguin Bank and inner Maui Nui. Additionally, 66% of the sightings (1,922 out of 2,911) were contained within the child BIA boundary, that highlights humpback whales' known association with shallow waters for breeding. However, we acknowledge that there is uncertainty in this estimate.

Supporting notes for data support score: Score = 3; The revised humpback whale BIAs presented here were informed by data on movements from 71 satellite tag deployments during nine unique years spanning 1995 to 2019. The maximum number of days transmitted within the MHI breeding area perimeter was 42 days. The area within which reproductive behavior is assumed (i.e., MHI breeding area perimeter) was informed by movement-model estimated behaviors on satellite tag tracks, identified as the switch from area restricted search to directed travel behavior (Palacios et al., 2019, 2020; Henderson et al., 2022). The child BIA (core range) was supported by satellite tag data and all four sources of sighting data (CRC and NIWC Pacific/HDR, Inc. small boat surveys, NMFS ship-based line-transect surveys, and MMRC aerial surveys). The revised boundaries are supported by satellite tagged whale occupancy patterns and concentrations of sightings from both earlier (1990s to 2000s) and recent (2010s) survey efforts. Concentrations of sighting locations from all available efforts conducted throughout the MHI from 1993-2020 generally agree with revised BIA boundaries. Although there remains uncertainty in the most recent abundance estimate (Becker et al., 2022), it was derived from more recent data than the earlier estimate from Calambokidis et al. (2008), which can be considered a valid minimum estimate given recent evidence that the population has continued to increase in localized foraging regions (e.g., Alaska; Muto et al., 2019). Considering these lines of evidence and their strengths and weaknesses, we assigned data support scores of 2 for the parent BIA and 3 for the child BIA.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: No information to suggest either area is used dynamically or ephemerally; boundaries based on static (bathymetric) features.

Boundary certainty: 3

Supporting notes for boundary certainty: We have intermediate confidence in Boundary Certainty for the parent BIA and high confidence in the boundary certainty for the child BIA. While the parent BIA boundary (1,000-m isobath) generally conforms to primary-use areas based on satellite tag data and sightings, the majority of satellite tags used in this assessment were deployed off Maui Nui and the majority of sighting locations were collected over two decades ago (aerial surveys). In addition, only a small number of adult females with calves were satellite tagged (n=6) and thus the movements from available satellite tag data are biased towards adult males or adults without calves. We have high confidence in the child BIA boundary based on both supporting data used in this assessment and from previous studies.

Months of year designation is applicable: January, February, March, April, May, December

Tagging data supporting designation (Y/N): Y

# of tags: 71 tags

# of years in which supporting tagging data collected: 9 (1999-2019)

Supporting information: Data from 84 satellite tags deployed on humpback whales off Maui (n=61) and Kauaʻi/Niʻihau (n=23) during dedicated efforts by Oregon State University (OSU; 1995-2019; Mate et al., 1998; Palacios et al., 2019, 2020) and Naval Information Warfare Center Pacific (NIWCP; 2017-2019; Henderson et al., 2019, 2022) were used for this assessment. Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered according to CRC and OSU's protocols (see supplementary material) and subsequently fit to a continuous-time correlated random walk model via the package crawl (Johnson et al. 2008; Johnson and London, 2018). Crawl fitted models were used to predict locations at a fine temporal interval for residence time calculations (10 minutes) and locations were re-routed around a polygon representing the islands with an added 50 m distance using the pathroutr package (London, 2020). Revised BIA based on 71 satellite tag deployments deployed during nine unique years spanning 1995 to 2019. Maximum total number of days of transmitted data within the breeding area perimeter reached up to just over a month long (42 days).

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 2911

# of years in which supporting visual data collected: 21 (1993-2021)

Supporting information: Sighting data during the December-May humpback whale breeding season used for this assessment were collected from four separate sources and in different manners: (1) opportunistically from non-systematic, small boat surveys focusing on odontocetes conducted by CRC throughout the main Hawaiian Islands 2000-2020 (see Baird et al., 2013 for details on surveys); (2) ship-based line-transect surveys for cetaceans conducted by NMFS throughout the main Hawaiian Islands and Northwestern Hawaiian Islands from 2002-2020, with sightings in 2009, 2019 and 2010 (see Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020 for details on surveys); (3) dedicated small boat survey efforts conducted by HDR Inc. off Kauaʻi/Niʻihau from 2017-2019 ; and (4) aerial surveys conducted throughout the main Hawaiian Islands during February through April by Marine Mammal Research Consultants Ltd. (MMRC) from 1993-2003, collected by J. Mobley (MMRC; Mobley et al., 2001; Mobley, 2004) and provided by PacIOOS (Pacific Islands Ocean Observing System). Although there are NMFS survey and sighting data available off the northwestern Hawaiian Islands and areas outside of the breeding area perimeter, the focus of this BIA is on the main Hawaiian Islands; therefore, northwestern Hawaiian Islands sightings were not considered in this assessment and 11 NMFS sightings outside of the breeding area perimeter off the main Hawaiian Islands were excluded from the BIA revision process. Vessel tracklines during the humpback whale breeding season and within the main Hawaiian Islands breeding area perimeter considered in this BIA (December-May) from all four sources combine to a total of 123,117 km of effort in the main Hawaiian Islands, with a total of 2,911 humpback whale sightings (1993-2020).

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

Supporting information: Calambokidis et al. (2008)

Genetic analyses conducted supporting designation (Y/N): N

What factors justify the boundary selection?: Baird et al. (2015) delineated an R-BIA for humpback whales in the main Hawaiian Islands based on areas with high densities of visual sightings. In this revised assessment, we used information from a large collection of satellite tag deployments to examine the proportion of time that individual whales spend inside the established BIA boundaries (i.e., residence time) compared to outside the boundaries and use this to inform the adequacy of the 2015 boundaries. Sighting locations from several sources were also mapped to compare with the spatial distribution of satellite-tagged whales. We restricted this revised assessment to the area around the Hawaiian Archipelago extending from the coastline to 50 km offshore, as described in Palacios et al. (2019, 2020) and Henderson et al. (2022), which is hereafter considered the "breeding area perimeter". This breeding area perimeter was informed by the relative distance from the islands wherein satellite-tagged humpback whale movement behavior switched from area-restricted search (ARS; indicative of residence while in the breeding area) to directed travel (i.e., start of migration), as estimated by state-space models (Palacios et al., 2019, 2020; Henderson et al., 2022). This particular R-BIA concerns important breeding areas within the MHI; therefore, we focused our assessment on the portion of the breeding area perimeter ranging from Middle Bank Seamount to Hawaiʻi Island (i.e., excluding the MHI), which is also where most data are available. From here on, this area will be referred to as the MHI breeding area perimeter.

Based on the spatial distribution of sightings and occupancy pattern of satellite-tagged whales, we revised the BIA from 2015 by extending the boundary to the 1,000-m isobath around all MHI, including Middle Bank and Kaʻula. In contrast to the 2015 BIA boundary, the revised boundary encompasses a broader area used by humpback whales during the breeding season. The updated boundary also extends farther west to include areas of importance (e.g., Middle Bank) as indicated by both satellite tag and recent sighting data. The revised BIA is hereafter referred as the 'parent' BIA. In addition, we delineated a child BIA representing the 'core range' for this species based on notably high intensity of use within the broader updated boundary (1,000-m isobath); we designated this area as the 200-m isobath as this isobath generally agreed with increased occupancy levels relative to the entire MHI breeding area perimeter and parent BIA, based on the distribution of all data sources. For both parent and child BIA boundaries, the inner (shoreward) boundary was defined as a 50-m distance band from shore. The area of the parent BIA is 23,042 km2 and the area of the child BIA is 6,679 km2. Satellite tag and sighting data used to inform revised BIA boundaries spanned the months of December through May (with locations occurring within the breeding area perimeter). Thus, these boundaries likely encompass the most important reproductive areas for North Pacific humpback whales in the MHI from December through May.

Data sources: Marine Mammal Research Consultants (Mobley et al., 2001; Mobley, 2004) accessed 2021 through PacIOOS Voyager; Cascadia Research Collective, unpublished 2000-2020 (accessed 2021), Baird et al., (2013); HDR Inc., (2017-2019) accessed 2021; National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2009-2020) accessed 2021, Barlow, (2006), Bradford et al., (2017), Yano et al., (2018, 2020); Oregon State University (1995-2019), Mate et al., (1998), Palacios et al., (2019, 2020) accessed 2021; Naval Information Warfare Center Pacific (2017-2019), accessed 2021, Henderson et al., (2019, 2022).

Approximate % of population that uses this area for the designated purpose (if known): 75

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Allen, A.N., Harvey, M., Harrell, L., Jansen, A., Merkens, K.P., Wall. C.C., Cattiau, J., and Oleson, E.M. (2021). A convolutional neural network for automated detection of humpback whale song in a diverse, long-term passive acoustic dataset. Front. Mar. Sci. 8, 607321. Doi: 10.3389/fmars.2021.607321

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22(2):446-464

Barlow, J., Calambokidis, J., Falcone, E.A., Baker, C.S., Burdin, A.M., Clapham, P.J., et al. (2011). Humpback whale abundance in the North Pacific estimated by photographic capture-recapture with bias correction from simulation studies. Mar. Mamm. Sci. 27(4), 793-818. doi: 10.1111/j.1748-7692.2010.00444.x

Becker, E.A., K.A. Forney, E.M. Oleson, A.L. Bradford, R. Hoopes, J.E. Moore, and J. Barlow. 2022. Abundance, distribution, and seasonality of cetaceans within the U.S. Exclusive Economic Zone around the Hawaiian Archipelago based on species distribution models. U.S. Dept. of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-131, 45 p. doi:10.25923/9e50-d280

Calambokidis, J.C., E.A. Falcone, T.J. Quinn, A.M. Burdin, P.J. Clapham, J.K.B. Ford, C.M. Gabriele, R. LeDuc, D. Mattila, L. Rojas-Bracho, J.M. Straley, B.L. Taylor, J. Urbán-R., D. Weller, B.H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K. Flynn, A. Havron, J. Huggins, and N. Maloney. 2008. SPLASH: Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific. Final report for Contract AB133F-03-RP-00078, U.S. Dept of Commerce, Western Administrative Center, Seattle, Washington, USA.

Caretta, J.V., K.A. Forney, E.M. Oleson, D.W. Weller, A.R. Lang, J. Baker, M.M. Muto, B. Hanson, A.J. Orr, H. Huber, M.S. Lowry, J. Barlow, J.E. Moore, D. Lynch, L. Carswell, and R.L. Brownell Jr. 2019. U.S. Pacific Marine Mammal Stock Assessments: 2018. U.S. Department of Commerce, NOAA.

Cartwright, R., and Sullivan, M. (2009). Behavioral ontogeny in humpback whale (Megaptera novaeangliae) calves during their residence in Hawaiian waters. Mar. Mamm. Sci. 25(3), 659-680. doi: 10.1111/j.1748-7692.2009.00286.x

Cartwright, R., B. Gillespie, K. LaBonte, T. Mangold, A. Venema, K. Eden, and M. Sullivan. 2012. Between a rock and a hard place: habitat selection in female-calf humpback whale (Megaptera novaeangliae) pairs on the Hawaiian breeding grounds. PLOS ONE 7(5):e38004

Cerchio. S., C.M. Gabriele, T.F. Norris, and L.M. Herman. 1998. Movements of humpback whales between Kauai and Hawaii: Implications for population structure and abundance estimation in the Hawaiian Islands. Marine Ecology Progress Series 175:13-22

Craig, A.S., and L.M. Herman. 2000. Habitat preferences of female humpback whales Megaptera novaeangliae in the Hawaiian Islands are associated with reproductive status. Marine Ecology Progress Series 193:209-216

Craig, A.S., Herman, L.M., and Pack, A.A. (2002). Male mate choice and male-male competition coexist in the humpback whale (Megaptera novaeangliae). Can. J. Zool. 80, 745-755. Doi: 10.1139/z02-050

Craig, A.S., L.M. Herman, A.A. Pack, and J.O. Waterman. 2014. Habitat segregation by female humpback whales in Hawaiian waters: Avoidance of males? Behaviour 151:613-631

Henderson, E.E., Aschettino, J., Deakos, M., Alongi, G., and Leota, T. (2019). Quantifying the behavior of humpback whales (Megaptera novaeangliae) and potential responses to sonar. Aquat. Mamm. 45(6), 612-631. doi: 10.1578/am.45.6.2019.612

Henderson, E.E., Aschettino, J., and Engelhaupt, D. (2021). Dive and movement behavior of humpback whale competitive group and a multiday association between a primary escort and female in Hawaiʻi. Mar. Mamm. Sci. 38(2), 835-846. doi: 10.1111/mms.12891

Henderson, E.E., Deakos, M., Aschettino, J., Engelhaupt, D., and Alongi, G. (2022). Behavior and inter-island movements of satellite-tagged humpback whales in Hawaiʻi, USA. Mar. Ecol. Prog. Ser. 685, 197-213. doi:10.3354/meps13976

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

Johnston, D.W., Chapla, M.E., Williams, L.E., and Mattila, D.K. (2007). Identification of humpback whale Megaptera novaeangliae wintering habitat in the Northwestern Hawaiian Islands using spatial habitat modeling. Endanger. Species Res. 3, 249-257. Doi:10.3354/esr00049

Lammers, M.O., Fisher-Pool, P.I., Au, W.W.L., Meyer, C.G., Wong, K.B., an Brainard, R.E. 2011. Humpback whale Megaptera novaeangliae song reveals wintering activity in the Northwestern Hawaiian Islands. Mar. Ecol. Prog. Ser. 423, 261-268. Doi: 10.3354/meps08959

London, J.M. 2021. Pathroutr: an R package for (re-)routing paths around barriers (version v0.2.1). Zenodo http://doi.org/10.5281/zenodo.4321827

Mate, B.R., R. Gisiner, and J. Mobley. 1998. Local and migratory movements of Hawaiian humpback whales tracked by satellite telemetry. Canadian Journal of Zoology 76:863-868

Mobley, J.R., Jr., G.B. Bauer, and L.M. Herman. 1999. Changes over a ten-year interval in the distribution and relative abundance of humpback whales (Megaptera novaeangliae) wintering in Hawaiian waters. Aquatic Mammals 25(2):63-72

Mobley, J.R., Jr., S. Spitz, and R. Grotefendt. 2001. Abundance of humpback whales in Hawaiian waters: Results of 1993-2000 aerial surveys. Report prepared for the Hawaiian Islands Humpback Whale National Marine Sanctuary.

Mobley, J.R. 2004. Results of marine mammal surveys on U.S. Navy underwater ranges in Hawaii and Bahamas. Final report submitted to Office of Naval Research, Marine Mammal Program, under award number #N000140210841. March 22, 2004

Möller, L.M., C.R.M. Attard, K. Bilgmann, V. Andrews-Goff, I. Jonsen, D. Paton, and M.C. Double. 2020. Movements and behaviour of blue whales satellite tagged in an Australian upwelling system. Scientific Reports 10:21165 doi:10.1038/s41598-020-78143-2

Muto, M.M., V.T. Helker, G.J. Delean, R.P. Angliss, P.L. Boveng, J.M. Breiwick, G.M. Brost, M.F. Cameron, P.J. Clapham, S.P. Dahle, M.E. Dahlheim, B.S. Fadely, M.C. Ferguson, L.W. Fritz, R.C. Hobbs, Y.V. Ivashchenko, A.S. Kennedy, J.M. London, S.A. Mizroch, R.R. Ream, E.L. Richmond, K.E.W. Shelden, K.L. Sweeney, R.G. Towell, P.R. Wade, J.M. Waite, and A.N. Zerbini. 2019. Alaska marine mammal stock assessments, 2019. U.S. Dep. Commer., NOAA. Tech Memo. NMFS-AFSC-404, 395 p.

Pack, A.A., L.M. Herman, A.S. Craig, S.S. Spitz, J.O. Waterman, E.Y.K. Herman, M.H. Deakos, S. Hakala, and C. Lowe. 2018. Comparing depth and seabed terrain preferences of individually identified female humpback whales (Megaptera novaeangliae), with and without calf, off Maui, Hawaii. Marine Mammal Science 34(5) doi: 10.1111/mms.12495

Palacios, D.M., B.R. Mate, C.S. Baker, C.E. Hayslip, T.M. Follett, D. Steel, B.A. Lagerquist, L.M. Irvine, and M.H. Winsor. 2019. Tracking North Pacific humpback whales to unravel their basin-wide movements. Final technical report prepared for Pacific Life Foundation. Marine Mammal Institute, Oregon State University, Newport, Oregon, USA. 30 June 2019. 58 pp. doi:10.5399/osu/1117 https://ir.library.oregonstate.edu/concern/technical_reports/z890s0924

Palacios, D.M., B.R. Mate, C.S. Baker, B.A. Lagerquist, L.M. Irvine, T.M. Follett, D. Steel, and C.E. Hayslip. 2020. Humpback whale tagging in support of marine mammal monitoring across multiple navy training areas in the Pacific Ocean: Final report for the Hawaiian breeding area in Spring 2019, including historical data from previous tagging efforts. Prepared for Commander, US Pacific Fleet, and Commander, Naval Sea Systems Command. Submitted to Naval Facilities Engineering Command Southwest, San Diego, California, under Cooperative Ecosystem Studies Unit, Department of the Navy Cooperative Agreement No. N62473-19-2-0002. 15 May 2020. 122 pp.

Patton, D., and Lawless, S. (2021). Surface and underwater observation of a humpback whale (Megaptera novaeangliae) birth in progress off Lahaina, Maui, and subsequent encounter of the female with a healthy calf. Aquat. Mamm. 47(6), 550-558. doi: 10.1578/AM.47.6.2021.550

Ransome, N., Bejder, L., Jenner, M., Penfold, G., Brosig, V.J., Kitson, C., et al. (2022). Observations of parturition in humpback whales (Megaptera novaeangliae) and occurrence of escorting and competitive behavior around birthing females. Mar. Mamm. Sci. 38(2), 408-432. doi:10.1111/mms.12864

Yano, K.M., E.M. Oleson, J.L. Keating, L.T. Ballance, M.C. Hill, A.L. Bradford, A.N. Allen, T.W. Joyce, J.E. Moore, and A. Henry. 2018. Cetacean and seabird data collected during the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS), July-December 2017. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TM-NMFS-PIFSC-72, 110 p. doi:10.25923/7avn-gw82

Yano, K.M., Oleson, E.M., Hill, M.C., Keating-McCullough, J.L., and Lammers, M.O. (2019). Spring survey reveals large numbers of humpback whales in the Northwestern Hawaiian Islands. Poster presented at the World Marine Mammal Conference, Barcelona, Spain, 2019.

Yano, K.M., E.M. Oleson, J.L.K. McCullough, M.C. Hill, and A.E. Henry. 2020. Cetacean and seabird data collected during the winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey (Winter HICEAS), January-March 2020. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-111, 72 p. doi:10.25923/ehfg-dp78

Supplementary Description 6. 17. Humpback whale reproductive area

Species name: Humpback whale (*Megaptera novaeangliae*)

Descriptive name: Northwestern Hawaiian Islands - Watch List Area

BIA type: Reproductive Area

BIA label: R-BIA0-s-b1-HI036-0

Transboundary across: None

Hierarchy: Non-hierarchical; single watch list area

Importance score: 0 (Intensity: 1, Data support: 1)

Supporting notes for intensity score: Score = 1; Humpback whales make extensive movements from high-latitude feeding grounds to the tropical, shallow waters of the Hawaiian archipelago for breeding during winter months. Humpback whales can be found in Hawaiʻi from late fall through spring, although they typically use Hawaiian waters from December through May, with the highest concentration of whales occurring between February through March. It has been estimated that over 50% of North Pacific humpback whales use Hawaiian waters as breeding grounds; the most recent estimated abundance for the Hawaiʻi region is 10,103 (no CV estimated) individuals (Calambokidis et al., 2008). However, the majority of this information was derived from data collected in the main Hawaiian Islands. More recent model-based methods estimated an abundance of 11,278 humpback whales (CV=0.56) in the Hawaiian Islands (both NWHI and MHI) during peak abundance (mid-February to mid-March) in 2020; however, this may be an underestimate of all whales that overwinter in Hawaiian waters as it does not consider individuals outside of this peak period, and all of the data that informed the estimate occurred in the MHI (Becker et al., 2022). It is challenging to estimate the relative proportion of humpback whales in the entire Hawaiian Archipelago that use the NWHI (as represented by this watch list area) for reproductive activities, so the intensity of use of this area remains uncertain.

Supporting notes for data support score: Score = 1;

- Passive acoustic findings support the seasonal presence of humpback whales in the NWHI (Allen et al., 2021; Johnston et al., 2007; Lammers et al., 2011) during winter to spring months.
- Three whales satellite tagged in the MHI moved west into the NWHI for a brief period of time; the remaining 81 satellite tagged humpback whales stayed inside the MHI region (Palacios et al., 2019, 2020; Henderson et al., 2019, 2022).
- A total of 30 sightings during ship-based line-transect surveys in the NWHI region. Sightings occurred during the last two months of the winter breeding season for humpback whales considered here (December-May).
- Watch list area boundary (200-m isobath) aligns with predicted suitable habitat, based on sightings (n=9 sightings) and acoustic detections (Johnston et al., 2007)
- Available information on abundance and density estimates are recent but are not specific to the NWHI region (includes both NWHI and MHI); the model that provided these estimates was largely informed by data from the MHI and more data from the NWHI are needed to inform future modeling efforts (Becker et al., 2022)

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: No information to suggest either area is used dynamically or ephemerally; boundaries based on static (bathymetric) features.

Boundary certainty: 1

Supporting notes for boundary certainty: We have low confidence in Boundary Certainty for the watch list area (score = 1). While there is ample evidence from acoustic monitoring to support the seasonal presence of humpback whales in the NWHI, these data do not resolve spatial patterns of humpback whale use in this region. Predicted suitable habitat and predicted densities have been derived (Johnston et al., 2007; Becker et al., 2022), however, these are based on limited spatial points in the region.

Months of year designation is applicable: January, February, March, April, May, December

Tagging data supporting designation (Y/N): Y

# of tags: 3 out of 84

# of years in which supporting tagging data collected: 2017-2019

Supporting information: A total of three individuals out of 84 whales satellite tagged (Maui, n=61; Kauaʻi/Niʻihau, n=23) by Oregon State University (OSU; 1995-2019; Mate et al., 1998; Palacios et al., 2019, 2020) and Naval Information Warfare Center Pacific (NIWC Pacific; 2017-2019; Henderson et al., 2019, 2022) were documented moving into the NWHI region and were mapped here. Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, raw location data were filtered according to CRC and OSU's protocols (see supplementary material). Because we map the tracking data to simply show the movements of these three individuals (and not to determine the spatial boundary), data were not subsequently modeled as done in the MHI humpback whale R-BIA. One of the three individuals that moved into the NWHI entered the NWHI at the end of March, whereas the movements of the other two individuals that entered the NWHI were in April.

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 30

# of years in which supporting visual data collected: 2013, 2019

Supporting information: Sighting data in the NWHI during the humpback whale breeding season considered here (December-May) was available from two shipboard line-transect surveys undertaken by NMFS in 2013 and 2019 (PACES and TRIALS, respectively; Becker et al., 2022; Yano et al., 2019). A total of 30 sightings of humpback whales in the region of interest

(Kuaihelani (Midway Atoll) to Nihoa) were obtained during this effort, although all but one sighting (May 2013) were during a single month (April 2019) and thus are not representative of all humpback whales that may use the NWHI during the December-May breeding season considered here. While NMFS has conducted several ship-based line-transect surveys for cetaceans extending to the NWHI region, these additional surveys occurred outside of the primary humpback whale breeding season, and thus, there are no sightings of humpbacks in the NWHI from these surveys (e.g., Barlow, 2006; Bradford et al., 2017; Yano et al., 2018). Survey tracklines during the humpback whale breeding season and within the NWHI breeding area perimeter considered in this watch list area (December-May) from all NMFS surveys combined to approximately 5,190 km of effort.

Acoustic detections/records supporting designation (Y/N): Y

Supporting information: Lammers et al. (2011), Johnston et al. (2007), Allen et al. (2021)

Photo-ID evidence supporting designation (Y/N): Y

Supporting information: Yano et al. (2019)

Genetic analyses conducted supporting designation (Y/N): N

What factors justify the boundary selection?: Baird et al. (2015) did not delineate an R-BIA for humpback whales in the NWHI due to limited supporting information at the time of the study. While evidence of humpback whale use of this region has increased since then, available supporting data is from (1) individual bottom-mounted acoustic receivers that do not provide much information on spatial distribution and relative abundance (Allen et al., 2021) and (2) movements from only a few satellite-tagged individuals, who spent little time within the NWHI (west of Middle Bank) before departing north (within 5 days; Henderson et al., 2019, 2022; Palacios et al., 2020). There remains uncertainty in the intensity of use of the NWHI by all wintering humpback whales in the Hawaiian Archipelago, and notably, the proportion of humpbacks that divide their time between the MHI and the NWHI versus those that may exclusively use the NWHI during the breeding season (Lammers et al., 2011). Therefore, we delineated a watch list area in the NWHI for humpback whale reproductive activities in this assessment. Future BIA efforts could consider transitioning this watch list area into a full BIA if additional studies address knowledge gaps in relative abundance and connectivity between the MHI and NWHI. Satellite tag deployments on humpback whales within the NWHI would greatly advance our ability to clarify their use of the NWHI and delineate a BIA in future efforts. The time period for this watch list area was assigned as December through May, which is supported by acoustic detection rates (Allen et al., 2021; Lammers et al., 2011; Johnston et al., 2007). We used suitable wintering habitat from spatial modeling (Johnston et al., 2007) to inform the watch list area boundary spanning Hōlanikū (Kure Atoll, westmost extent) to Nihoa (eastmost extent), and mapped available sighting locations and satellite tracking data as lines of support. Similar to the MHI humpback whale R-BIA, we considered a 50 km buffer around the NWHI to be the NWHI breeding area perimeter and area of interest in this assessment (Palacios et al., 2019, 2020; Henderson et al., 2019, 2022).

We designated the 200-m isobath in the NWHI as the spatial boundary for this watch list area, which was identified as suitable wintering habitat by Johnston et al. (2007), and is supported by available satellite tag data and visual sightings. The area of the watch list area is 13,305 km2.

Data sources: National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2009-2020) accessed 2021, Barlow, (2006), Bradford et al., (2017), Yano et al., (2018, 2019, 2020); Oregon State University (1995-2019), Mate et al., (1998), Palacios et al., (2019, 2020) accessed 2021; Naval Information Warfare Center Pacific (2017-2019), accessed 2021, Henderson et al., (2019, 2022).

Approximate % of population that uses this area for the designated purpose (if known): unknown

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: unknown

References: Allen, A.N., Harvey, M., Harrell, L., Jansen, A., Merkens, K.P., Wall. C.C., Cattiau, J., and Oleson, E.M. (2021). A convolutional neural network for automated detection of humpback whale song in a diverse, long-term passive acoustic dataset. Front. Mar. Sci. 8, 607321. Doi: 10.3389/fmars.2021.607321

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22(2):446-464

Barlow, J., Calambokidis, J., Falcone, E.A., Baker, C.S., Burdin, A.M., Clapham, P.J., et al. (2011). Humpback whale abundance in the North Pacific estimated by photographic capture-recapture with bias correction from simulation studies. Mar. Mamm. Sci. 27(4), 793-818. doi: 10.1111/j.1748-7692.2010.00444.x

Becker, E.A., K.A. Forney, E.M. Oleson, A.L. Bradford, R. Hoopes, J.E. Moore, and J. Barlow. 2022. Abundance, distribution, and seasonality of cetaceans within the U.S. Exclusive Economic Zone around the Hawaiian Archipelago based on species distribution models. U.S. Dept. of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-131, 45 p. doi:10.25923/9e50-d280

Calambokidis, J.C., E.A. Falcone, T.J. Quinn, A.M. Burdin, P.J. Clapham, J.K.B. Ford, C.M. Gabriele, R. LeDuc, D. Mattila, L.

Rojas-Bracho, J.M. Straley, B.L. Taylor, J. Urbán-R., D. Weller, B.H. Witteveen, M. Yamaguchi, A. Bendlin, D. Camacho, K. Flynn, A. Havron, J. Huggins, and N. Maloney. 2008. SPLASH: Structure of Populations, Levels of Abundance and Status of Humpback Whales in the North Pacific. Final report for Contract AB133F-03-RP-00078, U.S. Dept of Commerce, Western Administrative Center, Seattle, Washington, USA.

Caretta, J.V., K.A. Forney, E.M. Oleson, D.W. Weller, A.R. Lang, J. Baker, M.M. Muto, B. Hanson, A.J. Orr, H. Huber, M.S. Lowry, J. Barlow, J.E. Moore, D. Lynch, L. Carswell, and R.L. Brownell Jr. 2019. U.S. Pacific Marine Mammal Stock Assessments: 2018. U.S. Department of Commerce, NOAA.

Cartwright, R., and Sullivan, M. (2009). Behavioral ontogeny in humpback whale (Megaptera novaeangliae) calves during their residence in Hawaiian waters. Mar. Mamm. Sci. 25(3), 659-680. doi: 10.1111/j.1748-7692.2009.00286.x

Cartwright, R., B. Gillespie, K. LaBonte, T. Mangold, A. Venema, K. Eden, and M. Sullivan. 2012. Between a rock and a hard place: habitat selection in female-calf humpback whale (Megaptera novaeangliae) pairs on the Hawaiian breeding grounds. PLOS ONE 7(5):e38004

Cerchio. S., C.M. Gabriele, T.F. Norris, and L.M. Herman. 1998. Movements of humpback whales between Kauai and Hawaii: Implications for population structure and abundance estimation in the Hawaiian Islands. Marine Ecology Progress Series 175:13-22

Craig, A.S., and L.M. Herman. 2000. Habitat preferences of female humpback whales Megaptera novaeangliae in the Hawaiian Islands are associated with reproductive status. Marine Ecology Progress Series 193:209-216

Craig, A.S., Herman, L.M., and Pack, A.A. (2002). Male mate choice and male-male competition coexist in the humpback whale (Megaptera novaeangliae). Can. J. Zool. 80, 745-755. Doi: 10.1139/z02-050

Craig, A.S., L.M. Herman, A.A. Pack, and J.O. Waterman. 2014. Habitat segregation by female humpback whales in Hawaiian waters: Avoidance of males? Behaviour 151:613-631

Henderson, E.E., Aschettino, J., Deakos, M., Alongi, G., and Leota, T. (2019). Quantifying the behavior of humpback whales (Megaptera novaeangliae) and potential responses to sonar. Aquat. Mamm. 45(6), 612-631. doi: 10.1578/am.45.6.2019.612

Henderson, E.E., Aschettino, J., and Engelhaupt, D. (2021). Dive and movement behavior of humpback whale competitive group and a multiday association between a primary escort and female in Hawaiʻi. Mar. Mamm. Sci. 38(2), 835-846. doi: 10.1111/mms.12891

Henderson, E.E., Deakos, M., Aschettino, J., Engelhaupt, D., and Alongi, G. (2022). Behavior and inter-island movements of satellite-tagged humpback whales in Hawaiʻi, USA. Mar. Ecol. Prog. Ser. 685, 197-213. doi:10.3354/meps13976

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

Johnston, D.W., Chapla, M.E., Williams, L.E., and Mattila, D.K. (2007). Identification of humpback whale Megaptera novaeangliae wintering habitat in the Northwestern Hawaiian Islands using spatial habitat modeling. Endanger. Species Res. 3, 249-257. Doi:10.3354/esr00049

Lammers, M.O., Fisher-Pool, P.I., Au, W.W.L., Meyer, C.G., Wong, K.B., an Brainard, R.E. 2011. Humpback whale Megaptera novaeangliae song reveals wintering activity in the Northwestern Hawaiian Islands. Mar. Ecol. Prog. Ser. 423, 261-268. Doi: 10.3354/meps08959

London, J.M. 2021. Pathroutr: an R package for (re-)routing paths around barriers (version v0.2.1). Zenodo http://doi.org/10.5281/zenodo.4321827

Mate, B.R., R. Gisiner, and J. Mobley. 1998. Local and migratory movements of Hawaiian humpback whales tracked by satellite telemetry. Canadian Journal of Zoology 76:863-868

Mobley, J.R., Jr., G.B. Bauer, and L.M. Herman. 1999. Changes over a ten-year interval in the distribution and relative abundance of humpback whales (Megaptera novaeangliae) wintering in Hawaiian waters. Aquatic Mammals 25(2):63-72

Mobley, J.R., Jr., S. Spitz, and R. Grotefendt. 2001. Abundance of humpback whales in Hawaiian waters: Results of 1993-2000 aerial surveys. Report prepared for the Hawaiian Islands Humpback Whale National Marine Sanctuary.

Mobley, J.R. 2004. Results of marine mammal surveys on U.S. Navy underwater ranges in Hawaii and Bahamas. Final report submitted to Office of Naval Research, Marine Mammal Program, under award number #N000140210841. March 22, 2004

Möller, L.M., C.R.M. Attard, K. Bilgmann, V. Andrews-Goff, I. Jonsen, D. Paton, and M.C. Double. 2020. Movements and behaviour of blue whales satellite tagged in an Australian upwelling system. Scientific Reports 10:21165 doi:10.1038/s41598-020-78143-2

Muto, M.M., V.T. Helker, G.J. Delean, R.P. Angliss, P.L. Boveng, J.M. Breiwick, G.M. Brost, M.F. Cameron, P.J. Clapham, S.P. Dahle, M.E. Dahlheim, B.S. Fadely, M.C. Ferguson, L.W. Fritz, R.C. Hobbs, Y.V. Ivashchenko, A.S. Kennedy, J.M. London, S.A. Mizroch, R.R. Ream, E.L. Richmond, K.E.W. Shelden, K.L. Sweeney, R.G. Towell, P.R. Wade, J.M. Waite, and A.N. Zerbini. 2019. Alaska marine mammal stock assessments, 2019. U.S. Dep. Commer., NOAA. Tech Memo. NMFS-AFSC-404, 395 p.

Pack, A.A., L.M. Herman, A.S. Craig, S.S. Spitz, J.O. Waterman, E.Y.K. Herman, M.H. Deakos, S. Hakala, and C. Lowe. 2018. Comparing depth and seabed terrain preferences of individually identified female humpback whales (Megaptera novaeangliae), with and without calf, off Maui, Hawaii. Marine Mammal Science 34(5) doi: 10.1111/mms.12495

Palacios, D.M., B.R. Mate, C.S. Baker, C.E. Hayslip, T.M. Follett, D. Steel, B.A. Lagerquist, L.M. Irvine, and M.H. Winsor. 2019. Tracking North Pacific humpback whales to unravel their basin-wide movements. Final technical report prepared for Pacific Life Foundation. Marine Mammal Institute, Oregon State University, Newport, Oregon, USA. 30 June 2019. 58 pp. doi:10.5399/osu/1117 https://ir.library.oregonstate.edu/concern/technical_reports/z890s0924

Palacios, D.M., B.R. Mate, C.S. Baker, B.A. Lagerquist, L.M. Irvine, T.M. Follett, D. Steel, and C.E. Hayslip. 2020. Humpback whale tagging in support of marine mammal monitoring across multiple navy training areas in the Pacific Ocean: Final report for the Hawaiian breeding area in Spring 2019, including historical data from previous tagging efforts. Prepared for Commander, US Pacific Fleet, and Commander, Naval Sea Systems Command. Submitted to Naval Facilities Engineering Command Southwest, San Diego, California, under Cooperative Ecosystem Studies Unit, Department of the Navy Cooperative Agreement No. N62473-19-2-0002. 15 May 2020. 122 pp.

Patton, D., and Lawless, S. (2021). Surface and underwater observation of a humpback whale (Megaptera novaeangliae) birth in progress off Lahaina, Maui, and subsequent encounter of the female with a healthy calf. Aquat. Mamm. 47(6), 550-558. doi: 10.1578/AM.47.6.2021.550

Ransome, N., Bejder, L., Jenner, M., Penfold, G., Brosig, V.J., Kitson, C., et al. (2022). Observations of parturition in humpback whales (Megaptera novaeangliae) and occurrence of escorting and competitive behavior around birthing females. Mar. Mamm. Sci. 38(2), 408-432. doi:10.1111/mms.12864

Yano, K.M., E.M. Oleson, J.L. Keating, L.T. Ballance, M.C. Hill, A.L. Bradford, A.N. Allen, T.W. Joyce, J.E. Moore, and A. Henry. 2018. Cetacean and seabird data collected during the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS), July-December 2017. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TM-NMFS-PIFSC-72, 110 p. doi:10.25923/7avn-gw82

Yano, K.M., Oleson, E.M., Hill, M.C., Keating-McCullough, J.L., and Lammers, M.O. (2019). Spring survey reveals large numbers of humpback whales in the Northwestern Hawaiian Islands. Poster presented at the World Marine Mammal Conference, Barcelona, Spain, 2019.

Yano, K.M., E.M. Oleson, J.L.K. McCullough, M.C. Hill, and A.E. Henry. 2020. Cetacean and seabird data collected during the winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey (Winter HICEAS), January-March 2020. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-111, 72 p. doi:10.25923/ehfg-dp78

Supplementary Description 6. 18. Melon-headed whale small and resident pop.

Species name: Melon-headed whale (*Peponocephala electra*)

Stock or population: Kohala Stock

Descriptive name: Kohala Residents - Hawai'i Island

BIA type: Small and Resident Pop.

BIA label: S-BIA2-s-b3-HI006-0

Transboundary across: None

Hierarchy: Non-hierarchical; single BIA

Importance score: 2 (Intensity: 2, Data support: 3)

Intensity matrix: Abundance: 2, Range: 2

Supporting notes for intensity score: Aschettino (2010) estimated an abundance of 447 individuals (CV=0.12) for the Kohala resident stock using mark-recapture analyses based on photo-identification data from 2003 through 2008 collected by CRC, other researchers, and community scientists. Although additional photos from this population have been collected since then, only a subset have been added to the CRC photo-ID catalog and no efforts have been made to estimate abundance since the 2010 Aschettino analysis. For the purposes of this assessment will assume the stock is within the 126 to 500 category (score = 2) of the BIA Intensity scoring criteria. The resulting area of the BIA (i.e., population range size) is 3,816 km2 (score = 2).

Although the abundance estimate used to derive the intensity score is dated, it is specific to this island-associated stock and based on photo-identification data collected from extensive survey effort and opportunistic sightings. The estimate (447, CV=0.12) is within the 126-500 individual range, and the CV is small (Aschettino 2010). Although the 95% CI for the estimate is above 500 (519), we have categorized the estimate in the 126-500 individual bin. A subsequent assessment looking for missed matches in the catalog, which would inflate the abundance estimate, suggests that the estimate is biased high. Although the tag deployments used to help inform the BIA boundary were relatively short, they were deployed during six different years and tagged individuals displayed similar use of nearshore habitat off the Kohala shoreline, with some individuals moving farther offshore into the ʻAlenuihāhā Channel where survey effort has been extremely limited.

Supporting notes for data support score: Data Support score = 3.

• This stock has been studied for 17 years (2005-2021), primarily through dedicated small boat survey efforts. Additional photographic data supplied by other researchers and community science contributions spans a 36-year period.
• Genetic analyses indicate significant differentiation between the Kohala resident and Hawaiian Islands stocks (Martien et al. 2017).
• A total of 39 sightings from CRC effort, one sighting from NMFS ship-based line-transect surveys, 10 encounters from other researchers and community scientists since 1986, with re-sightings of individuals up to 23 years (1986-2008, 4 separate occasions).
• Nine satellite tag deployments (1,794 filtered Argos locations) transmitting for up to ~26 days, the majority of which showed similar insular habitat use with two individuals moving farther offshore near Maui for a brief period.
• Tag positional uncertainty and irregularity accounted for through crawl model, and boundary encompasses nearly all of crawl standard error (68% confidence interval) ellipses

This island-associated stock specific to the Kohala region off Hawaiʻi Island has been formally recognized since the 2013 NMFS stock assessment report, and is supported by long-term, high resighting rates (up to 23 years) and information on movements through satellite tag deployments (Aschettino et al., 2011; Baird, 2016; Caretta et al., 2021). Only a subset of photographs collected since the Aschettino et al. (2011) analyses have been added to the photo-identification catalog for this stock (CRC unpublished), and thus a revised relative abundance estimate is not available. Despite this, more recent information on movements from satellite tag data maintain support for the existence of this small and resident stock with a relatively small range off Kohala, Hawaiʻi Island.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: This population is resident to this area year-round and no information (from available data) suggests the area is used dynamically or ephemerally.

Boundary certainty: 3

Supporting notes for boundary certainty: We have high confidence in Boundary Certainty for the BIA for Kohala resident melon-headed whales. The boundary encompasses the entire stock based on sightings and satellite tag locations and positional uncertainty was accounted for in satellite tag data. With the exception of two tagged individuals that moved offshore towards Maui for a brief period before returning to insular waters, all nine tagged individuals used the same restricted area off Kohala.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 9

# of years in which supporting tagging data collected: 6 (2008-2017)

Supporting information: Satellite tags were deployed on nine melon-headed whales during dedicated survey efforts off leeward Hawaiʻi Island from 2008 to 2017 (Baird, 2016; West et al., 2018). Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk using the package crawl implemented in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 1-hour interval and locations on land were re-routed around a polygon representing the 200-m isobath using the pathroutr package (London, 2020).

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 40

# of years in which supporting visual data collected: 14 (2005-2021)

Supporting information: Sighting data were collected from non-systematic, dedicated small boat surveys conducted off Hawaiʻi Island from 2002-2021 (see Baird et al., 2013 for details on surveys). Surveys off Hawaiʻi Island total 97,438 km of effort with a total of 74 melon-headed whale sightings. Thirty-nine of these sightings were of Kohala residents (based on a long-term photo-identification catalog) or within the known range of Kohala residents based on satellite tag data; the remaining 35 sightings were known or suspected to be part of the broader Hawaiian Islands stock and thus were excluded from the BIA boundary determination process. In addition, sightings from other researchers and community science contributions have added to the available information on this population (Aschettino et al. 2011). Additional sighting data were available from NMFS ship-based line-transect surveys (Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020), and those with confirmed photographic assignment to the Kohala resident stock or within the known range of this stock were used in boundary determinations (n=1); effort from these surveys total 4,906 km.

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 263

# of years of photo records to compare: 6 (2003-2008)

Maximum # of years same individual photographed in area: 24

Supporting information: A total of 39 sightings from CRC effort, 1 from NMFS ship-based line-transect surveys, 10 encounters from other researchers and community scientists since 1986, with re-sightings of individuals up to 23 years (1986-2008, 4 separate occasions).

Genetic analyses conducted supporting designation (Y/N): Y

Weak/moderate/strong support for genetic differentiation: Preliminary

Nature of supporting information: Strong

Supporting information: Genetic analyses indicate significant differentiation between the Kohala resident and Hawaiian Islands populations (Martien et al. 2017).

What factors justify the boundary selection?: Using data available through 2013, Baird et al. (2015) delineated a single BIA for Kohala resident melon-headed whales based on sighting data from small boat survey efforts and spatial use from available satellite tag deployments. Additional sighting, photographic, and satellite tag data collected since the original assessment were used to update this BIA boundary for Kohala resident melon-headed whales.

The basis for the BIA was a minimum convex polygon (MCP) encompassing all sighting and satellite-tag derived crawl locations. A 3-km distance band was added to the outer boundary of the MCP to account for positional uncertainty estimated by crawl; such a distance captures nearly all of the positional uncertainty generated by the model. The inner (shoreward) boundary was defined as the 200-m isobath based on the shallowest sighting off the island from CRC dedicated survey efforts (shallowest sighting = 280-m deep). The resulting area of the parent BIA (i.e., population range size) is 3,816 km2.

Data sources: Cascadia Research Collective (unpub. data, 2005-2020); National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020; accessed 2021); Aschettino 2010; Baird et al., 2013, 2015l

Approximate % of population that uses this area for the designated purpose (if known): 100

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Abecassis, M., J. Polovina, R.W. Baird, A. Copeland, J.C. Drazen, R. Domokos, E. Oleson, Y. Jia, G.S. Schorr, D.L. Webster, and R.D. Andrews. 2015. Characterizing a foraging hotspot for short-finned pilot whales and Blainville's beaked whales located off the west side of Hawaiʻi Island by using tagging and oceanographic data. PLoS ONE 10(11):e0142628 doi:10.1371/journal.pone.0142628

Baird, R.W., D.J. McSweeney, G.S. Schorr, S.D. Mahaffy, D.L. Webster, J. Barlow, M.B. Hanson, J.P. Turner, and R.D. Andrews. 2009. Studies of beaked whales in Hawaiʻi: Population size, movements, trophic ecology, social organisation, and behaviour. ECS Special Publication 1:23-25

Baird, R.W., G.S. Schorr, D.L. Webster, D.J. McSweeney, M.B. Hanson, and R.D. Andrews. 2010. Movements and habitat use of Cuvier's and Blainville's beaked whales in Hawaiʻi: Results from satellite tagging in 2009/2010. Report prepared under Order No. AB133F09SE4843 from the Southwest Fisheries Science Center, La Jolla, CA.

Baird, R.W., G.S. Schorr, D.L. Webster, S.D. Mahaffy, D.J. McSweeney, M.B. Hanson, and R.D. Andrews. 2011. Open-ocean movements of a satellite-tagged Blainville's beaked whale (Mesoplodon densirostris): Evidence for an offshore population in Hawaiʻi? Aquatic Mammals 37:506-511

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main

Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Baird, R.W. 2019. Behavior and ecology of not-so-social odontocetes: Cuvier's and Blainville's beaked whales. Pages 305-329 in: Ethology and Behavioral Ecology of Toothed Whales and Dolphins, the Odontocetes. Edited by B. Würsig. Springer.

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22(2):446-464

Bradford, A.L., K.A. Forney, E.M. Oleson, and J. Barlow. 2017. Abundance estimates of cetaceans from a line-transect survey within the U.S. Hawaiian Islands Exclusive Economic Zone. Fishery Bulletin 115:129-142

Bradford, A.L., E.M. Oleson, K.A. Forney, J.E. Moore, and J. Barlow. 2021. Line-transect abundance estimates of cetaceans in U.S. waters around the Hawaiian Islands in 2002, 2010, and 2017. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-PIFSC-115, 52 p. doi:10.25923/daz4-kw84

Caretta, J.V., E.M. Oleson, K.A. Forney, M.M. Muto, D.W. Weller, A.R. Lang, J. Baker, B. Hanson, A.J. Orr, J. Barlow, J.E. Moore, and R.L. Brownwell Jr. 2021. U.S. Pacific Marine Mammal Stock Assessments: 2020. U.S. Department of Commerce, NOAA.

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Mahaffy, S.D., R.W. Baird, D.J. McSweeney, D.L. Webster, and G.S. Schorr. 2015. Group structure and mating strategies of Cuvier's (Ziphius cavirorstris) and Blainville's (Mesoplodon densirostris) beaked whales off the island of Hawaiʻi. Poster presented at the 21st Biennial Conference on the Biology of Marine Mammals, San Francisco, California, December 14-18, 2015.

McSweeney, D.J., R.W. Baird, and S.D. Mahaffy. 2007. Site fidelity, associations, and movements of Cuvier's (Ziphius cavirostris) and Blainville's (Mesoplodon densirostris) beaked whales off the island of Hawaiʻi. Marine Mammal Science 23(3):666-687. Doi:10.1111/j.1748-7692.2007.00135.x

Schorr, G.S., R.W. Baird, M.B. Hanson, D.L. Webster, D.J. McSweeney, and R.D. Andrews. 2009. Movements of satellite-tagged Blainville's beaked whales off the island of Hawaiʻi. Endangered Species Research 10:203-213

Yano, K.M., E.M. Oleson, J.L. Keating, L.T. Ballance, M.C. Hill, A.L. Bradford, A.N. Allen, T.W. Joyce, J.E. Moore, and A. Henry. 2018. Cetacean and seabird data collected during the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS), July-December 2017. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TM-NMFS-PIFSC-72, 110 p. doi:10.25923/7avn-gw82

Yano, K.M., E.M. Olesn, J.L.K. McCullough, M.C. Hill, and A.E. Henry. 2020. Cetacean and seabird data collected during the winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey (Winter HICEAS), January-March 2020. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-111, 72 p. doi:10.25923/ehfg-dp78

Supplementary Description 6. 19. Minke whale reproductive area

Species name: Minke whale (*Balaenoptera acutorostrata*)

Descriptive name: Main Hawaiian Islands - Watch List Area

BIA type: Reproductive Area

BIA label: R-BIA0-s-b1-HI027-0

Transboundary across: None

Hierarchy: Non-hierarchical; single watch list area

Importance score: 0 (Intensity: 1, Data support: 1)

Supporting notes for intensity score: We assigned this watch list area an Intensity score of 1 based on the following reasons:

• Although it is inferred that minke whales make latitudinal movements from temperate feeding grounds to tropical/sub-tropical breeding grounds like other migratory baleen whales, no definitive evidence (e.g., movements from satellite tag data, re-sightings of individuals) exists to support such movements between Hawaiʻi and northern feeding grounds. However, trends in acoustic detections rates off Oʻahu indicated that Hawaiian waters are likely an end-point destination for minke whales rather than a transitional location (Oswald et al. 2011)
• Minke whales have been acoustically detected throughout the main Hawaiian Islands during winter and spring months, with detection numbers peaking between January through March
• Abundance estimates were generated for the minke whales in Hawaiʻi based on sightings data from NMFS line transect surveys (estimated abundance (n)=438, CV=1.05; Bradford et al. 2021); however, these estimates were based on only two visual sightings that were collected during the HICEAS surveys, which primarily occurred outside of the breeding season defined for this watch list area
• Minke whale density has been previously estimated utilizing localized acoustic detections on PMRF (Martin et al. 2013, 2015); however, the area reported by these studies is only a small fraction of the watch list area described in this assessment
• No other reproductive area within US waters is being delineated for minke whales

Supporting notes for data support score: We assigned this watch list area a Data Support score of 1 based on the following reasons:

• Passive acoustic findings support the seasonal presence of minke whales in Hawaiian waters during winter and spring months. Other migratory baleen whale species follow a similar seasonal distribution using tropical/sub-tropical waters for breeding grounds.
• Minke whales producing boing calls are believed to be males engaging in courtship or reproductive behaviors
• No cow/calf pairs have been documented, but the sample size of sightings for minke whales in this region is extremely small
• The watch list area boundary essentially encompasses the WHICEAS survey area where minke whales were frequently detected; however, minke whales have been detected outside of the watch list area delineated in this assessment (e.g., north of the watch list area and in the NWHI). Limited survey effort outside of the MHI in winter precludes a better understanding of their distribution in this region.
• The acoustic detections critical to defining the watch list area boundary do not resolve spatial patterns in minke whale density (e.g., number of whales per unit area), such that we were unable to identify areas of concentrated use within their broader range.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: No information is available to suggest the area is used dynamically or ephemerally.

Boundary certainty: 1

Supporting notes for boundary certainty: The watch list area boundary described in this assessment is based on presence-only data and essentially encompasses the surveyed area for the WHICEAS 2020 survey. Based on limited detections outside of this range and in the Northwestern Hawaiian Islands, it is likely minke whales use a broader area.

Months of year designation is applicable: January, February, March, April, October, November, December

Tagging data supporting designation (Y/N): N

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 13

# of years in which supporting visual data collected: 8 (2002-2021)

Supporting information: Visual sighting data were collected during ship-based line-transect surveys conducted by the National Marine Fisheries Service (NMFS) from 2002 through 2020. Visual sightings of minke whales (n=6) were documented during each Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS; 2002, 2010, 2017), a winter survey of the MHI (2009), and the winter HICEAS (WHICEAS; 2020); all visual sightings occurred within the breeding season defined for this assessment (see Barlow, 2006; Bradford et al. 2017, 2021; Yano et al. 2018, 2020 for details on survey methods). In addition, four minke whale sightings available from HDR Inc., small boat survey efforts during the breeding season (Oct-Apr) were included in this assessment, as were three minke whale sightings corroborated with photographs contributed to CRC through their Hawaiʻi community science photo contribution program.

Acoustic detections/records supporting designation (Y/N): Y

# of observations/records: 2324

# of years in which supporting acoustic data collected: 7 (2012-2020)

Supporting information: Minke whale detections at PMRF were made using the seafloor mounted range hydrophones, and time difference of arrival methods were used to localize the animal when calls were detected on at least four hydrophones. The localizations were then grouped into individual tracks, although only the first detection of each track was used here. More details on localization and tracking methods can be found in Martin et al. (2020).

Towed hydrophone array acoustic detection data were available from two NMFS ship-based line-transect surveys: the HICEAS 2017 survey and WHICEAS 2020 survey. A towed hydrophone array was deployed about 300 m behind each ship in each survey. The array was monitored from sunrise to sunset by acousticians who recorded the occurrence of known vocalizations (such as minke whale boings) in real time. Details of the signal processing methods can be found in Yano et al. (2018). Detections from both HICEAS and WHICEAS surveys were binned at 30-minute intervals, such that any number of minke whale detections recorded during each 30-minute interval of effort were represented as a single point of presence. Since these detections were not localized or grouped by individual as done at PMRF, all detections have been included for analysis, and therefore should not be taken as representative of the number of animals present, only the extent of their occurrence.

Photo-ID evidence supporting designation (Y/N): N

Genetic analyses conducted supporting designation (Y/N): N

What factors justify the boundary selection?: Baird et al. (2015) did not delineate an R-BIA for minke whales in the Hawaiian Islands due to insufficient supporting information at the time of the study. In this assessment, we use minke whale acoustic detection locations to inform the watch list area boundary for breeding grounds in the main Hawaiian Islands during winter months. Based on acoustic detection rates (Martin et al. 2020; Oswald et al. 2011; Thompson and Friedl, 1982), we consider the period spanning October through April to be the minke whale breeding season for this watch list area. Available location data on visual sightings of minke whales were also included in this assessment.

The basis for the watch list area boundary was a minimum convex polygon (MCP) encompassing the majority of acoustic detections and all visual sightings around the main Hawaiian Islands. The inner (shoreward) boundary of the watch list area was defined as the 500-m isobath. The depth of localized minke whale acoustic detections off Kauaʻi, Hawaiʻi and the Marianas Islands (similar subtropical waters; Martin et al. 2013; Martin et al. 2020; Norris et al. 2017) and a lack of evidence supporting minke whale presence in shallower waters (e.g., no contributed sightings from ecotourism operators, no minke whale sightings from CRC efforts; CRC unpublished) suggest that these whales do not frequent nearshore, shallow waters. Although some acoustic detections used in this assessment fall within the 500-m isobath, these detections were from NMFS towed hydrophone surveys which did not localize detections like the PMRF array, and thus the true location of the individuals detected is unknown. The size of the watch list area is 333,658 km2.

Data sources: Cascadia Research Collective (unpub. data, 2021); Pacific Islands Fisheries Science Center (Barlow see Barlow, 2006; Bradford et al. 2017; Yano et al. 2018, 2020); HDR, Inc. (unpub. data, 2005-2010); Baird et al., 2015

Approximate % of population that uses this area for the designated purpose (if known): 100

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baker, C.S., and L.M. Herman. 1981. Migration and local movement of humpback whales (Megaptera novaeangliae) through Hawaiian waters. Canadian Journal of Zoology 59:460-469.

Balcomb, K.M. 1987. The whales of Hawaii, including all species of marine mammals in Hawaiian and adjacent waters. Marine Mammal Fund, San Francisco, CA.

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22(2):446-464

Bradford, A.L., K.A. Forney, E.M. Oleson, and J. Barlow. 2017. Abundance estimates of cetaceans from a line-transect survey within the U.S. Hawaiian Islands Exclusive Economic Zone. Fishery Bulletin 115:129-142

Bradford, A.L., E.M. Oleson, K.A. Forney, J.E. Moore, and J. Barlow. 2021. Line-transect abundance estimates of cetaceans in U.S. waters around the Hawaiian Islands in 2002, 2010, and 2017. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-PIFSC-115, 52 p. doi:10.25923/daz4-kw84

Croll, D.A., C.W. Clark, A. Acevedo, B.R. Tershy, R.S. Flores, J. Gedamke, and R.J. Urban. 2002. Only male fine whales sing loud songs. Nature 417:809-811

Herman, L.M., A.A. Pack, S.S. Spitz, E.Y.K. Herman, K. Rose, S. Hakala, and M.H. Deakos. 2013. Humpback whale song: Who sings? Behavioral Ecology and Sociobiology 67:1653-1663

Martin, S.W., T.A. Marques, L. Thomas, R.P. Morissey, S. Jarvis, N. DiMarzio, D. Moretti, and D.K. Mellinger. 2013. Estimating minke whale (Balaenoptera acutorostrata) boing sound density using passive acoustic sensors. Marine Mammal Science 29(1): 142-

158 doi:10.1111/j.1748-7692.2011.00561.x

Martin, S.W., C.R. Martin, B.M. Matsuyama, and E.E. Henderson. 2015. Minke whales (Balaenoptera acutorostrata) respond to navy training. The Journal of the Acoustical Society of America 137:2522-2541 doi:10.1121/1.4919319

Martin, C.R., E.E. Henderson, S.W. Martin, T.A. Helble, R.A. Manzano-Roth, B.M. Matsuyama, and G.A. Alongi. 2020. FY18 Annual Report on Pacific Missile Range Facility Marine Mammal Monitoring. Naval Information Warfare Center, Pacific. Technical Report 3202 72 p.

Norris, T., S. Martin, L. Thomas, T. Yack, J.N. Oswald, E-M. Nosal, and V. Janik. 2012. Acoustic ecology and behavior of minke whales in the Hawaiian and Marianas Islands: Localization, abundance estimation, and characterization of minke whale “boings”. Advances in Experimental Medicine and Biology 730:149-153 doi:10.1007/978-1-4419-7311-5_33

Norris, T.F., K.J. Dunleavy, T.M. Yack, and E.L. Ferguson. 2017. Estimation of minke whale abundance from an acoustic line transect survey of the Mariana Islands. Marine Mammal Science 33(2):574-592 doi:10.1111/mms.12397

Oswald, J.N., W.W.L. Au, and F. Duennebier. 2011. Minke whale (Balaenoptera acutorostrata) boings detected at the Station ALOHA Cabled Observatory. The Journal of the Acoustical Society of America 129:3353-3360 doi:10.1121/1.3575555

Rankin, S., and J. Barlow. 2005. Source of the North Pacific “boing” sound attributed to minke whales. The Journal of the Acoustical Society of America 118:3346-3351 doi:10.1121/1.2046747

Rankin, S., T.F. Norris, M.A. Smultea, C. Oedekoven, A.M. Zoidis, E. Sliva, and J. Rivers. 2007. A visual sighting and acoustic detections of minke whales, Balaenoptera acutorostrata (Cetacea: Balaenopteridae), in nearshore Hawaiian waters. Pacific Science 61(3):395-398

Shallenberger, E.W. 1981. The status of Hawaiian cetaceans. Marine Mammal Commission Report No. MMC-77/23.

Thompson, P.O., and W.A. Friedl. 1982. A long term study of low frequency sounds from several species of whales off Oahu, Hawaii. Cetology 45:1-19.

Yano, K.M., E.M. Oleson, J.L. Keating, L.T. Ballance, M.C. Hill, A.L. Bradford, A.N. Allen, T.W. Joyce, J.E. Moore, and A. Henry. 2018. Cetacean and seabird data collected during the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS), July-December 2017. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TM-NMFS-PIFSC-72, 110 p. doi:10.25923/7avn-gw82

Yano, K.M., E.M. Olesn, J.L.K. McCullough, M.C. Hill, and A.E. Henry. 2020. Cetacean and seabird data collected during the winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey (Winter HICEAS), January-March 2020. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-111, 72 p. doi:10.25923/ehfg-dp78

Supplementary Description 6. 20. Pantropical spotted dolphin small and resident pop.

Species name: Pantropical spotted dolphin (*Stenella attenuata*)

Descriptive name: Oʻahu-Maui Nui-Hawaiʻi Island - Parent

BIA type: Small and Resident Pop.

BIA label: S-BIA1-s-b2-HI009-0abc

Transboundary across: None

Hierarchy: Hierarchical BIA; Parent of children abc

Importance score: 1 (Intensity: 1, Data support: 2)

Intensity matrix: Abundance: 1, Range: 1

Supporting notes for intensity score: Abundance estimates specific to each island-associated stock of pantropical spotted dolphins in Hawaiʻi are not available (Caretta et al., 2021). Although photo-identification catalogs have been recently established for this species, we do not have sufficient information to infer relative abundance based on the number of unique individuals in the catalog at this time (Gless et al., 2021). Courbis et al. (2014) estimated an effective population size around 220 for Hawaiʻi Island spotted dolphins using microsatellites from biopsy samples; however sample sizes were too small to estimate this value for the other stocks. Habitat-based density model estimates were recently derived for this species in Hawaiian waters (Becker et al., in press); however, the authors note that the density estimates represent a hybrid of habitat characteristics of both insular and pelagic pantropical spotted dolphin stocks and thus would be inappropriate for inference on insular stocks only. Despite these unknowns, considering encounter rates, group size, and distribution of effort among these regions (Baird et al., 2013), it is likely that abundance for each island-associated stock is within the 501 to 2,000 (abundance score = 1) category of the BIA Intensity scoring criteria; therefore, the total abundance within the parent BIA is likely within this range (501 to 2,000 individuals) or possibly larger. The size of the MCP representing the BIA is 57,111 km2.

The abundance estimate range used here is based on long-term study of pantropical spotted dolphins around the islands (22 years) taking into account encounter rates and group sizes of this species, along with evidence from genetic studies. Multiple lines of evidence (genetic, tagging, and photo-ID) support the existence of these small and resident stocks. Although the tag deployments used to help inform the BIA boundary were short, they were deployed during four different years and tagged individuals displayed similar use of nearshore habitat, with some individuals moving along windward sides of the island or offshore waters where survey effort has been limited. In addition, one tagged individual moved across all three recognized stock boundaries, providing evidence for some inter-island movements, hence the grouping of all stock ranges into a single parent BIA.

Supporting notes for data support score: Data Support score = 2.

• This population (all three insular stocks) has been studied for 22 years (2000-2021), although primarily through small boat survey efforts.
• Strong evidence for demographic independence among island-associated stocks based on genetic analysis (Courbis et al., 2014).
• A total of 604 sightings from CRC effort and 49 encounters from NMFS effort
• Five satellite tag deployments (1,335 filtered Argos locations) transmitting for up to ~22 days, all of which showed similar insular habitat use with one individual moving among all island areas
• Tag positional uncertainty and irregularity accounted for through crawl model, and boundary encompasses nearly all of crawl standard error (68% confidence interval) ellipses

The existence of separate small, resident, island-associated stocks has been recognized for several years (Baird et al., 2013; Baird, 2016; Caretta et al., 2021; Oleson et al., 2013) and is supported by genetic studies (Courbis et al., 2014), long-term sighting data (Baird et al., 2013; Gless et al., 2022), and information on movements through satellite tag deployments (Baird and Webster, 2019; Kratofil et al., 2022). Preliminary findings on resighting rates from photo-identification further support long-term residency to these islands (Gless et al., 2022). There is a fair amount of area within the BIA boundary with no sighting or tag locations; however, the MCP methods ultimately support the spatial extent of the boundary. While is it possible the BIA overestimates the range of these island-associated stocks in the very deep (>4,000 m) waters along the west side of the boundary, based on recent evidence of inter-island movements (Baird and Webster, 2019; Kratofil et al., 2022) and taking into account survey effort, it is likely that insular spotted dolphins use the areas in between the islands (e.g., Kaiwi Channel, Penguin Bank, ʻAlenuihāhā Channel), more often than is apparent from existing data. Further, the BIA may underestimate their range on windward sides of the islands as survey efforts have primarily focused on leeward sides (due to poor working conditions in the former) and information on movements are limited to a low satellite tag sample size (Baird and Webster, 2019; Kratofil et al., 2022).

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: No information to suggest the area is used dynamically or ephemerally.

Boundary certainty: 2

Supporting notes for boundary certainty: We have intermediate confidence in Boundary Certainty for the parent BIA for OMNHI pantropical spotted dolphins. The boundary encompasses three separate stocks based on a long-term sighting dataset curated from extensive survey effort and available information from satellite tag deployments. Some satellite-tagged animals used similar insular habitat off windward areas of the island where survey effort has been limited, and positional uncertainty was accounted for in satellite tag data. The boundary includes areas of known habitat that insular pantropical spotted dolphins likely use but where spatial data are lacking due to limited effort.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 5

# of years in which supporting tagging data collected: 4 (2015-2018)

Supporting information: Satellite tags were deployed on five spotted dolphins during dedicated survey efforts off Oʻahu in 2016 (n=2), Maui Nui in 2017 and 2018 (n=2) and Hawaiʻi Island in 2015 (n=1; Baird and Webster, 2019; Kratofil, Baird, and Webster, 2022). Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk using the package crawl implemented in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 1-hour interval and locations on land were re-routed around a polygon representing the islands with an added 50-m distance using the pathroutr package (London, 2020).

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 649

# of years in which supporting visual data collected: 22 (2000-2021)

Supporting information: Sighting data used in this assessment were collected from both non-systematic, dedicated small boat surveys conducted by CRC off Oʻahu, Maui Nui, and Hawaiʻi Island in six, nine, and 20 years, respectively, spanning 2000-2021 (see Baird et al., 2013 for details on surveys) and from ship-based line-transect cetacean surveys conducted by NMFS throughout the Hawaiian Archipelago in 11 years between 2002-2020 (see Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020 for details on surveys). CRC surveys off these islands combined total to 123,856 km of effort with 604 sightings of pantropical spotted dolphins. NMFS surveys around these three island areas (near and offshore) total to 15,211 km of effort with 57 sightings of pantropical spotted dolphins. Eight of the 57 NMFS sightings were excluded from the BIA boundary determination process as these sightings were notably far offshore and likely part of the pelagic spotted dolphin stock (i.e., not representative of the insular spotted dolphin populations described in this assessment).

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of years of photo records to compare: 1996-2021

Supporting information: There is a joint CRC/Pacific Whale Foundation (PWF) photo-identification catalog for spotted dolphins from all three insular stocks (Gless et al., 2022; Machernis et al., 2021). Findings from initial matching efforts (Gless et al., 2022) combined with genetic studies (Courbis et al., 2014) and information from available satellite tag data (Baird and Webster, 2019; Kratofil, Baird, and Webster, 2022) indicate that spotted dolphins are long-term residents to these insular waters (Baird et al., 2013; Baird, 2016). For example, photo-identified individuals with distinctive markings have been resighted off Hawaiʻi island in eight years over time spans ranging up to 14 years (Gless et al., 2022).

Genetic analyses conducted supporting designation (Y/N): Y

Nature of supporting information: Strong

Supporting information: There are four stocks of pantropical spotted dolphins recognized within the EEZ around the Hawaiian Islands, one pelagic and three insular stocks, the latter defined by nearshore regions around Oʻahu, Maui Nui, and Hawaiʻi Island (Caretta et al., 2021; Oleson et al., 2013). These three insular populations are considered demographically independent from one another based on genetic differentiation (Courbis et al., 2014).

What factors justify the boundary selection?: Baird et al. (2015) delineated three separate BIAs for insular pantropical spotted dolphin stocks based on sighting data from small boat survey efforts. For this assessment, a parent BIA boundary was drawn based on sighting data, satellite tag data, and stock boundaries to represent the larger area encompassing the Oʻahu, Maui Nui, and Hawaiʻi Island (OMNHI) spotted dolphin stocks in light of recent evidence of movement among these island areas (Baird and Webster, 2019; Kratofil et al., 2022). Child BIAs were delineated for each island-associated stock to highlight stock-specific areas of use.

The basis for the BIA was a minimum convex polygon (MCP) encompassing all sighting and satellite-tag derived crawl locations. A 3-km distance was added to the outer boundary of the MCP to account for positional uncertainty estimated by crawl. The inner (shoreward) boundary was defined as a 50-m distance from shore such to include shallow waters used by spotted dolphins in these regions. The resulting area of the parent BIA (including three recognized stocks) is 57,111 km2.

Data sources: Cascadia Research Collective (unpub. data, 2000-2021; accessed 2021); Baird et al., 2013, 2015; Baird and Webster, 2019; National Marine Fisheries Service, Pacific Islands Fisheries Science Center 2002-2020 (accessed 2021)

Approximate % of population that uses this area for the designated purpose (if known): 100

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Baird, R.W., and D.L. Webster. 2019. Movements of satellite-tagged pantropical spotted dolphins in relation to stock boundaries in Hawaiian waters. Document PSRG-2019-15 submitted to the Pacific Scientific Review Group, March 5-7, 2019, Olympia, WA

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22(2):446-464

Bradford, A.L., K.A. Forney, E.M. Oleson, and J. Barlow. 2017. Abundance estimates of cetaceans from a line-transect survey within the U.S. Hawaiian Islands Exclusive Economic Zone. Fishery Bulletin 115:129-142
Bradford, A.L., E.M. Oleson, K.A. Forney, J.E. Moore, and J. Barlow. 2021. Line-transect abundance estimates of cetaceans in U.S. waters around the Hawaiian Islands in 2002, 2010, and 2017. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-PIFSC-115, 52 p. doi:10.25923/daz4-kw84

Becker, E.A., K.A. Forney, E.M. Oleson, A.L. Bradford, J.E. Moore, and J. Barlow. 2021. Habitat-based density estimates for cetaceans within the waters of the U.S. Exclusive Economic Zone around the Hawaiian Archipelago. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-PIFSC-116, 38 p. doi:10.25923/x9q9-rd73

Caretta, J.V., E.M. Oleson, K.A. Forney, M.M. Muto, D.W. Weller, A.R. Lang, J. Baker, B. Hanson, A.J. Orr, J. Barlow, J.E. Moore, and R.L. Brownell Jr. 2021. U.S. Pacific Marine Mammal Stock Assessments: 2020. U.S. Department of Commerce, NOAA.

Courbis, S., R.W. Baird, F. Cipriano, and D. Duffield. 2014. Multiple populations of pantropical spotted dolphins in Hawaiian waters. Journal of Heredity 105:627-641.

Gless, E.J., S.D. Mahaffy, G.L. Olson, S.H. Stack, J.J. Currie, and R.W. Baird. 2022. Photo-identification of pantropical spotted dolphins in Hawaiian waters reveal long-term re-sightings, supporting the existence of island-associated resident populations. Abstract submitted to the 24th Biennial Conference on the Biology of Marine Mammals, Palm Beach, Florida August 2022

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

Kratofil, M.A., R.W. Baird, and D.L. Webster. 2022. Spatial use of pantropical spotted dolphins in relation to stock boundaries and environmental features in Hawaiian waters. Abstract accepted to the 24th Biennial Conference on the Biology of Marine Mammals, Palm Beach, Florida August 2022

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Machernis, A.F., S.H. Stack, G.L. Olson, F.A. Sullivan, and J.J. Currie. 2021. External scarring as an indicator of fisheries interactions with bottlenose (Tursiops truncatus) and pantropical spotted (Stenella attenuata) dolphins in Maui Nui, Hawaii. Aquatic Mammals 47:482-498. doi.org/10.1578/AM.47.5.2021.482

Oleson, E.M., R.W. Baird, K.K. Martien, and B.L. Taylor. 2013. Island-associated stocks of odontocetes in the main Hawaiian Islands: a synthesis of available information to facilitate evaluation of stock structure. Document PSRG-2013-16 presented to the Pacific Scientific Review Group, Del Mar, April 2013.

Pittman, S.J., A.J. Winship, M. Poti, B.P. Kinlan, J.B. Leirness, R.W. Baird, J. Barlow, E.A. Becker, K.A. Forney, M.C. Hill, P.I. Miller, J. Mobley, and E.M. Oleson. 2016. Chapter 6: Marine Mammals - Cetaceans. pp. 227-265. In: B.M. Costa and M.S. Kendall (eds.), Marine Biogeographic Assessment of the Main Hawaiian Islands. Bureau of Ocean Energy Management and National Oceanic and Atmospheric Administration. OCS Study BOEM 2016-035 and NOAA Technical Memorandum NOS NCCOS 214. 359 pp.

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Yano, K.M., E.M. Oleson, J.L. Keating, L.T. Ballance, M.C. Hill, A.L. Bradford, A.N. Allen, T.W. Joyce, J.E. Moore, and A. Henry. 2018. Cetacean and seabird data collected during the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS), July-December 2017. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TM-NMFS-PIFSC-72, 110 p. doi:10.25923/7avn-gw82

Yano, K.M., E.M. Olesn, J.L.K. McCullough, M.C. Hill, and A.E. Henry. 2020. Cetacean and seabird data collected during the winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey (Winter HICEAS), January-March 2020. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-111, 72 p. doi:10.25923/ehfg-dp78

Supplementary Description 6. 21. Pantropical spotted dolphin small and resident pop.

Species name: Pantropical spotted dolphin (*Stenella attenuata*)

Stock or population: Hawai'i Island stock

Descriptive name: Oʻahu-Maui Nui-Hawaiʻi Island - Child (Hawai'i Island)

BIA type: Small and Resident Pop.

BIA label: S-BIA1-s-b2-HI009-b

Transboundary across: None

Hierarchy: Hierarchical BIA; Child b

Importance score: 1 (Intensity: 1, Data support: 2)

Intensity matrix: Abundance: 1, Range: 1

Supporting notes for intensity score: Intensity score = 1. As noted in the parent BIA scoring, there are no abundance estimates available for the three insular stocks of pantropical spotted dolphins represented by these child BIAs (Caretta et al., 2021). However, based on expert opinion and available data, each island-associated stock likely numbers under 1,500 individuals. We estimated that each child BIA contains 33% of the OMNHI population, although recognize that there are several sources of uncertainty associated with this estimate. The area of the Hawaii Island stock child BIA is 10,768 km2.

Each child BIA was drawn with the intention to represent the primary range of each island-associated stock based on available data. No abundance estimates are available for these stocks; estimates used to inform the abundance scores for these BIAs were derived from expert elicitation. Based on available movement data (Baird and Webster, 2019; Kratofil, Baird, and Webster, 2022) and findings from genetic studies (Courbis et al., 2014), pantropical spotted dolphins associated with these island areas are unlikely to make extensive movements outside ranges described here. Therefore, we assigned an Intensity score of 1 for each of the child BIAs.

Supporting notes for data support score: Data Support score = 2.

The child BIAs described here for island-associated stocks of pantropical spotted dolphins were drawn based on the known extent of their ranges from a combination of satellite tag data and sighting data collected over 22 years of small boat survey efforts (Baird et al., 2013), and are further supported by genetic studies indicating that permanent movements among island areas are unlikely to occur (Courbis et al., 2014). Preliminary photo-identification findings support some degree of site fidelity to these island areas (Gless et al., 2022).

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: This population is resident to this area year-round and no information (from available data) suggests the area is used dynamically or ephemerally.

Boundary certainty: 2

Supporting notes for boundary certainty: We have intermediate certainty in each of the child BIA boundaries. Modelling efforts by Pittman et al. (2016) suggest that insular pantropical spotted dolphins may be more likely to use leeward sides of the islands. Only a limited number of satellite tags have been deployed on pantropical spotted dolphins from these populations, most of which displayed similar nearshore leeward habitat use, although one individual moved across all three island areas along the windward side of the islands. The frequency of such inter-island movements is unknown due to limited sample size and lack of information on re-sighting rates of photo-identified individuals. There remains uncertainty in the true primary ranges of each stock. Despite this, and considering the quantity, quality, and longevity of other supporting information (sightings, genetics, etc.), we feel these boundaries reflect the primary range of each population based on available data.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 1

# of years in which supporting tagging data collected: 1 (2015)

Supporting information: A single satellite tags was deployed on a spotted dolphin during dedicated survey efforts off Hawaiʻi Island in 2015 (n=1; Baird and Webster, 2019; Kratofil, Baird, and Webster, 2022). Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk using the package crawl implemented in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 1-hour interval and locations on land were re-routed around a polygon representing the islands with an added 50-m distance using the pathroutr package (London, 2020).

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 508

# of years in which supporting visual data collected: 22 (2002-2021)

Supporting information: Sighting data used in this assessment were collected from both non-systematic, dedicated small boat surveys conducted by CRC off Oʻahu, Maui Nui, and Hawaiʻi Island in six, nine, and 20 years, respectively, spanning 2000-2021 (see Baird et al., 2013 for details on surveys) and ship-based line-transect surveys for cetaceans conducted by NMFS throughout the Hawaiian Archipelago in 11 years between 2002-2020 (see Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020 for details on surveys). CRC surveys off these islands combined total to 121,088 km of effort with 600 sightings of pantropical spotted dolphins. NMFS surveys around these three islands (near and offshore) total to 15,211 km of effort with 57 sightings of pantropical spotted dolphins. Eight of the 57 PIFSC sightings were excluded from the BIA boundary determination process as these sightings were notably far offshore and likely not representative of the insular spotted dolphin populations described in this assessment (e.g., pelagic spotted dolphin sightings). Off Hawaii Island there were a total of 504 sightings over 22 year period (sightings every year)

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of years of photo records to compare: 1996-2021

Supporting information: There is a joint CRC/Pacific Whale Foundation (PWF) photo-identification catalog for spotted dolphins from all three insular stocks (Gless et al., 2022; Machernis et al., 2021). Findings from initial matching efforts (Gless et al., 2022) combined with genetic studies (Courbis et al., 2014) and information from available satellite tag data (Baird and Webster, 2019; Kratofil, Baird, and Webster, 2022) indicate that spotted dolphins are long-term residents to these insular waters (Baird et al., 2013; Baird, 2016). For example, photo-identified individuals with distinctive markings have been resighted off Hawaiʻi island in eight years over time spans ranging up to 14 years (Gless et al., 2022).

Genetic analyses conducted supporting designation (Y/N): Y

Weak/moderate/strong support for genetic differentiation: Strong

Nature of supporting information: Strong

Supporting information: There are four stocks of pantropical spotted dolphins recognized within the EEZ around the Hawaiian Islands, one pelagic and three insular stocks, the latter defined by nearshore regions around Oʻahu, Maui Nui, and Hawaiʻi Island (Caretta et al., 2021; Oleson et al., 2013). These three insular populations are considered demographically independent from one another based on genetic differentiation (Courbis et al., 2014).

What factors justify the boundary selection?: Although there exists some evidence of movement between these island areas (Baird and Webster, 2019; Kratofil et al., 2022), pantropical spotted dolphins generally remain near their island-associated regions. Furthermore, genetic studies suggest that permanent movements among regions are rare (Courbis et al., 2014). Rather than attempt to describe core ranges within each stock, we delineated child BIAs for the OMNHI stocks with the intent to highlight the primary ranges of each island-associated stock. The Hawaiʻi Island spotted dolphin BIA was based on a MCP encompassing all sighting and crawl locations for the island.

Data sources: Cascadia Research Collective (unpub. data, 2000-2021, accessed 2021); Baird et al., 2013, 2015; Baird and Webster, 2019; National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020) accessed 2021.

Approximate % of population that uses this area for the designated purpose (if known): 33

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Baird, R.W., and D.L. Webster. 2019. Movements of satellite-tagged pantropical spotted dolphins in relation to stock boundaries in Hawaiian waters. Document PSRG-2019-15 submitted to the Pacific Scientific Review Group, March 5-7, 2019, Olympia, WA

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22(2):446-464

Bradford, A.L., K.A. Forney, E.M. Oleson, and J. Barlow. 2017. Abundance estimates of cetaceans from a line-transect survey within the U.S. Hawaiian Islands Exclusive Economic Zone. Fishery Bulletin 115:129-142

Becker, E.A., K.A. Forney, E.M. Oleson, A.L. Bradford, J.E. Moore, and J. Barlow. 2021. Habitat-based density estimates for cetaceans within the waters of the U.S. Exclusive Economic Zone around the Hawaiian Archipelago. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-PIFSC-116, 38 p. doi:10.25923/x9q9-rd73

Caretta, J.V., E.M. Oleson, K.A. Forney, M.M. Muto, D.W. Weller, A.R. Lang, J. Baker, B. Hanson, A.J. Orr, J. Barlow, J.E. Moore, and R.L. Brownell Jr. 2021. U.S. Pacific Marine Mammal Stock Assessments: 2020. U.S. Department of Commerce, NOAA.

Courbis, S., R.W. Baird, F. Cipriano, and D. Duffield. 2014. Multiple populations of pantropical spotted dolphins in Hawaiian waters. Journal of Heredity 105:627-641.

Gless, E.J., S.D. Mahaffy, G.L. Olson, S.H. Stack, J.J. Currie, and R.W. Baird. 2022. Photo-identification of pantropical spotted dolphins in Hawaiian waters reveal long-term re-sightings, supporting the existence of island-associated resident populations. Abstract submitted to the 24th Biennial Conference on the Biology of Marine Mammals, Palm Beach, Florida August 2022

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

Kratofil, M.A., R.W. Baird, and D.L. Webster. 2022. Spatial use of pantropical spotted dolphins in relation to stock boundaries and environmental features in Hawaiian waters. Abstract accepted to the 24th Biennial Conference on the Biology of Marine Mammals, Palm Beach, Florida August 2022

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Machernis, A.F., S.H. Stack, G.L. Olson, F.A. Sullivan, and J.J. Currie. 2021. External scarring as an indicator of fisheries interactions with bottlenose (Tursiops truncatus) and pantropical spotted (Stenella attenuata) dolphins in Maui Nui, Hawaii. Aquatic Mammals 47:482-498. doi.org/10.1578/AM.47.5.2021.482

Oleson, E.M., R.W. Baird, K.K. Martien, and B.L. Taylor. 2013. Island-associated stocks of odontocetes in the main Hawaiian Islands: a synthesis of available information to facilitate evaluation of stock structure. Document PSRG-2013-16 presented to the Pacific Scientific Review Group, Del Mar, April 2013.

Pittman, S.J., A.J. Winship, M. Poti, B.P. Kinlan, J.B. Leirness, R.W. Baird, J. Barlow, E.A. Becker, K.A. Forney, M.C. Hill, P.I. Miller, J. Mobley, and E.M. Oleson. 2016. Chapter 6: Marine Mammals - Cetaceans. pp. 227-265. In: B.M. Costa and M.S. Kendall (eds.), Marine Biogeographic Assessment of the Main Hawaiian Islands. Bureau of Ocean Energy Management and National Oceanic and Atmospheric Administration. OCS Study BOEM 2016-035 and NOAA Technical Memorandum NOS NCCOS 214. 359 pp.

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Yano, K.M., E.M. Oleson, J.L. Keating, L.T. Ballance, M.C. Hill, A.L. Bradford, A.N. Allen, T.W. Joyce, J.E. Moore, and A. Henry. 2018. Cetacean and seabird data collected during the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS), July-December 2017. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TM-NMFS-PIFSC-72, 110 p. doi:10.25923/7avn-gw82

Yano, K.M., E.M. Olesn, J.L.K. McCullough, M.C. Hill, and A.E. Henry. 2020. Cetacean and seabird data collected during the winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey (Winter HICEAS), January-March 2020. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-111, 72 p. doi:10.25923/ehfg-dp78

Supplementary Description 6. 22. Pantropical spotted dolphin small and resident pop.

Species name: Pantropical spotted dolphin (*Stenella attenuata*)

Stock or population: 4-island stock

Descriptive name: Oʻahu-Maui Nui-Hawaiʻi Island - Child (Maui Nui)

BIA type: Small and Resident Pop.

BIA label: S-BIA1-s-b2-HI009-a

Transboundary across: None

Hierarchy: Hierarchical BIA; Child a

Importance score: 1 (Intensity: 1, Data support: 2)

Intensity matrix: Abundance: 1, Range: 2

Supporting notes for intensity score: Intensity score = 1. As noted in the parent BIA scoring, there are no abundance estimates available for the three insular stocks of pantropical spotted dolphins represented by these child BIAs (Caretta et al., 2021). However, based on expert opinion and available data, each island-associated stock likely numbers under 1,500 individuals. We estimated that each child BIA contains 33% of the OMHI population, although recognize that there are several sources of uncertainty associated with this estimate. The area of the Maui Nui BIA is 6,743 km2.

Each child BIA was drawn with the intention to represent the primary range of each island-associated stock based on available data. No abundance estimates are available for these stocks; estimates used to inform the abundance scores for these BIAs were derived from expert elicitation. Based on available movement data (Baird and Webster, 2019; Kratofil, Baird, and Webster, 2022) and findings from genetic studies (Courbis et al., 2014), pantropical spotted dolphins associated with these island areas are unlikely to make extensive movements outside ranges described here. Therefore, we assigned an Intensity score of 1 for each of the child BIAs.

Supporting notes for data support score: Data Support score = 2.

The child BIAs described here for island-associated stocks of pantropical spotted dolphins were drawn based on the known extent of their ranges from a combination of satellite tag data and sighting data collected over 22 years of small boat survey efforts (Baird et al., 2013), and are further supported by genetic studies indicating that permanent movements among island areas are unlikely to occur (Courbis et al., 2014). Preliminary photo-identification findings support some degree of site fidelity to these island areas (Gless et al., 2022).

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: This population is resident to the area year-round and no information (from available data) suggests the area is used dynamically or ephemerally.

Boundary certainty: 2

Supporting notes for boundary certainty: We have intermediate confidence in Boundary Certainty for the parent BIA for OMNHI pantropical spotted dolphins. The boundary encompasses three separate stocks based on a long-term sighting dataset curated from extensive survey effort and available information from satellite tag deployments. Some satellite-tagged animals used similar insular habitat off windward areas of the island where survey effort has been limited, and positional uncertainty was accounted for in satellite tag data. The boundary includes areas of known habitat that insular pantropical spotted dolphins likely use but where spatial data are lacking due to limited effort.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 2

# of years in which supporting tagging data collected: 2 (2017-2018)

Supporting information: Two satellite tags were deployed on spotted dolphins during dedicated survey efforts off Maui Nui in 2017 and 2018 (n=2; Baird and Webster, 2019; Kratofil, Baird, and Webster, 2022). Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk using the package crawl implemented in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 1-hour interval and locations on land were re-routed around a polygon representing the islands with an added 50-m distance using the pathroutr package (London, 2020).

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 83

# of years in which supporting visual data collected: 11 (2000-2020)

Supporting information: Sighting data used in this assessment were collected from both non-systematic, dedicated small boat surveys conducted by CRC off Oʻahu, Maui Nui, and Hawaiʻi Island in six, nine, and 20 years, respectively, spanning 2000-2021 (see Baird et al., 2013 for details on surveys) and ship-based line-transect surveys for cetaceans conducted by NMFS throughout the Hawaiian Archipelago in 11 years between 2002-2020 (see Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020 for details on surveys). CRC surveys off these islands combined total to 121,088 km of effort with 600 sightings of pantropical spotted dolphins. NMFS surveys around these three islands (near and offshore) total to 15,211 km of effort with 57 sightings of pantropical spotted dolphins. Eight of the 57 PIFSC sightings were excluded from the BIA boundary determination process as these sightings were notably far offshore and likely not representative of the insular spotted dolphin populations described in this assessment (e.g., pelagic spotted dolphin sightings). Off Maui Nui there was a total of 83 sightings combined from 2000 to 2020 in 11 years of survey effort.

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of years of photo records to compare: 1996-2021

Supporting information: There is a joint CRC/Pacific Whale Foundation (PWF) photo-identification catalog for spotted dolphins from all three insular stocks (Gless et al., 2022; Machernis et al., 2021). Findings from initial matching efforts (Gless et al., 2022) combined with genetic studies (Courbis et al., 2014) and information from available satellite tag data (Baird and Webster, 2019; Kratofil, Baird, and Webster, 2022) indicate that spotted dolphins are long-term residents to these insular waters (Baird et al., 2013; Baird, 2016). For example, photo-identified individuals with distinctive markings have been resighted off Maui Nui over time spans ranging up to 20 years (Gless et al., 2022).

Genetic analyses conducted supporting designation (Y/N): Y

Nature of supporting information: Strong

Supporting information: There are four stocks of pantropical spotted dolphins recognized within the EEZ around the Hawaiian Islands, one pelagic and three insular stocks, the latter defined by nearshore regions around Oʻahu, Maui Nui, and Hawaiʻi Island (Caretta et al., 2021; Oleson et al., 2013). These three insular populations are considered demographically independent from one another based on genetic differentiation (Courbis et al., 2014).

What factors justify the boundary selection?: Although there exists some evidence of movement between these island areas (Baird and Webster, 2019; Kratofil et al., 2022), pantropical spotted dolphins generally remain near their island-associated regions. Furthermore, genetic studies suggest that permanent movements among regions are rare (Courbis et al., 2014). Rather than attempt to describe core ranges within each stock, we delineated child BIAs for the OMNHI stocks with the intent to highlight the primary ranges of each island-associated stock. For Maui Nui spotted dolphins, the BIA was defined as the leeward portion of its recognized stock boundary based on a previous study suggesting they prefer leeward waters (Pittman et al., 2016), and modified to include crawl locations that fell outside of the boundary.

Data sources: Cascadia Research Collective (unpub. data, 2000-2021; accessed 2021); Baird et al., 2013, 2015; Baird and Webster, 2019; National Marine Fisheries Service, Pacific Islands Fisheries Science Center 2002-2020 (accessed 2021)

Approximate % of population that uses this area for the designated purpose (if known): 33

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Baird, R.W., and D.L. Webster. 2019. Movements of satellite-tagged pantropical spotted dolphins in relation to stock boundaries in Hawaiian waters. Document PSRG-2019-15 submitted to the Pacific Scientific Review Group, March 5-7, 2019, Olympia, WA

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22(2):446-464

Bradford, A.L., K.A. Forney, E.M. Oleson, and J. Barlow. 2017. Abundance estimates of cetaceans from a line-transect survey within the U.S. Hawaiian Islands Exclusive Economic Zone. Fishery Bulletin 115:129-142

Becker, E.A., K.A. Forney, E.M. Oleson, A.L. Bradford, J.E. Moore, and J. Barlow. 2021. Habitat-based density estimates for cetaceans within the waters of the U.S. Exclusive Economic Zone around the Hawaiian Archipelago. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-PIFSC-116, 38 p. doi:10.25923/x9q9-rd73

Caretta, J.V., E.M. Oleson, K.A. Forney, M.M. Muto, D.W. Weller, A.R. Lang, J. Baker, B. Hanson, A.J. Orr, J. Barlow, J.E. Moore, and R.L. Brownell Jr. 2021. U.S. Pacific Marine Mammal Stock Assessments: 2020. U.S. Department of Commerce, NOAA.

Courbis, S., R.W. Baird, F. Cipriano, and D. Duffield. 2014. Multiple populations of pantropical spotted dolphins in Hawaiian waters. Journal of Heredity 105:627-641.

Gless, E.J., S.D. Mahaffy, G.L. Olson, S.H. Stack, J.J. Currie, and R.W. Baird. 2022. Photo-identification of pantropical spotted dolphins in Hawaiian waters reveal long-term re-sightings, supporting the existence of island-associated resident populations. Abstract submitted to the 24th Biennial Conference on the Biology of Marine Mammals, Palm Beach, Florida August 2022

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

Kratofil, M.A., R.W. Baird, and D.L. Webster. 2022. Spatial use of pantropical spotted dolphins in relation to stock boundaries and environmental features in Hawaiian waters. Abstract accepted to the 24th Biennial Conference on the Biology of Marine Mammals, Palm Beach, Florida August 2022

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Machernis, A.F., S.H. Stack, G.L. Olson, F.A. Sullivan, and J.J. Currie. 2021. External scarring as an indicator of fisheries interactions with bottlenose (Tursiops truncatus) and pantropical spotted (Stenella attenuata) dolphins in Maui Nui, Hawaii. Aquatic Mammals 47:482-498. doi.org/10.1578/AM.47.5.2021.482

Oleson, E.M., R.W. Baird, K.K. Martien, and B.L. Taylor. 2013. Island-associated stocks of odontocetes in the main Hawaiian Islands: a synthesis of available information to facilitate evaluation of stock structure. Document PSRG-2013-16 presented to the Pacific Scientific Review Group, Del Mar, April 2013.

Pittman, S.J., A.J. Winship, M. Poti, B.P. Kinlan, J.B. Leirness, R.W. Baird, J. Barlow, E.A. Becker, K.A. Forney, M.C. Hill, P.I. Miller, J. Mobley, and E.M. Oleson. 2016. Chapter 6: Marine Mammals - Cetaceans. pp. 227-265. In: B.M. Costa and M.S. Kendall (eds.), Marine Biogeographic Assessment of the Main Hawaiian Islands. Bureau of Ocean Energy Management and National Oceanic and Atmospheric Administration. OCS Study BOEM 2016-035 and NOAA Technical Memorandum NOS NCCOS 214. 359 pp.

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Yano, K.M., E.M. Oleson, J.L. Keating, L.T. Ballance, M.C. Hill, A.L. Bradford, A.N. Allen, T.W. Joyce, J.E. Moore, and A. Henry. 2018. Cetacean and seabird data collected during the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS), July-December 2017. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TM-NMFS-PIFSC-72, 110 p. doi:10.25923/7avn-gw82

Yano, K.M., E.M. Olesn, J.L.K. McCullough, M.C. Hill, and A.E. Henry. 2020. Cetacean and seabird data collected during the winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey (Winter HICEAS), January-March 2020. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-111, 72 p. doi:10.25923/ehfg-dp78

Supplementary Description 6. 23. Pantropical spotted dolphin small and resident pop.

Species name: Pantropical spotted dolphin (*Stenella attenuata*)

Stock or population: O'ahu stock

Descriptive name: Oʻahu-Maui Nui-Hawaiʻi Island - Child (O'ahu)

BIA type: Small and Resident Pop.

BIA label: S-BIA1-s-b2-HI009-c

Transboundary across: None

Hierarchy: Hierarchical BIA; Child c

Importance score: 1 (Intensity: 1, Data support: 2)

Intensity matrix: Abundance: 1, Range: 1

Supporting notes for intensity score: Intensity score = 1. As noted in the parent BIA scoring, there are no abundance estimates available for the three insular stocks of pantropical spotted dolphins represented by these child BIAs (Caretta et al., 2021). However, based on expert opinion and available data, each island-associated stock likely numbers under 1,500 individuals. We estimated that each child BIA contains 33% of the OMNHI population, although recognize that there are several sources of uncertainty associated with this estimate. The size of this child BIA is 12,952 km2.

Each child BIA was drawn with the intention to represent the primary range of each island-associated stock based on available data. No abundance estimates are available for these stocks; estimates used to inform the abundance scores for these BIAs were derived from expert elicitation. Based on available movement data (Baird and Webster, 2019; Kratofil, Baird, and Webster, 2022) and findings from genetic studies (Courbis et al., 2014), pantropical spotted dolphins associated with these island areas are unlikely to make extensive movements outside ranges described here. Therefore, we assigned an Intensity score of 1 for each of the child BIAs.

Supporting notes for data support score: Data Support score = 2.

The child BIAs described here for island-associated stocks of pantropical spotted dolphins were drawn based on the known extent of their ranges from a combination of satellite tag data and sighting data collected over 22 years of small boat survey efforts (Baird et al., 2013), and are further supported by genetic studies indicating that permanent movements among island areas are unlikely to occur (Courbis et al., 2014). Preliminary photo-identification findings support some degree of site fidelity to these island areas (Gless et al., 2022).

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: This population is resident to this area year-round and no information (from available data) suggests the area is used dynamically or ephemerally.

Boundary certainty: 2

Supporting notes for boundary certainty: We have intermediate certainty in each of the child BIA boundaries. Modelling efforts by Pittman et al. (2016) suggest that insular pantropical spotted dolphins may be more likely to use leeward sides of the islands. Only a limited number of satellite tags have been deployed on pantropical spotted dolphins from these populations, most of which displayed similar nearshore leeward habitat use, although one individual moved across all three island areas along the windward side of the islands. The frequency of such inter-island movements is unknown due to limited sample size and lack of information on re-sighting rates of photo-identified individuals. There remains uncertainty in the true primary ranges of each stock. Despite this, and considering the quantity, quality, and longevity of other supporting information (sightings, genetics, etc.), we feel these boundaries reflect the primary range of each population based on available data.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 2

# of years in which supporting tagging data collected: 1 (2016)

Supporting information: Two satellite tags were deployed on spotted dolphins during dedicated survey efforts off Oʻahu in 2016 (Baird and Webster, 2019; Kratofil, Baird, and Webster, 2022). Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk using the package crawl implemented in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 1-hour interval and locations on land were re-routed around a polygon representing the islands with an added 50-m distance using the pathroutr package (London, 2020).

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 62

# of years in which supporting visual data collected: 8 (2002-2020)

Supporting information: Sighting data used in this assessment were collected from both non-systematic, dedicated small boat surveys conducted by CRC off Oʻahu, Maui Nui, and Hawaiʻi Island in six, nine, and 20 years, respectively, spanning 2000-2021 (see Baird et al., 2013 for details on surveys) and ship-based line-transect surveys for cetaceans conducted by NMFS throughout the Hawaiian Archipelago in 11 years between 2002-2020 (see Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020 for details on surveys). CRC surveys off these islands combined total to 121,088 km of effort with 600 sightings of pantropical spotted dolphins. NMFS surveys around these three islands (near and offshore) total to 15,211 km of effort with 57 sightings of pantropical spotted dolphins. Eight of the 57 NMFS sightings were excluded from the BIA boundary determination process as these sightings were notably far offshore and likely not representative of the insular spotted dolphin populations described in this assessment (e.g., pelagic spotted dolphin sightings). Off Oahu there were a total of 62 sightings from 2002 through 2020 in eight separate survey years.

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of years of photo records to compare: 1996-2021

Supporting information: There is a joint CRC/Pacific Whale Foundation (PWF) photo-identification catalog for spotted dolphins from all three insular stocks (Gless et al., 2022; Machernis et al., 2021). Findings from initial matching efforts (Gless et al., 2022) combined with genetic studies (Courbis et al., 2014) and information from available satellite tag data (Baird and Webster, 2019; Kratofil, Baird, and Webster, 2022) indicate that spotted dolphins are long-term residents to these insular waters (Baird et al., 2013; Baird, 2016). For example, photo-identified individuals with distinctive markings have been resighted off Oahu over time spans ranging up to 5 years (Gless et al., 2022).

Genetic analyses conducted supporting designation (Y/N): Y

Nature of supporting information: Strong

Supporting information: There are four stocks of pantropical spotted dolphins recognized within the EEZ around the Hawaiian Islands, one pelagic and three insular stocks, the latter defined by nearshore regions around Oʻahu, Maui Nui, and Hawaiʻi Island (Caretta et al., 2021; Oleson et al., 2013). These three insular populations are considered demographically independent from one another based on genetic differentiation (Courbis et al., 2014).

What factors justify the boundary selection?: Although there exists some evidence of movement between these island areas (Baird and Webster, 2019; Kratofil et al., 2022), pantropical spotted dolphins generally remain near their island-associated regions. Furthermore, genetic studies suggest that permanent movements among regions are rare (Courbis et al., 2014). Rather than attempt to describe core ranges within each stock, we delineated child BIAs for the OMNHI stocks with the intent to highlight the primary ranges of each island-associated stock. The Oʻahu spotted dolphin BIA was based on an MCP encompassing all sighting and crawl locations, and was modified to exclude the leeward areas of Maui Nui, as neither of the satellite tagged Oʻahu dolphins used this area, as well as the satellite track segment from Molokaʻi to Hawaiʻi Island as it is currently unknown whether such movements are part of their primary range, and genetic studies indicate that such movements rarely occur (Courbis et al. 2014).

Data sources: Cascadia Research Collective (unpub. data, 2000-2021, accessed 2021); Baird et al., 2013, 2015; Baird and Webster, 2019; National Marine Fisheries Service, Pacific Islands Fisheries Science Center 2002-2020, accessed 2021.

Approximate % of population that uses this area for the designated purpose (if known): 33

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Baird, R.W., and D.L. Webster. 2019. Movements of satellite-tagged pantropical spotted dolphins in relation to stock boundaries in Hawaiian waters. Document PSRG-2019-15 submitted to the Pacific Scientific Review Group, March 5-7, 2019, Olympia, WA

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22(2):446-464

Bradford, A.L., K.A. Forney, E.M. Oleson, and J. Barlow. 2017. Abundance estimates of cetaceans from a line-transect survey within the U.S. Hawaiian Islands Exclusive Economic Zone. Fishery Bulletin 115:129-142

Becker, E.A., K.A. Forney, E.M. Oleson, A.L. Bradford, J.E. Moore, and J. Barlow. 2021. Habitat-based density estimates for cetaceans within the waters of the U.S. Exclusive Economic Zone around the Hawaiian Archipelago. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-PIFSC-116, 38 p. doi:10.25923/x9q9-rd73

Caretta, J.V., E.M. Oleson, K.A. Forney, M.M. Muto, D.W. Weller, A.R. Lang, J. Baker, B. Hanson, A.J. Orr, J. Barlow, J.E. Moore, and R.L. Brownell Jr. 2021. U.S. Pacific Marine Mammal Stock Assessments: 2020. U.S. Department of Commerce, NOAA.

Courbis, S., R.W. Baird, F. Cipriano, and D. Duffield. 2014. Multiple populations of pantropical spotted dolphins in Hawaiian waters. Journal of Heredity 105:627-641.

Gless, E.J., S.D. Mahaffy, G.L. Olson, S.H. Stack, J.J. Currie, and R.W. Baird. 2022. Photo-identification of pantropical spotted dolphins in Hawaiian waters reveal long-term re-sightings, supporting the existence of island-associated resident populations.

Abstract submitted to the 24th Biennial Conference on the Biology of Marine Mammals, Palm Beach, Florida August 2022

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

Kratofil, M.A., R.W. Baird, and D.L. Webster. 2022. Spatial use of pantropical spotted dolphins in relation to stock boundaries and environmental features in Hawaiian waters. Abstract accepted to the 24th Biennial Conference on the Biology of Marine Mammals, Palm Beach, Florida August 2022

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Machernis, A.F., S.H. Stack, G.L. Olson, F.A. Sullivan, and J.J. Currie. 2021. External scarring as an indicator of fisheries interactions with bottlenose (Tursiops truncatus) and pantropical spotted (Stenella attenuata) dolphins in Maui Nui, Hawaii. Aquatic Mammals 47:482-498. doi.org/10.1578/AM.47.5.2021.482

Oleson, E.M., R.W. Baird, K.K. Martien, and B.L. Taylor. 2013. Island-associated stocks of odontocetes in the main Hawaiian Islands: a synthesis of available information to facilitate evaluation of stock structure. Document PSRG-2013-16 presented to the Pacific Scientific Review Group, Del Mar, April 2013.

Pittman, S.J., A.J. Winship, M. Poti, B.P. Kinlan, J.B. Leirness, R.W. Baird, J. Barlow, E.A. Becker, K.A. Forney, M.C. Hill, P.I. Miller, J. Mobley, and E.M. Oleson. 2016. Chapter 6: Marine Mammals - Cetaceans. pp. 227-265. In: B.M. Costa and M.S. Kendall (eds.), Marine Biogeographic Assessment of the Main Hawaiian Islands. Bureau of Ocean Energy Management and National Oceanic and Atmospheric Administration. OCS Study BOEM 2016-035 and NOAA Technical Memorandum NOS NCCOS 214. 359 pp.

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Yano, K.M., E.M. Oleson, J.L. Keating, L.T. Ballance, M.C. Hill, A.L. Bradford, A.N. Allen, T.W. Joyce, J.E. Moore, and A. Henry. 2018. Cetacean and seabird data collected during the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS), July-December 2017. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TM-NMFS-PIFSC-72, 110 p. doi:10.25923/7avn-gw82

Yano, K.M., E.M. Olesn, J.L.K. McCullough, M.C. Hill, and A.E. Henry. 2020. Cetacean and seabird data collected during the winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey (Winter HICEAS), January-March 2020. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-111, 72 p. doi:10.25923/ehfg-dp78

Supplementary Description 6. 24. Pygmy killer whale small and resident pop.

Species name: Pygmy killer whale (*Feresa attenuata*)

Descriptive name: O'ahu-Maui Nui

BIA type: Small and Resident Pop.

BIA label: S-BIA3-s-b2-HI025-0

Transboundary across: None

Hierarchy: Non-hierarchical; single BIA

Importance score: 3 (Intensity: 3, Data support: 2)

Intensity matrix: Abundance: 3, Range: 2

Supporting notes for intensity score: NMFS does not formally recognize this population as a stock within the U.S. Hawaiian EEZ, and there is no specific abundance estimate for this population. The latest abundance estimate for the entire Hawaiʻi stock of pygmy killer whales, derived from a line-transect survey within the U.S. Hawaiian EEZ conducted in 2017, was 10,328 (CV = 0.75) (Bradford et al., 2021). As of April 2021, the photo-identification catalog for the Oʻahu/Maui Nui community of pygmy killer whales includes a total of 121 slightly distinctive, distinctive, or very distinctive markings (from fair-, good-, or excellent-quality photographs), which includes individuals with resighting rates up to 17 years (2000-2016; CRC unpublished). Photos span a 21-year period, thus is it likely that this includes a number of individuals that have died or been born during the time period. This number may also include individuals originating from a larger, pelagic population that may occasionally visit waters off Oʻahu but remain isolated from known resident pygmy killer whales (e.g., see Mahaffy et al., 2013). Combined, these lines of evidence suggest that the catalog size is larger than the actual population size. Therefore, we assumed the population is comprised of 125 or fewer individuals (abundance score = 3). The size of the resulting BIA is 7,416 km2 (range size score = 2).

Although we cannot provide a specific abundance estimate for this island-associated population, the number of individuals included in the long-term photo-ID catalog with high resighting rates, based both on CRC survey effort and contributed sightings, suggests the population is small. Although the tag deployments were short, they were deployed during different years and tagged individuals displayed varying movement patterns.

Supporting notes for data support score: Data Support Score = 3.

• This population has been studied for 21 years (2000-2020), although not surveyed every year. Additional photographic data supplied by other researchers and community scientists spans a 14-year period (2007-2020).
• A total of 10 sightings from CRC effort, three from NMFS ship-based line-transect effort, 102 encounters from other researchers and community scientists, with re-sightings up to 17 years (2000-2016)
• Four satellite tag deployments (637 filtered Argos locations) transmitting for up to ~26 days, which showed variable movement patterns among individuals
• Tag positional uncertainty and irregularity accounted for through crawl model, and boundary encompasses all of crawl standard error (68% confidence interval) ellipses

Although an island-associated stock has not yet been recognized for this species, the probable existence of such stocks has been acknowledged (Oleson et al., 2013) and both long-term resighting rates and satellite tag data provide evidence for an insular population that uses the waters from Oʻahu to Lānaʻi (Baird et al., 2011b; Baird, 2016; CRC unpublished). Although no abundance estimates specific to this population are available, long-term photo-identification analyses, based on data collected from both dedicated and opportunistic efforts, suggests this community is small and resident (Baird, 2016; CRC unpublished; Mahaffy et al., 2013). The MCP boundary is based on limited sightings (n=13) from dedicated effort and limited number of satellite tag deployments (n=4), however substantial contributions from non-CRC sources (researchers, community scientists) supplied over a long period (14 years) further support the existence of a small and resident population off Oʻahu with some movements to and from Maui Nui.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: This population is resident to this area year-round and no information (from available data) suggests the area is used dynamically or ephemerally.

Boundary certainty: 2

Supporting notes for boundary certainty: We have intermediate confidence in Boundary Certainty for the S-BIA for Oʻahu-Maui Nui pygmy killer whales. The boundary encompasses the entire population using available data and positional uncertainty was accounted for in satellite tag data. Although the BIA includes an area off southwest Lānaʻi with no records, knowing that there have been some individuals documented moving between Lānaʻi and Oʻahu and that this area is characterized by bathymetric depths where these whales are typically found, it is likely that inter-island travelers do use this area. In addition, the spatial extents of the boundary are ultimately supported by the MCP methods and objective estimates of uncertainty in tag locations. As noted earlier, supporting data from dedicated survey effort are limited. For example, based on the habitat features pygmy killer whales use off Oʻahu from available data, their range may extend into similar habitat off the windward side of Oʻahu and Maui Nui where effort has been precluded due to typical poor working conditions, and where few existing sightings have unknown population assignment.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 4

# of years in which supporting tagging data collected: 2 (2010-2016)

Supporting information: Satellite tags were deployed on four pygmy killer whales off the leeward side of Oʻahu during dedicated survey efforts: three in 2010 and one in 2016 (Baird et al., 2011b). Detailed methods on satellite tag data processing are provided as supplementary material. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk model via the crawl package in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 1-hour interval and locations on land were re-routed around a polygon representing the 400-m isobath using the pathroutr package (London, 2020) (shallowest sighting off Oʻahu=450 m, CRC unpublished).

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 13

# of years in which supporting visual data collected: 5 (2000-2017)

Supporting information: Sighting data were collected from non-systematic, dedicated small boat surveys conducted off Oʻahu in six years spanning 2002-2017 and Maui Nui in nine years spanning 2000-2020 (see Baird et al., 2011a, 2013 for details on surveys). Surveys off these islands combined total 26,418 km of effort with ten sightings of pygmy killer whales. In addition, community scientist contributions off Oʻahu and Maui Nui include 102 encounters of pygmy killer whales over a period of 14 years (2007-2020), comprising over 60% of all individuals in CRC's photo-identification catalog from those islands. Resighting rates from both sources of information and social network analyses suggest that pygmy killer whales found off Lānaʻi are associated with those off Oʻahu, or that there are some inter-island movements between these regions (CRC unpublished). CRC has only encountered pygmy killer whales off Lānaʻi twice (2000, 2017), but most of the effort off Maui Nui has been in relatively shallow (<400 m deep) water where pygmy killer whales are unlikely to be found. Given re-sightings between these regions, both Oʻahu and Lānaʻi sightings will be included in the BIA for this population. While community science contributions rarely include associated latitude and longitude to include in the boundary delineation process, in this assessment we use the information on social structure and relative abundance that these contributions have supported. Additional sighting data were available from NMFS ship-based line-transect surveys (Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020), and those with confirmed photographic assignment to the Oʻahu/Maui Nui insular population or within the known range of the insular population were used in boundary determinations (n=3); effort from these surveys total to 4,231 km)

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 121

# of years of photo records to compare: 21 (2000-2021)

Maximum # of years same individual photographed in area: 17 (2000-2016)

Supporting information: Resighting rates from both sources of information and social network analyses suggest that pygmy killer whales found off Lānaʻi are associated with those off Oʻahu, or that there are some inter-island movements between these regions (CRC unpublished). Given re-sightings between these regions, both Oʻahu and Lānaʻi sightings will be included in the BIA for this population. As of April 2021, the photo-identification catalog for the Oʻahu/Maui Nui community of pygmy killer whales includes a total of 121 slightly distinctive, distinctive, or very distinctive markings (from fair-, good-, or excellent-quality photographs), which includes individuals with resighting rates up to 17 years (2000-2016; CRC unpublished). Photos span a 21-year period, thus is it likely that this includes a number of individuals that have died or been born during the time period. This number may also include individuals originating from a larger, pelagic population. Combined these suggest that the catalog size is larger than the actual population size, and we thus assume the population is comprised of 125 or fewer individuals.

Genetic analyses conducted supporting designation (Y/N): Y

Nature of supporting information: Weak

Supporting information: Genetic analysis of biopsy samples of pygmy killer whales from within the main Hawaiian Islands found one shared mitochondrial haplotype between individuals from the Oʻahu and Hawaiʻi Island populations, as well as haplotypes found only in one or the other location (B. Hancock-Hanser, pers. comm.).

What factors justify the boundary selection?: Baird et al., (2015) did not delineate a S-BIA for this population; however, with increased quantity and quality of information on their population structure since the initial assessment, we believed a Oʻahu-Maui Nui pygmy killer whale S-BIA was warranted. Both sighting and satellite tag data were used to inform the BIA boundary for the Oʻahu-Maui Nui pygmy killer whale population.

The basis for the S-BIA was a minimum convex polygon (MCP) encompassing all sighting and satellite-tag derived crawl locations. A 3 km distance was added to the outer boundary of the MCP to account for positional uncertainty estimated by crawl; such a distance captures all of the positional uncertainty generated by the model. The inner (shoreward) boundary along the coasts of Oʻahu and Lānaʻi was defined as the 400-m isobath based on the shallowest sighting from survey effort (450 m). The resulting area of the parent BIA (i.e., population range size) is 7,416 km2.

Data sources: Cascadia Research Collective (unpub. data, 2000-2020); National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020; accessed 2021); Baird et al., 2011a, 2011b, 2013; Mahaffy et al., 2013; Oleson et al., 2013

Approximate % of population that uses this area for the designated purpose (if known): 100

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Baird, R.W., G.S. Schorr, D.L. Webster, D.J. McSweeney, M.B. Hanson, and R.D. Andrews. 2011a. Movements of two satellite-tagged pygmy killer whales (Feresa attenuata) off the island of Hawaiʻi. Marine Mammal Science 24(7):E332-E337 doi: 10.1111/j.1748-7692.2010.00458.x

Baird, R.W., G.S. Schorr, D.L. Webster, S.D. Mahaffy, J.M. Aschettino, and T Cullins. 2011b. Movements and spatial use of satellite-tagged odontocetes in the western main Hawaiian Islands: results of field work undertaken off Oʻahu in October 2010 and Kauaʻi in February 2011. Annual progress report under Grant No. N00244-10-1-0048 from the Naval Postgraduate School.

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Bradford, A.L., E.M. Oleson, K.A. Forney, J.E. Moore, and J. Barlow. 2021. Line-transect abundance estimates of cetaceans in U.S. waters around the Hawaiian Islands in 2002, 2010, and 2017. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-PIFSC-115, 52 p. doi:10.25923/daz4-kw84

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Mahaffy, S.D., R.W. Baird, T. Cullins, G.S. Schorr, D.L. Webster, and D.J. McSweeney. 2013. A small resident social group of pygmy killer whales off the island of Oʻahu: photo-identification and satellite tagging reveal differences in social patterns of this species in the Hawaiian archipelago. Poster presented at the 20th Biennial Conference on the Biology of Marine Mammals, Dunedin, New Zealand, 9-13 December 2013.

McSweeney, D.J., R.W. Baird, S.D. Mahaffy, D.L. Webster, and G.S. Schorr. 2009. Site fidelity and association patterns of a rare species: Pygmy killer whales (Feresa attenuata) in the main Hawaiian Islands. Marine Mammal Science 25(3):557-572 doi: 10.1111/j.1748-7692.2008.00267.x

Oleson, E.M., R.W. Baird, K.K. Martien, and B.L. Taylor. 2013. Island-associated stocks of odontocetes in the main Hawaiian Islands: a synthesis of available information to facilitate evaluation of stock structure. Document PSRG-2013-16 presented to the Pacific Scientific Review Group, Del Mar, April 2013.

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Supplementary Description 6. 25. Pygmy killer whale small and resident pop.

Species name: Pygmy killer whale (*Feresa attenuata*)

Descriptive name: Hawai'i Island

BIA type: Small and Resident Pop.

BIA label: S-BIA2-s-b2-HI001-0

Transboundary across: None

Hierarchy: Non-hierarchical; single BIA

Importance score: 2 (Intensity: 2, Data support: 2)

Intensity matrix: Abundance: 2, Range: 2

Supporting notes for intensity score: NMFS has not formally recognized this population as a stock within the Hawaiian EEZ, and there is no specific abundance estimate for this population. The latest abundance estimate for the entire Hawaiʻi stock of pygmy killer whales, derived from a line-transect survey within the US Hawaiian EEZ conducted in 2017, was 10,328 (CV = 0.75) (Bradford et al., 2021). As of April 2021, the photo-identification catalog for the Hawaiʻi Island community of pygmy killer whales includes a total of 290 individuals which have slightly distinctive, distinctive, or very distinctive markings (from fair-, good-, or excellent-quality photographs) (CRC unpublished). This includes individuals photo-identified over a 36-year period (1986 through April 2021), and thus likely includes many individuals that have died or been born during this period. Based on this, for this small resident BIA, we assumed the population is within the 126 to 500 category (score = 2) of the BIA Intensity scoring criteria. The size of the modified MCP representing the BIA is 5,202 km2 (score = 2).

Although we cannot provide a specific abundance estimate for this island-associated population, the long-term photo-ID catalog with high resighting rates, based on extensive survey effort and utilizing opportunistic sightings, suggests the population is small. Although the tag deployments were short, they were deployed during different years and tagged individuals displayed similar movement patterns along the slope of Hawaiʻi Island.

Supporting notes for data support score: We assigned this BIA a Data Support score of 2.

- This population has been studied for 20 years (2002-2021), although not surveyed every year. Additional photographic data supplied by other researchers and community science contributions spans a 36-year period.
- Sightings consisted of 52 from CRC effort, one from NMFS ship-based line-transect effort, and 110 from other researchers and community scientists since 1986
- Re-sightings of individuals span over 30 years (1986 to 2017, 30 separate encounters) with some individuals re-sighted on up to 49 different occasions
- Two satellite tag deployments (392 filtered Argos locations) transmitting for up to ~23 days, both of which showed similar spatial use patterns along the west and southeast slope of Hawaiʻi Island
- Tag positional uncertainty and irregularity accounted for through crawl model, and boundary encompasses nearly all of crawl standard error (68% confidence interval) ellipses

Despite the fact that an island-associated stock has yet to be recognized for this population of pygmy killer whales, the likelihood of this stock's existence has been recognized for some time (McSweeney et al., 2009; Oleson et al., 2013) and is backed up by long-term, high resighting rates (over 30 years; individual resighting counts up to 49 separate occasions) and available information on movements through satellite tag deployments. Within this community there is also evidence of long-term associations, suggesting a stable social structure similar to false killer whales or short-finned pilot whales (Mahaffy et al., 2015; Mahaffy et al., 2021; McSweeney et al., 2009). Despite these lines of support, a large proportion of Hawaiʻi Island resident pygmy killer whales in CRC's catalog (67%) have only been sighted once or twice since 2000 (CRC unpublished), so it is likely the range of this population is greater than currently recognized. No abundance estimates specific to this population are available, although long-term photo-identification analyses from both dedicated and opportunistic efforts support the existence of a small and resident population. The distribution of sighting and crawl-predicted locations is fairly consistent within the MCP boundary with the exception of some areas farther offshore where no sightings occurred, or no satellite tag locations were obtained.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: This population is resident to this area year-round and no information (from available data) suggests the area is used dynamically or ephemerally.

Boundary certainty: 2

Supporting notes for boundary certainty: We have intermediate confidence in Boundary Certainty for the BIA for Hawaiʻi Island pygmy killer whales. The boundary encompasses the entire population and positional uncertainty was accounted for in satellite tag data. However, as noted earlier, the boundary includes some areas farther offshore where there was reduced effort and a lack of sightings. Despite this, the boundary is ultimately supported by the data through the MCP methods and objective estimates of uncertainty in tag locations. In addition, based on known habitat use of this population of pygmy killer whales, this population's range may extend into similar habitat around the rest of Hawaiʻi Island (e.g., 1,000-3,500 m bathymetric depths) where typical weather conditions have precluded small boat survey efforts.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 2 tags, 2 individuals, 392 filtered locations

# of years in which supporting tagging data collected: 2

Supporting information: Satellite tags were deployed on two pygmy killer whales during dedicated survey efforts off the west side of Hawaiʻi Island, one each in 2008 and 2009 (see Baird et al., 2011a). Detailed methods on satellite tag data processing methods are provided as supplementary material with the corresponding manuscript. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk model via the crawl package in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 1-hour interval and locations on land were re-routed around a polygon representing the 100-m isobath around the island using the pathroutr package (London, 2020). Crawl locations interpolated over large periods without any underlying Argos locations were removed prior to analyses (gap threshold = 1 day).

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 53 sightings

# of years in which supporting visual data collected: 17

Supporting information: Sighting data were collected from non-systematic, dedicated small boat surveys conducted off Hawaiʻi Island from 2002-2021 (see Baird et al., 2013 for details on surveys). Surveys off Hawaiʻi Island total 97,438 km of effort with a total of 52 pygmy killer whale sightings. In addition, community science contributions have added substantially to the available information on this population. As of April 2021, over 60% of the individuals comprising CRC's photo-identification catalog of Hawaiʻi Island pygmy killer whales were identified based on non-CRC contributions (n=110 encounters), collected over a period of 36 years (1986-2021; CRC unpublished). While community science contributions rarely include associated latitude and longitude to include in the boundary delineation process (typically only general island or regional locality is provided), in this assessment we use the information on social structure and relative abundance that these photographic contributions have supported. Additional sighting data were available from NMFS ship-based line-transect surveys (Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020), and those with confirmed photographic assignment to the Hawaiʻi Island insular population were used in boundary determinations (n=1 out of 3 total); effort from these surveys total 4,336 km)

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 290

# of years of photo records to compare: 36 (1986-2021)

Maximum # of years same individual photographed in area: 20 yrs over 30-yr span

Supporting information: As of April 2021, the photo-identification catalog for the Hawaiʻi Island community of pygmy killer whales includes a total of 290 individuals which have slightly distinctive, distinctive, or very distinctive markings (from fair-, good-, or excellent-quality photographs) (CRC unpublished). This includes individuals photo-identified over a 36-year period (1986 through April 2021).). Individuals identified off Hawaiʻi Island have been resighted over time spans up to 30 years (1986-2017; 30 separate re-sightings), up to 49 different occasions (re-sightings), providing evidence for the existence of a long-term, island-associated resident population (Baird, 2016; CRC unpublished).

Genetic analyses conducted supporting designation (Y/N): Y

Nature of supporting information: Weak

Supporting information: Genetic analysis of biopsy samples of pygmy killer whales from within the main Hawaiian Islands found one shared mitochondrial haplotype between individuals from the Oʻahu and Hawaiʻi Island populations, as well as haplotypes found only in one or the other location (B. Hancock-Hanser, pers. comm.). Although no analyses to assess the potential for demographic independence between island-associated communities have been undertaken.

What factors justify the boundary selection?: Both sighting and satellite tag data were used to inform the S-BIA boundary for the Hawaiʻi Island pygmy killer whale population. The BIA for this population in this assessment is similar to what Baird et al., (2015) described, albeit with increased quantity and quality (e.g., satellite tag data processing methods) of supporting data.

The basis for the BIA was a minimum convex polygon (MCP) encompassing all sighting and satellite-tag derived crawl locations. A 3-km distance was added to the outer boundary of the MCP to account for positional uncertainty estimated by crawl; such a distance captures nearly all of the positional uncertainty generated by the model. The inner (shoreward) BIA boundary was defined as the 100-m isobath based on the shallowest sighting off this island (115 m deep; CRC unpublished). Although the shallowest sighting off this area was at 115-m depth, sighting rates (# sightings/100 hours of survey effort) increased with depth to approximately 1,500 m depth with only a few sightings in deeper waters (sighting depth range=115-3,700 m; CRC unpublished). The resulting area of the parent BIA (i.e., population range size) is 5,201 km2.

Data sources: Cascadia Research, unpublished data, 1986-2021 (accessed 2021); National Marine Fisheries Service (2002-2020) accessed 2021; McSweeney et al., 2009; Baird et al., 2011a, 2013

Approximate % of population that uses this area for the designated purpose (if known): 100

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Baird, R.W., G.S. Schorr, D.L. Webster, D.J. McSweeney, M.B. Hanson, and R.D. Andrews. 2011a. Movements of two satellite-tagged pygmy killer whales (Feresa attenuata) off the island of Hawaiʻi. Marine Mammal Science 24(7):E332-E337 doi: 10.1111/j.1748-7692.2010.00458.x

Baird, R.W., G.S. Schorr, D.L. Webster, S.D. Mahaffy, J.M. Aschettino, and T Cullins. 2011b. Movements and spatial use of satellite-tagged odontocetes in the western main Hawaiian Islands: results of field work undertaken off Oʻahu in October 2010 and Kauaʻi in February 2011. Annual progress report under Grant No. N00244-10-1-0048 from the Naval Postgraduate School.

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Bradford, A.L., E.M. Oleson, K.A. Forney, J.E. Moore, and J. Barlow. 2021. Line-transect abundance estimates of cetaceans in U.S. waters around the Hawaiian Islands in 2002, 2010, and 2017. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-PIFSC-115, 52 p. doi:10.25923/daz4-kw84

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Mahaffy, S.D., R.W. Baird, T. Cullins, G.S. Schorr, D.L. Webster, and D.J. McSweeney. 2013. A small resident social group of pygmy killer whales off the island of Oʻahu: photo-identification and satellite tagging reveal differences in social patterns of this species in the Hawaiian archipelago. Poster presented at the 20th Biennial Conference on the Biology of Marine Mammals, Dunedin, New Zealand, 9-13 December 2013.

Mahaffy, S.D., R.W. Baird, and B.L. Hancock-Hanser. 2021. Long-term associations, life history, and lack of dispersal: unique insights from pygmy killer whales off the island of Hawaiʻi. Abstract accepted to the 24th Biennial Conference on the Biology of Marine Mammals, Palm Beach, Florida, USA, 13-17 December 2021

Mahaffy, S.D., R.W. Baird, D.J. McSweeney, D.L. Webster, and G.S. Schorr. 2015. High site fidelity, strong associations, and long-term bonds: short-finned pilot whales off the island of Hawaiʻi. Marine Mammal Science 31(4):1427-1451 doi:10.1111/mms.12234

McSweeney, D.J., R.W. Baird, S.D. Mahaffy, D.L. Webster, and G.S. Schorr. 2009. Site fidelity and association patterns of a rare species: Pygmy killer whales (Feresa attenuata) in the main Hawaiian Islands. Marine Mammal Science 25(3):557-572 doi: 10.1111/j.1748-7692.2008.00267.x

Oleson, E.M., R.W. Baird, K.K. Martien, and B.L. Taylor. 2013. Island-associated stocks of odontocetes in the main Hawaiian Islands: a synthesis of available information to facilitate evaluation of stock structure. Document PSRG-2013-16 presented to the Pacific Scientific Review Group, Del Mar, April 2013.

Supplementary Description 6. 26. Rough-toothed dolphin small and resident pop.

Species name: Rough-toothed dolphin (*Steno bredanensis*)

Descriptive name: Kaua'i/Ni'ihau-O'ahu - Parent

BIA type: Small and Resident Pop.

BIA label: S-BIA1-s-b2-HI026-0a

Transboundary across: None

Hierarchy: Hierarchical BIA; Parent of children a

Importance score: 1 (Intensity: 1, Data support: 2)

Intensity matrix: Abundance: 1, Range: 1

Supporting notes for intensity score: This population has not been formally recognized by NMFS as a stock within the Hawaiian EEZ, and there is no specific abundance estimate for the KNO rough-toothed dolphin population. The latest abundance estimate for the entire Hawaiʻi stock of rough-toothed dolphins, derived from a line-transect survey within the US Hawaiian EEZ conducted in 2017, was 76,375 (CV = 0.41; Bradford et al. 2021). The most recent estimate for rough-toothed dolphins associated with Kauaʻi/Niʻihau was reported by Baird et al. (2008) at 1,665 (CV = 0.33), based on photo-identification data collected between 2003 and 2006. However, this estimate is dated and did not account for unmarked or Oʻahu animals, and hence, underestimates the true KNO population size at that time. As of May 2021, the photo-identification catalog for this species includes 1,033 slightly distinctive, distinctive, or very distinctive individuals (from fair-, good-, or excellent-quality photographs) encountered off Kauaʻi, Niʻihau, and Oʻahu (CRC unpublished). The photo-identification catalog likely includes several individuals that have died or been born into the population, but for this assessment we assumed the population is within the 501-2,000 category of the BIA Intensity scoring criteria. (score = 1). The resulting area of the parent BIA (i.e., population range size) is 25,083 km2 (range size score = 1).

Although we cannot provide a recent abundance estimate specific to this population (including Oʻahu animals), the distinct individual identification total, based on a long-term photo-ID catalog curated from both CRC survey effort and contributed sightings, falls in the (1) category and the overall range size is relatively large considering the movements and sightings to west Oʻahu. Although the tag deployments were short, they were deployed over several years and during different seasons.

Supporting notes for data support score: Data Support score = 2.

- This population has been studied for 19 years (2002-2021). Contributed photos from other researchers and community scientists span a period of 15 years (2006-2020).
- A total of 295 sightings from CRC effort, 17 sightings from NMFS ship-based line-transect surveys, 82 encounters from non-CRC contributors, with re-sightings up to 17 years (2003 to 2020)
- Genetic differentiation from Hawaiʻi Island-associated population
- 19 satellite tag deployments (3,642 filtered Argos locations) transmitting for up to ~28 days, all of which showed similar spatial use patterns (Kaulakahi Channel, windward sides of Kauaʻi/Niʻihau, circumnavigation of Kauaʻi) with the exception of the individual that moved to west Oʻahu over a period of 5 days
- Tag positional uncertainty and irregularity accounted for through crawl model, and boundary encompasses nearly all of crawl standard error (68% confidence interval) ellipses

Despite longevity and variety of information available on this population, no recent abundance estimates specific to this population are available, and the BIA boundary includes a large amount of space where no data points exist to support movements through the Kaʻieʻie Waho Channel between Kauaʻi and Oʻahu.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: This population is resident to this area year-round and no information (from available data) suggests the area is used dynamically or ephemerally.

Boundary certainty: 2

Supporting notes for boundary certainty: We have intermediate confidence in Boundary Certainty for the parent BIA for KNO rough-toothed dolphins. The parent BIA boundary encompasses the entire population and we attempted to account for positional uncertainty in satellite tag data. The parent BIA boundary includes a large amount of space, but the extents are supported by the data using the MCP method and objective estimates of uncertainty in tag locations.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 19

# of years in which supporting tagging data collected: 8 (2011-2018)

Supporting information: Satellite tags were deployed on a total of 19 rough-toothed dolphins during dedicated survey efforts off Kauaʻi and Niʻihau from 2011-2018 (Shaff and Baird, 2021). Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk model via the crawl package in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 1-hour interval. Locations on land were re-routed around a polygon representing the 200-m isobath (shallowest sighting of rough-toothed dolphins in this region) using the pathroutr package for R (London, 2020).

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 312

# of years in which supporting visual data collected: 15 (2002-2021)

Supporting information: Sighting data were collected from non-systematic, dedicated small boat surveys conducted off Kauaʻi and Niʻihau in 13 years spanning 2003-2021 and Oʻahu in six years spanning 2002-2017 (see Baird et al., 2013 and Baird et al., 2019 for details on surveys). Surveys off Kauaʻi, Niʻihau, and Oʻahu total to 33,850 km of effort with a total of 295 rough-toothed dolphin sightings. In addition, photographic contributions collected over 15 years by other researchers and community scientists (n=82 non-CRC sightings) have substantially supplemented what we know of these populations, particularly rough-toothed dolphins encountered off Oʻahu, where CRC efforts have been limited relative to Kauaʻi/Niʻihau. While community science contributions rarely come with associated latitude and longitude to include in the boundary delineation process (typically only general island or regional locality is provided), in this assessment we use the information on social structure and relative abundance that these photographic contributions have supported. Additional sighting data were available from NMFS ship-based line-transect surveys (Barlow, 2006; Bradford et al., 2017; et al., 2021; Yano et al., 2018, 2020), and those with confirmed photographic assignment to the insular population or within the known range of the insular population were used in boundary determinations (n=17); effort from these sightings in the area shown in manuscript figure total 7,238 km (9 individual surveys between 2002-2020).

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 1033

# of years of photo records to compare: 13 (2003-2020)

Maximum # of years same individual photographed in area: 17 (2003-2020)

Supporting information: As of May 2021, the photo-identification catalog for this species includes 1,033 slightly distinctive, distinctive, or very distinctive individuals (from fair-, good-, or excellent-quality photographs) encountered off Kauaʻi, Niʻihau, and Oʻahu (CRC unpublished). The photo-identification catalog likely includes several individuals that have died or been born into the population, but for this assessment we will assume the population is within the 501-2,000 range of the BIA criteria.

Genetic analyses conducted supporting designation (Y/N): Y

Nature of supporting information: Strong

Supporting information: Genetic analysis of samples collected of rough-toothed dolphins revealed no significant differences in mtDNA or nuclear DNA for individuals off Kauaʻi/Niʻihau versus off Oʻahu (Albertson et al., 2016), but did reveal differentiation from individuals sampled off Hawaiʻi Island.

What factors justify the boundary selection?: Baird et al. (2015) did not delineate a S-BIA for this population; however, given increased quantity and quality of information on rough-toothed dolphins in this region since the original assessment, a BIA for this population was warranted. Both sightings and satellite tag data were used to inform the parent BIA boundary for the KNO rough-toothed dolphin population. Because one satellite tagged dolphin moved to west Oʻahu and some individuals off Oʻahu have associated with those off Kauaʻi/Niʻihau, all Kauaʻi, Niʻihau, and Oʻahu sightings were included in the parent BIA. In addition, a child BIA was delineated to represent the core area of use for this population. It is worth noting that given the limited association between Oʻahu and Kauaʻi/Niʻihau dolphins, in addition to the Oʻahu community's high site fidelity, there is likely a second core area for the KNO population off Oʻahu that we do not have sufficient information to delineate a child BIA for at this time.

The basis for the parent BIA was a minimum convex polygon (MCP) around all sighting and satellite-tag derived crawl locations, with the inner (shoreward) boundary defined by the 200-m isobath (based on the shallowest sighting from survey effort at 265 m). The BIA was established by adding a 3 km distance to the outer boundary of the MCP to account for positional uncertainty in the locations estimated by crawl; such a distance captures most, but not all of the positional uncertainty generated by the model. The resulting area of the parent BIA (i.e., population range size) is 25,083 km2.

Data sources: Cascadia Research Collective (unpub. data, 2003-2020); Albertson et al., 2016; Baird et al., 2008, 2013, 2019, 2021; Oleson et al., 2013; Shaff & Baird, 2021; National Marine Fisheries Service (2002-2020; accessed 2021).

Approximate % of population that uses this area for the designated purpose (if known): 100

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Albertson, G.R., R.W. Baird, M. Oremus, M.M. Poole, K.K. Martien, and C.S. Baker. 2016. Staying close to home? Genetic differentiation of rough-toothed dolphins near oceanic islands in the central Pacific Ocean. Conservation Genetics 18:33-51 doi:10.1007/s10592-016-0880-z

Baird, R.W., D.L. Webster, S.D. Mahaffy, D.J. McSweeny, G.S. Schorr, and A.D. Ligon. 2008. Site fidelity and association patterns in a deep-water dolphin: Rough-toothed dolphins (Steno bredanensis) in the Hawaiian Archipelago. Marine Mammal Science 24(3):535-553

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Baird, R.W., D.L. Webster, S.M. Jarvis, E.E. Henderson, S.L. Watwood, S.D. Mahaffy, B.D. Guenther, J.K. Lerma, C.J. Cornforth, A.W. Vanderzee, and D.B. Anderson. 2019. Odontocete studies on the Pacific Missile Range Facility in August 2018: Satellite-tagging, photo-identification, and passive acoustic monitoring. Prepared for Commander, Pacific Fleet, under Contract No. N62470-15-D-8006 Task Order 6274218F0107 issued to HDR Inc., Honolulu, HI June 2019.

Baird, R.W., C.J. Cornforth, S.M. Jarvis, N.A. DiMarzio, K. Dolan, E.E. Henderson, S.W. Martin, S.L. Watwood, S.D. Mahaffy, B.D. Guenther, J.K. Lerma, A.E. Harnish, and M.A. Kratofil. 2021. Odontocete studies on the Pacific Missile Range Facility in February 2020: Satellite-tagging, photo-identification, and passive acoustic monitoring. Prepared for Commander, Pacific Fleet, Environmental Readiness Division, Pearl Harbor, HI, under Contract No. N62470-15-D-8006 Task Order N6247015D8006 issued to HDR Inc., Honolulu, HI December 2020.

Bradford, A.L., E.M. Oleson, K.A. Forney, J.E. Moore, and J. Barlow. 2021. Line-transect abundance estimates of cetaceans in U.S. waters around the Hawaiian Islands in 2002, 2010, and 2017. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-PIFSC-115, 52 p. doi:10.25923/daz4-kw84

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22(2):446-464

Douglas, D.C., R. Weinzierl, S.C. Davidson, R. Kays, M. Wikelski, and G. Bohrer. 2012. Moderating Argos location errors in animal tracking data. Methods in Ecology and Evolution 3(6):999-1007.

Duong, T., and M.L. Hazelton. 2003. Plug-in bandwidth matrices for bivariate kernel density estimation. Journal of Nonparametric Statistics 15:17-30.

Duong, T., and M.L. Hazelton. 2005. Cross-validation bandwidth matrices for multivariate kernel density estimation. Scandinavian Journal of Statistics 32:485-506.

Duong, T. 2007. Ks: Kernel density estimation and kernel discriminant analysis for multivariate data in R. Journal of Statistical Software 21:1-16.

Duong, T. 2021. Ks: Kernel smoothing. R package version 1.12.0 https://CRAN.R-project.org/package=ks

Hauser, D.D.W., K.L. Laidre, R.S. Suydam, and P.R. Richard. 2014. Population-specific home ranges and migration timing of Pacific Arctic beluga whales (Delphinapterus leucas). Polar Biology 37:1171-1183

Hill, M.C., A.R. Bendlin, A.M. Van Cise, A. Milette-Winfree, A.D., Ligon, A.C. Ü, M.H. Deakos, and E.M. Oleson. 2019. Short-finned pilot whales (Globicephala macrorhynchus) of the Mariana Archipelago: individual affiliations, movements, and spatial use. Marine Mammal Science 35(3):797-824 doi:10.1111/mms.12567

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

Kranstauber, B., A. Cameron, R. Weinzerl, T. Fountain, S. Tilak, M. Wikelski, and R. Kays. 2011. The Movebank data model for animal tracking. Environmental Modeling & Software 26:834-835

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Oleson, E.M., R.W. Baird, K.K. Martien, and B.L. Taylor. 2013. Island-associated stocks of odontocetes in the main Hawaiian Islands: a synthesis of available information to facilitate evaluation of stock structure. Document PSRG-2013-16 presented to the Pacific Scientific Review Group, Del Mar, April 2013.

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Shaff, J.F., and R.W. Baird. 2021. Diel and lunar variation in diving behavior of rough-toothed dolphins (Steno bredanensis) off Kaua‘i, Hawai‘i. Marine Mammal Science, doi:10.1111/mms.12811

Worton, B.J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:164-168

Yano, K.M., E.M. Oleson, J.L. Keating, L.T. Ballance, M.C. Hill, A.L. Bradford, A.N. Allen, T.W. Joyce, J.E. Moore, and A. Henry. 2018. Cetacean and seabird data collected during the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS), July-December 2017. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TM-NMFS-PIFSC-72, 110 p. doi:10.25923/7avn-gw82

Yano, K.M., E.M. Olesn, J.L.K. McCullough, M.C. Hill, and A.E. Henry. 2020. Cetacean and seabird data collected during the winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey (Winter HICEAS), January-March 2020. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-111, 72 p. doi:10.25923/ehfg-dp78

Supplementary Description 6. 27. Rough-toothed dolphin small and resident pop.

Species name: Rough-toothed dolphin (*Steno bredanensis*)

Descriptive name: Kaua'i/Ni'ihau-O'ahu - Child (Kaua'i/Ni'ihau)

BIA type: Small and Resident Pop.

BIA label: S-BIA2-s-b2-HI026-a

Transboundary across: None

Hierarchy: Hierarchical BIA; Child a

Importance score: 2 (Intensity: 2, Data support: 2)

Intensity matrix: Abundance: 1, Range: 3

Supporting notes for intensity score: Using the same abundance estimate range as the parent BIA (501-2,000), we assume that approximately 50% of the population is contained within the KN child BIA, although recognize that there is uncertainty associated with this value. A total of 190 sightings (61 % of all sightings) were within the estimated core range. It is important to note that all tagged individuals used the core range and while the abundance estimate is dated. We assigned an Intensity score of 2 for the child BIA to recognize that the child BIA represents intensified use relative to the parent BIA, but also consider the fact that there may be another core area off Oʻahu that we currently do not have the data to identify. The area of the child BIA is 1,098 km2.

Supporting notes for data support score: Score = 2; We used the same satellite tag dataset used to delineate the parent BIA, and attempted to account for bias associated with varying deployment durations and pseudoreplication (i.e., pairs of animals tagged together and acting in concert) for core range analysis, using a widely used approach for estimating core range (KDEs).

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: This population is resident to this area year-round and no information (from available data) suggests the area is used dynamically or ephemerally.

Boundary certainty: 2

Supporting notes for boundary certainty: We have intermediate confidence in Boundary Certainty for the child BIA of the KNO rough-toothed dolphin population. Although there are some caveats that come with kernel density analysis, the estimated core range overlaps with concentrations of sightings and hourly satellite tag data and was used by all tagged individuals, deployed during different years, seasons, etc. As noted above, we attempted to account for some potential sources of bias in this analysis (e.g., tag deployment locality, spatial autocorrelation) by using a coarser timestep and a weighted KDE approach. However, tags used for this assessment did not transmit for longer than a month and nearly all were deployed in the same general region, introducing a tagging bias.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 19

# of years in which supporting tagging data collected: 8 (2011-2018)

Supporting information: Satellite tags were deployed on a total of 19 rough-toothed dolphins during dedicated survey efforts off Kauaʻi and Niʻihau from 2011-2018 (Shaff and Baird, 2021). Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk model via the crawl package in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 1-hour interval. Locations on land were re-routed around a polygon representing the 200-m isobath (shallowest sighting of rough-toothed dolphins in this region) using the pathroutr package for R (London, 2020).

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 312

# of years in which supporting visual data collected: 15 (2002-2021)

Supporting information: Sighting data were collected from non-systematic, dedicated small boat surveys conducted off Kauaʻi and Niʻihau in 13 years spanning 2003-2021 and Oʻahu in six years spanning 2002-2017 (see Baird et al., 2013 and Baird et al., 2019 for details on surveys). Surveys off Kauaʻi, Niʻihau, and Oʻahu total to 33,850 km of effort with a total of 295 rough-toothed dolphin sightings. In addition, photographic contributions collected over 15 years by other researchers and community scientists (n=82 non-CRC sightings) have substantially supplemented what we know of these populations, particularly rough-toothed dolphins encountered off Oʻahu, where CRC efforts have been limited relative to Kauaʻi/Niʻihau. While community science contributions rarely come with associated latitude and longitude to include in the boundary delineation process (typically only general island or regional locality is provided), in this assessment we use the information on social structure and relative abundance that these photographic contributions have supported. Additional sighting data were available from NMFS ship-based line-transect surveys (Barlow, 2006; Bradford et al., 2017; et al., 2021; Yano et al., 2018, 2020), and those with confirmed photographic assignment to the insular population or within the known range of the insular population were used in boundary determinations (n=17); effort from these sightings in the area shown in respective figure total to 7,238 km (9 individual surveys between 2002-2020).

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 1033

# of years of photo records to compare: 12 (2003-2020)

Maximum # of years same individual photographed in area: 17 (2003-2020)

Supporting information: As of May 2021, the photo-identification catalog for this species includes 1,033 slightly distinctive, distinctive, or very distinctive individuals (from fair-, good-, or excellent-quality photographs) encountered off Kauaʻi, Niʻihau, and Oʻahu (CRC unpublished) with re-sightings up to 17 years (2003 to 2020). The photo-identification catalog likely includes several individuals that have died or been born into the population.

Genetic analyses conducted supporting designation (Y/N): Y

Nature of supporting information: Strong

Supporting information: Genetic analysis of samples collected of rough-toothed dolphins revealed no significant differences in mtDNA or nuclear DNA for individuals off Kauaʻi/Niʻihau versus off Oʻahu (Albertson et al., 2016), but did reveal differentiation from individuals sampled off Hawaiʻi Island.

What factors justify the boundary selection?: Baird et al. (2015) did not delineate a S-BIA for this population; however, given increased quantity and quality of information on rough-toothed dolphins in this region since the original assessment, a BIA for this population was warranted. Both sightings and satellite tag data were used to inform the parent BIA boundary for the KNO rough-toothed dolphin population. Because one satellite tagged dolphin moved to west Oʻahu and some individuals off Oʻahu have associated with those off Kauaʻi/Niʻihau, all Kauaʻi, Niʻihau, and Oʻahu sightings were included in the parent BIA. In addition, a child BIA was delineated to represent the core area of use for this population. It is worth noting that given the limited association between Oʻahu and Kauaʻi/Niʻihau dolphins, in addition to the Oʻahu community's high site fidelity, there is likely a second core area for the KNO population off Oʻahu that we do not have sufficient information to delineate a child BIA for at this time.

Satellite tag locations are concentrated in the Kaulakahi Channel between Kauaʻi and Niʻihau. To estimate this population's core area(s) of use, whether to use as supplementary material or as part of the formal scoring process, we used kernel density estimation (KDE) to generate a utility distribution (UD) of the sample population (Worton, 1989) and used a 50% isopleth of the UD to represent the core range of the population. The following steps were completed to account for some caveats with this analysis: a coarser timestep of crawl locations was used (4-hours (n=1,324 crawl locations), to reduce autocorrelation); and one of each pair of tagged individuals moving in concert were removed (to reduce pseudoreplication). All tag locations were pooled together, and the contribution of each tag's location was weighted to the overall kernel density based on deployment length, and the KDE was re-scaled so it integrated to 1 (Hauser et al. 2014; Hill et al. 2019), such that locations from shorter deployments would have less weight than those with longer deployments. Kernel densities were estimated using the bivariate plug-in bandwidth (or smoothing parameter) matrix (Duong & Hazelton, 2003, 2005; Duong, 2007) accessed through the ks package for R (Duong, 2021). The location weighting was completed using the weights argument within the ks package (Duong, 2021). It is worth noting that given the limited association between Oʻahu and Kauaʻi/Niʻihau dolphins, in addition to the Oʻahu community's high site fidelity, there is likely a second core area for this population off Oʻahu that we do not have sufficient information to delineate a child BIA for at this time.

Data sources: Cascadia Research Collective (unpub. data, 2003-2020); Albertson et al., 2016; Baird et al., 2008, 2013, 2019, 2021; Oleson et al., 2013; Shaff & Baird, 2021; National Marine Fisheries Service (2002-2020) accessed 2021.

Approximate % of population that uses this area for the designated purpose (if known): 50

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Albertson, G.R., R.W. Baird, M. Oremus, M.M. Poole, K.K. Martien, and C.S. Baker. 2016. Staying close to home? Genetic differentiation of rough-toothed dolphins near oceanic islands in the central Pacific Ocean. Conservation Genetics 18:33-51 doi:10.1007/s10592-016-0880-z

Baird, R.W., D.L. Webster, S.D. Mahaffy, D.J. McSweeny, G.S. Schorr, and A.D. Ligon. 2008. Site fidelity and association patterns in a deep-water dolphin: Rough-toothed dolphins (Steno bredanensis) in the Hawaiian Archipelago. Marine Mammal Science 24(3):535-553

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Baird, R.W., D.L. Webster, S.M. Jarvis, E.E. Henderson, S.L. Watwood, S.D. Mahaffy, B.D. Guenther, J.K. Lerma, C.J. Cornforth, A.W. Vanderzee, and D.B. Anderson. 2019. Odontocete studies on the Pacific Missile Range Facility in August 2018: Satellite-tagging, photo-identification, and passive acoustic monitoring. Prepared for Commander, Pacific Fleet, under Contract No. N62470-15-D-8006 Task Order 6274218F0107 issued to HDR Inc., Honolulu, HI June 2019.

Baird, R.W., C.J. Cornforth, S.M. Jarvis, N.A. DiMarzio, K. Dolan, E.E. Henderson, S.W. Martin, S.L. Watwood, S.D. Mahaffy, B.D. Guenther, J.K. Lerma, A.E. Harnish, and M.A. Kratofil. 2021. Odontocete studies on the Pacific Missile Range Facility in February 2020: Satellite-tagging, photo-identification, and passive acoustic monitoring. Prepared for Commander, Pacific Fleet, Environmental Readiness Division, Pearl Harbor, HI, under Contract No. N62470-15-D-8006 Task Order N6247015D8006 issued to HDR Inc., Honolulu, HI December 2020.

Bradford, A.L., E.M. Oleson, K.A. Forney, J.E. Moore, and J. Barlow. 2021. Line-transect abundance estimates of cetaceans in U.S.

waters around the Hawaiian Islands in 2002, 2010, and 2017. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-PIFSC-115, 52 p. doi:10.25923/daz4-kw84

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22(2):446-464

Douglas, D.C., R. Weinzierl, S.C. Davidson, R. Kays, M. Wikelski, and G. Bohrer. 2012. Moderating Argos location errors in animal tracking data. Methods in Ecology and Evolution 3(6):999-1007.

Duong, T., and M.L. Hazelton. 2003. Plug-in bandwidth matrices for bivariate kernel density estimation. Journal of Nonparametric Statistics 15:17-30.

Duong, T., and M.L. Hazelton. 2005. Cross-validation bandwidth matrices for multivariate kernel density estimation. Scandinavian Journal of Statistics 32:485-506.

Duong, T. 2007. Ks: Kernel density estimation and kernel discriminant analysis for multivariate data in R. Journal of Statistical Software 21:1-16.

Duong, T. 2021. Ks: Kernel smoothing. R package version 1.12.0 https://CRAN.R-project.org/package=ks

Hauser, D.D.W., K.L. Laidre, R.S. Suydam, and P.R. Richard. 2014. Population-specific home ranges and migration timing of Pacific Arctic beluga whales (Delphinapterus leucas). Polar Biology 37:1171-1183

Hill, M.C., A.R. Bendlin, A.M. Van Cise, A. Milette-Winfree, A.D., Ligon, A.C. Ü, M.H. Deakos, and E.M. Oleson. 2019. Short-finned pilot whales (Globicephala macrorhynchus) of the Mariana Archipelago: individual affiliations, movements, and spatial use. Marine Mammal Science 35(3):797-824 doi:10.1111/mms.12567

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

Kranstauber, B., A. Cameron, R. Weinzerl, T. Fountain, S. Tilak, M. Wikelski, and R. Kays. 2011. The Movebank data model for animal tracking. Environmental Modeling & Software 26:834-835

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Oleson, E.M., R.W. Baird, K.K. Martien, and B.L. Taylor. 2013. Island-associated stocks of odontocetes in the main Hawaiian Islands: a synthesis of available information to facilitate evaluation of stock structure. Document PSRG-2013-16 presented to the Pacific Scientific Review Group, Del Mar, April 2013.

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Shaff, J.F., and R.W. Baird. 2021. Diel and lunar variation in diving behavior of rough-toothed dolphins (Steno bredanensis) off Kaua‘i, Hawai‘i. Marine Mammal Science, doi:10.1111/mms.12811

Worton, B.J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:164-168

Yano, K.M., E.M. Oleson, J.L. Keating, L.T. Ballance, M.C. Hill, A.L. Bradford, A.N. Allen, T.W. Joyce, J.E. Moore, and A. Henry. 2018. Cetacean and seabird data collected during the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS), July-December 2017. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TM-NMFS-PIFSC-72, 110 p. doi:10.25923/7avn-gw82

Yano, K.M., E.M. Olesn, J.L.K. McCullough, M.C. Hill, and A.E. Henry. 2020. Cetacean and seabird data collected during the winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey (Winter HICEAS), January-March 2020. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-111, 72 p. doi:10.25923/ehfg-dp78

Supplementary Description 6. 28. Rough-toothed dolphin small and resident pop.

Species name: Rough-toothed dolphin (*Steno bredanensis*)

Descriptive name: Maui Nui-Hawai'i Island

BIA type: Small and Resident Pop.

BIA label: S-BIA1-s-b2-HI016-0

Transboundary across: None

Hierarchy: Non-hierarchical; single BIA

Importance score: 1 (Intensity: 1, Data support: 2)

Intensity matrix: Abundance: 1, Range: 1

Supporting notes for intensity score: This population has not been formally recognized as a stock within the Hawaiian EEZ, and there is no specific abundance estimate for the Hawaiʻi Island rough-toothed dolphin population. The latest abundance estimate for the entire Hawaiʻi stock of rough-toothed dolphins, derived from a line-transect survey within the US Hawaiian EEZ conducted in 2017, was 76,375 (CV = 0.41; Bradford et al., 2021). The most recent estimate for rough-toothed dolphins associated with Hawaiʻi Island was reported by Baird et al., (2008) at 198 (CV = 0.12), based on photo-identification data collected between 2003 and 2006. This estimate did not account for unmarked animals, and thus likely underestimates total population size, although the proportion of individuals within groups that were considered "distinctive" was high (median=100%; Baird et al., 2008). Photo-identification efforts for this species have continued and as of May 2021, the photo-identification catalog for this species includes 748 slightly distinctive, distinctive, or very distinctive individuals (from fair-, good-, or excellent-quality photographs) encountered off Hawaiʻi Island and/or Maui Nui (CRC unpublished) between 2003 and 2020. Given the long-time span this includes, it is likely that several hundred individuals have died or been born into the population during this period, and thus the raw number from the photo-ID catalog should not be considered an abundance estimate. For this assessment we assumed the population is within the 501-2,000 category of the BIA Intensity scoring criteria (abundance score = 1), although it is also possible that the population size is less than 500 individuals, given the Baird et al. (2008) estimate. The size of the MCP representing the BIA is 15,112 km2 (range size score = 1).

Although we cannot provide a recent abundance estimate specific to this population, the total number of distinct identified individuals, based on a long-term photo-ID catalog curated from both CRC survey effort and contributed sightings, falls in the (1) category. It is possible that the true population size falls on the lower end of this category (i.e., closer to 500 or fewer) considering the time span CRC's catalog covers relative to the life history of this species. The overall range is fairly broad considering documented movements (albeit rare) between Hawaiʻi Island and Maui Nui. Although only one satellite tag has been deployed on a rough-toothed dolphin off Hawaiʻi Island, this individual remained off the leeward side of the island using areas with high density of sightings from CRC small boat survey efforts.

Supporting notes for data support score: Data Support score = 2.

- This population has been studied for 20 years by CRC through small boat survey efforts (2002-2021). Additional sightings documented by NMFS in nine of 10 survey years were also included. Contributed photos from other researchers and community scientists span a period of 35 years (1986-2020).
- A total of 213 sightings from CRC effort, 16 encounters from NMFS shipboard line-transect effort, 67 encounters from non-CRC contributors, with re-sightings off up to 17 years (2003 to 2020)
- Genetic differentiation from KNO population
- Documented movements (based on photo-ID data) between Hawaiʻi Island and Maui Nui by both known Hawaiʻi Island residents and Maui Nui groups.
- Little information available on occurrence and site fidelity of rough-toothed dolphins off Maui Nui (longest resighting period only 3 years), and their association (or lack thereof) with Hawaiʻi Island residents
- One satellite tag deployment (93 filtered Argos locations) that transmitted 7.5 days and moved within the revised BIA boundary, used areas with high concentrations of sightings
- Tag positional uncertainty and irregularity accounted for through crawl model, and boundary encompasses all of crawl standard error (68% confidence interval) ellipses

Despite longevity and variety of information available on this population, no recent abundance estimates specific to this population are available, and the boundary includes a large area where there are no data points (sightings, satellite tag locations) to add support, but the spatial extent is supported by the MCP methods. However, given the handful of documented inter-island movements based on photographic data and lack of survey effort in waters offshore and between island areas due to typically poor working conditions, rough-toothed dolphins may be present in this area more frequently than we have been able to observe. Additional satellite tag deployments would help further understanding of their spatial use off Hawaiʻi Island, and particularly any movements between this island and Maui Nui.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: This population is resident to this area year-round and no information (from available data) suggests the area is used dynamically or ephemerally.

Boundary certainty: 2

Supporting notes for boundary certainty: We have intermediate confidence in Boundary Certainty for the S-BIA for Maui Nui-Hawaiʻi Island rough-toothed dolphins. The boundary encompasses all sighting locations of known or suspected resident rough-toothed dolphins (where identification photographs were available) and positional uncertainty was accounted for (at least attempted) in satellite tag data. Aside from the portion of the boundary extending from north Hawaiʻi Island to Maui Nui, the distribution of sighting and crawl locations is fairly well distributed off west Hawaiʻi Island. However, as noted earlier, these animals may frequent areas off the windward sides of the island, between islands (inter-island movements), or deeper waters where survey efforts have been limited.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): N

# of tags: 1

# of years in which supporting tagging data collected: 1 (2018)

Supporting information: One satellite tag was deployed on a rough-toothed dolphin during a dedicated survey effort off Hawaiʻi Island in 2018. Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk model via the crawl package in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 1-hour interval.

Visual observations/records supporting designation (Y/N): N

# of observations/records: 229

# of years in which supporting visual data collected: 20 (2002-2021)

Supporting information: Sighting data used in this assessment were collected from both non-systematic, dedicated small boat surveys conducted every year off Hawaiʻi Island from 2002-2021 and off Maui Nui in nine years from 2000-2020 by CRC (see Baird et al., 2013b for details on surveys) and ship-based line-transect cetacean surveys conducted by NMFS throughout the Hawaiian Archipelago in 11 years (sightings in nine of 11 survey years) between 2002-2020 (see Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020 for details on surveys). CRC surveys off Hawaiʻi Island and Maui Nui total 114,230 km of effort with 215 sightings of rough-toothed dolphins, and NMFS surveys around Hawaiʻi Island (near and offshore, as mapped in manuscript supplementary material) total to 8,636 km of effort with 26 sightings of rough-toothed dolphins. Two CRC sightings and two NMFS sightings (three offshore, one south Molokaʻi) were excluded from the BIA boundary determination process as these individuals have only been seen once or twice and were not associated with known Hawaiʻi Island resident rough-toothed dolphins (CRC unpublished). An additional eight offshore NMFS sightings were excluded from this process as photographs of the individuals encountered were not yet processed through CRC's photo-identification catalog; thus, the population assignment (i.e., resident or not) for these individuals remains uncertain at this time (CRC unpublished). This combined with known limited movements supported by photo-identification suggests that large-scale, offshore movements are unlikely to occur. The final sample size for sighting locations was 229. In addition, other researchers and community science photographic and sightings contributions have added substantially to the information available on this population, yielding an additional 67 sightings off Hawaiʻi Island and Maui Nui over a period of 35 years (1986-2020) and comprising over 25% of all identifications in CRC's photo-identification catalog of MAHI rough-toothed dolphins (CRC unpublished). Individuals have been resighted off Hawaiʻi Island for timespans of up to 17 years (2003-2020) and Maui Nui (Lānaʻi) for timespans up to 3 years (2008-2011). While community science contributions rarely come with associated latitude and longitude to include in the boundary delineation process (typically only general island or regional locality is provided), in this assessment we use the information on social structure and relative abundance that these photographic contributions have supported.

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): N

# of individuals photographed: 748

# of years of photo records to compare: 18 (2003-2020)

Maximum # of years same individual photographed in area: 17 (2003-2020)

Supporting information: Individuals have been resighted off Hawaiʻi Island for timespans of up to 17 years (2003-2020) and Maui Nui (Lanaʻi) for timespans up to 3 years (2008-2011).). Photo-identification efforts for this species have continued and as of May 2021, the photo-identification catalog for this species includes 748 slightly distinctive, distinctive, or very distinctive individuals (from fair-, good-, or excellent-quality photographs) encountered off Hawaiʻi Island and/or Maui Nui (CRC unpublished) between 2003 and 2020.

Genetic analyses conducted supporting designation (Y/N): N

Weak/moderate/strong support for genetic differentiation: Strong

Nature of supporting information: Strong

Supporting information: Genetic analysis of biopsy samples collected from rough-toothed dolphins revealed no significant differences in mtDNA or nuclear DNA for individuals off Kauaʻi/Niʻihau versus off Oʻahu (Albertson et al., 2016), but did reveal differentiation from individuals sampled off Hawaiʻi Island.

What factors justify the boundary selection?: Baird et al. (2015) delineated a BIA for Hawaiʻi Island rough-toothed dolphins based on sighting data collected from dedicated small boat survey efforts. In this assessment, we revised the BIA boundary from Baird et al., (2015) using additional sightings and information from one satellite tag deployment since the 2015 study. In addition, we extended the revised boundary to encompass sightings off Maui Nui that document movements between this island area and Hawaiʻi Island based on photographic data.

The basis for the BIA was a minimum convex polygon (MCP) around all sighting and satellite tag derived crawl locations, with the inner (shoreward) boundary defined by the 300-m isobath (based on the shallowest sighting from survey effort at 395 m). The MCP encompassed all crawl locations and associated standard error (i.e., 68% confidence interval) error ellipses; therefore, nothing was added to the MCP to account for crawl-predicted error as done for other BIA accounts. The resulting area of the BIA (i.e., population range size) is 15,112 km2.

Data sources: Cascadia Research Collective (unpub. data, 2002-2021); National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020; accessed 2021); Albertson et al., 2016; Baird et al., 2008, 2013; Barlow 2006; Bradford 2017; Yano et al., 2018, 2020

Approximate % of population that uses this area for the designated purpose (if known): 100

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Albertson, G.R., R.W. Baird, M. Oremus, M.M. Poole, K.K. Martien, and C.S. Baker. 2016. Staying close to home? Genetic differentiation of rough-toothed dolphins near oceanic islands in the central Pacific Ocean. Conservation Genetics 18:33-51 doi:10.1007/s10592-016-0880-z

Baird, R.W., D.L. Webster, S.D. Mahaffy, D.J. McSweeny, G.S. Schorr, and A.D. Ligon. 2008. Site fidelity and association patterns in a deep-water dolphin: Rough-toothed dolphins (Steno bredanensis) in the Hawaiian Archipelago. Marine Mammal Science 24(3):535-553

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Baird, R.W., D.L. Webster, S.M. Jarvis, E.E. Henderson, S.L. Watwood, S.D. Mahaffy, B.D. Guenther, J.K. Lerma, C.J. Cornforth, A.W. Vanderzee, and D.B. Anderson. 2019. Odontocete studies on the Pacific Missile Range Facility in August 2018: Satellite-tagging, photo-identification, and passive acoustic monitoring. Prepared for Commander, Pacific Fleet, under Contract No. N62470-15-D-8006 Task Order 6274218F0107 issued to HDR Inc., Honolulu, HI June 2019.

Baird, R.W., C.J. Cornforth, S.M. Jarvis, N.A. DiMarzio, K. Dolan, E.E. Henderson, S.W. Martin, S.L. Watwood, S.D. Mahaffy, B.D. Guenther, J.K. Lerma, A.E. Harnish, and M.A. Kratofil. 2021. Odontocete studies on the Pacific Missile Range Facility in February 2020: Satellite-tagging, photo-identification, and passive acoustic monitoring. Prepared for Commander, Pacific Fleet, Environmental Readiness Division, Pearl Harbor, HI, under Contract No. N62470-15-D-8006 Task Order N6247015D8006 issued to HDR Inc., Honolulu, HI December 2020.

Barlow, J. 2006. Cetacean abundance in Hawaiian waters estimated from a summer/fall survey in 2002. Marine Mammal Science 22(2):446-464

Bradford, A.L., K.A. Forney, E.M. Oleson, and J. Barlow. 2017. Abundance estimates of cetaceans from a line-transect survey within the U.S. Hawaiian Islands Exclusive Economic Zone. Fishery Bulletin 115:129-142

Bradford, A.L., E.M. Oleson, K.A. Forney, J.E. Moore, and J. Barlow. 2021. Line-transect abundance estimates of cetaceans in U.S. waters around the Hawaiian Islands in 2002, 2010, and 2017. U.S. Dept. of Commerce, NOAA Technical Memorandum NMFS-PIFSC-115, 52 p. doi:10.25923/daz4-kw84

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

Oleson, E.M., R.W. Baird, K.K. Martien, and B.L. Taylor. 2013. Island-associated stocks of odontocetes in the main Hawaiian Islands: a synthesis of available information to facilitate evaluation of stock structure. Document PSRG-2013-16 presented to the Pacific Scientific Review Group, Del Mar, April 2013.

Yano, K.M., E.M. Oleson, J.L. Keating, L.T. Ballance, M.C. Hill, A.L. Bradford, A.N. Allen, T.W. Joyce, J.E. Moore, and A. Henry. 2018. Cetacean and seabird data collected during the Hawaiian Islands Cetacean and Ecosystem Assessment Survey (HICEAS), July-December 2017. U.S. Department of Commerce, NOAA Technical Memorandum, NOAA-TM-NMFS-PIFSC-72, 110 p. doi:10.25923/7avn-gw82

Yano, K.M., E.M. Olesn, J.L.K. McCullough, M.C. Hill, and A.E. Henry. 2020. Cetacean and seabird data collected during the winter Hawaiian Islands Cetacean and Ecosystem Assessment Survey (Winter HICEAS), January-March 2020. U.S. Department of Commerce, NOAA Technical Memorandum NOAA-TM-NMFS-PIFSC-111, 72 p. doi:10.25923/ehfg-dp78

Supplementary Description 6. 29. Short-finned pilot whale small and resident pop.

Species name: Short-finned pilot whale (*Globicephala macrorhynchus*)

Descriptive name: Main Hawaiian Islands - Parent

BIA type: Small and Resident Pop.

BIA label: S-BIA1-s-b3-HI030-0abc

Transboundary across: None

Hierarchy: Hierarchical BIA; Parent of children abc

Importance score: 1 (Intensity: 1, Data support: 3)

Intensity matrix: Abundance: 1, Range: 1

Supporting notes for intensity score: The most recent abundance estimate for short-finned pilot whales within Hawaiian waters is 12,607 individuals (CV=0.18), based on sightings from a line-transect survey conducted throughout the Hawaiian archipelago in 2017 (Bradford et al., 2021). However, this estimate includes individuals throughout the entire EEZ, and thus is not specific to the insular population we are delineating a BIA for herein. The number of distinct individuals (known or suspected to belong to the insular population) in CRC's photo-ID catalog is 1,725 (CRC unpublished). Considering the span of years that the photo-ID catalog covers (2000-2021) and the number of births/deaths that likely occurred during that period, we assume this population numbers around 2,000 individuals, although it could be larger considering information gaps in the western and central communities (CRC unpublished). Therefore, for this assessment we will assign an abundance score of 1 (501-2,000 individuals). The size of the polygon representing the parent BIA is 58,999 km2 (range size score =1).

No abundance estimate specific to this insular population is available. However, based on CRC's long-term photo-identification catalog, curated from both dedicated small boat survey efforts conducted over 22 years (over 800 sightings) and over 500 contributed sightings from other researchers and community scientists, we deem it reasonable to assume the MHI population is around 2,000 individuals (CRC unpublished). We have high confidence that this population is resident to the main Hawaiian Islands region based on both resighting information and movements from satellite tag data (Mahaffy et al., 2015; Baird, 2016). Most satellite tag deployments used to inform the parent BIA boundary transmitted for at least a month, and they were deployed during different years and seasons and tagged individuals generally displayed similar habitat use (shelf/slope waters) with some inter-island movements and only rare offshore excursions.

Supporting notes for data support score: We assigned a Data Support score of 3 for the parent BIA based on the following:

- This population has been studied for 22 years (2000-2021), although not surveyed every year and primarily through small boat surveys. Additional photographic data supplied by other researchers and community science contributions span a 22-year period (2000-2021).
- A total of 823 sightings from CRC effort, 13 sightings from NMFS ship-based line-transect surveys, 571 encounters from other researchers and community scientists since 2000, with re-sightings of individuals up to 18 years (2003-2020, on 79 separate occasions) and up to 109 separate times (over 15-year span, 2005-2019)
- 128 satellite tag deployments (30,374 filtered Argos locations) transmitting for up to ~200 days (median = 29 days), all of which generally showed similar habitat use around island areas (nearshore, shelf/slope waters) with some individuals moving among island areas and in very few instances, farther offshore before returning back to nearshore waters
- Boundary informed by well-established and widely used kernel density methods
- Tag positional uncertainty and irregularity accounted for through crawl model

The existence of this small and resident population insular to the main Hawaiian Islands is supported by long-term studies on sightings and photo-identification (Mahaffy et al., 2015), movements from satellite tag deployments (Abeccassis et al., 2015; Baird, 2016), and genetic structure (Van Cise et al., 2017). Although there is no abundance estimate available specific to this insular population, CRC's long-term photo-identification catalog indicates that this population is small and resident and likely is at the higher end of the criteria used in this assessment (CRC unpublished). The boundary and range size are supported by movements from over 100 satellite tag deployments collected over the past 16 years, with tags transmitting a month on average.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: While variation in fine-scale foraging habits over lunar cycles has been identified (Owen et al., 2019), such variation occurs over a very short time scale during the lunar cycle and does not result in complete abandonment of suitable habitat or foraging effort. Therefore, we assign the spatiotemporal variability indicator for this parent BIA as static.

Boundary certainty: 3

Supporting notes for boundary certainty: We have high confidence in the boundary certainty for the insular short-finned pilot whale parent BIA. This boundary encompasses their known range based on movements collected from 128 satellite tag deployments (108 individuals, 2006-2021), about half of which transmitted for over a month. Although some tagged whales have moved outside of the range depicted by this BIA, these individuals reflect a very small proportion of the population, and the quality and quantity of data supporting their insular habitat use suggests that such movements were anomalous. Positional uncertainty was accounted for in satellite tag data through the use of state-space models (crawl). Additionally, short-finned pilot whales around the islands have a unimodal distribution of sightings in relation to depth with the peak between 1,000 and 2,500 m depth (Baird et al. 2013), which is further supported by analyses of foraging hotspots for satellite tagged pilot whales off Hawaiʻi Island (Abecassis et al., 2015).

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 128

# of years in which supporting tagging data collected: 16 (2006-2021)

Supporting information: Location data from satellite tags were available for 128 deployments on short-finned pilot whales thought or known to be from one of the insular communities, from 2006-2021 (Baird, 2016). Individuals were assigned to the insular population and respective communities based on sighting histories and movements from satellite tag data (see Mahaffy et al. 2015; Baird 2016). Detailed methods on satellite tag data processing methods are provided as supplementary material with the manuscript. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk model using the package crawl implemented in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 4-hour interval and locations on land were re-routed around a polygon representing the 300-m isobath using the pathroutr package (London, 2020). Crawl locations interpolated over periods spanning 1 or more days without any underlying Argos locations were removed.

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 836

# of years in which supporting visual data collected: 21 (2000-2021)

Supporting information: Sighting and photographic data were collected from CRC non-systematic, dedicated small boat surveys conducted throughout the main Hawaiian Islands (MHI) from 2000-2021 (see Baird et al., 2013 for details on surveys). Surveys off these islands combined total 148,080 km of effort with a total of 837 short-finned pilot whale sightings (groups), 14 of which were of known or suspected to belong to a pelagic population and thus were not considered in this assessment (final CRC sample size = 823 sightings of MHI short-finned pilot whales). In addition, photos taken by other researchers during localized research efforts (e.g., Pacific Whale Foundation off Maui Nui, Dan McSweeney off Hawaiʻi Island) or during large-scale ship surveys (e.g., NMFS cruises), and community science contributions total to an additional 571 encounters with individuals from this population since 2000 (22-year span). Contributed encounters comprise over 40% of all MHI short-finned pilot whale identifications in CRC's photo-identification catalog. Ship-based line-transect surveys were undertaken by NMFS through the Hawaiian Archipelago in eleven years between 2002 and 2020; of the 89 short-finned pilot whale sightings within the MHI region from these surveys, 13 sightings were of individuals with confirmed photographic assignment to the insular MHI population. Population assignment of individuals from the remaining 76 NMFS sightings was either to a pelagic population or is currently unknown.

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 1725

# of years of photo records to compare: 20 (2000-2021)

Maximum # of years same individual photographed in area: 17 (2003-2020)

Supporting information: Short-finned pilot whales photo-identified during small boat survey efforts have been resighted on up to 109 separate occasions (over a span of 15 years) and across a maximum of 18 years (on 79 separate occasions; CRC unpublished). Movements from over 100 satellite-tagged whales also support fidelity to insular waters of the main Hawaiian Islands (Baird, 2016). Additionally, genetics, satellite tagging, and photo-identification data suggest the existence of three overlapping regional communities of short-finned pilot whales around the main Hawaiian Islands that are largely socially isolated: a western community which generally ranges from Niʻihau to Oʻahu, a central community from Oʻahu to Kahoʻolawe, and an eastern community centered around Hawaiʻi Island (Baird, 2016; Van Cise et al., 2017, CRC unpublished). A total of 810 sightings from CRC effort, 571 encounters from other researchers and community scientists since 2000, with re-sightings of individuals up to 18 years (2003-2020, on 79 separate occasions) and up to 109 separate times (over 15-year span, 2005-2019). The number of distinct individuals (known or suspected to belong to the insular population) in CRC's photo-ID catalog is 1,725 (CRC unpublished).

Genetic analyses conducted supporting designation (Y/N): Y

Weak/moderate/strong support for genetic differentiation: Preliminary

Nature of supporting information: Strong

Supporting information: Genetic analyses support the existence of an insular population (Van Cise et al., 2017).

What factors justify the boundary selection?: Baird et al. (2015) delineated a single BIA for short-finned pilot whales associated with Hawaiʻi Island based on high density areas identified from available satellite tag deployments, effectively the eastern community's core range. Additional sighting, photographic, and satellite tag data collected since the original 2015 study have been used to revise the BIA boundary in this assessment, extending the boundary to encompass not just Hawaiʻi Island but the entire known range of insular short-finned pilot whales (Kauaʻi to Hawaiʻi Island; hereafter, MHI short-finned pilot whales). Hierarchical BIAs have been delineated for this population based on the core ranges of regional communities of pilot whales (western, eastern, central), inferred from both photographic and satellite tag data.

The basis for the parent BIA was a 95% contour of the utilization distribution (UD) estimated through kernel density analysis of crawl locations (methods detailed below). Our intention with this approach was to capture the primary range of this population while excluding occasional offshore movements exhibited by a small proportion of tagged individuals. Considering the quantity (128 deployments over a 16-year span) and quality (typically a month of data from each tag) of our supporting data, we feel it is reasonable to assume that these excursions are not representative of the population's typical range and thus should be excluded from the parent BIA boundary. The inner (shoreward) boundary was defined as the 300-m isobath based on the shallowest sighting off these island areas from CRC dedicated survey efforts (shallowest sighting = 380 m deep). All sighting locations were encompassed by the parent BIA boundary. The resulting area of the parent BIA (i.e., population range size) is 58,999 km2.

Kernel density analysis

We used kernel density estimation (KDE) to generate a UD of the sample population (Worton, 1989) and used a 95% isopleth of the UD to represent the primary range of the population for the parent BIA. Prior to kernel density analyses, crawl positions during periods of large transmission gaps were removed from each individual's track (where applicable) such to avoid generation of artificially "dense" areas resulting from interpolation over long periods without any original Argos data; a 1-day gap threshold was used (i.e., interpolated crawl points removed during periods where Argos locations did not transmit for 1 or more days apart). Further, one of each pair of tagged individuals that acted in concert was removed (to reduce pseudoreplication; final analytical sample size = 93 tags with 18,243 4-hour crawl locations). All tag locations were pooled together, and the contribution of each tag's location was weighted to the overall kernel density based on deployment length, and the KDE was re-scaled so it integrated to one (Hauser et al., 2014; Hill et al., 2019). As a result, locations from shorter deployments have less weight than those with longer deployments. Kernel densities were estimated using the bivariate plug-in bandwidth (or smoothing parameter) matrix (Duong & Hazelton, 2003, 2005; Duong, 2007) accessed through the ks package for R (Duong, 2021). The location weighting was completed using the weights argument within the ks package (Duong, 2021).

Data sources: Cascadia Research Collective (unpub. data, 2000-2021); National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020; accessed 2021); Abecassis et al., 2015; Baird et al., 2013, 2015; Bradford et al., 2021; Mahaffy et al., 2015; Oleson et al., 2013; Van Cise et al., 2017

Approximate % of population that uses this area for the designated purpose (if known): 100

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Abecassis, M., J. Polovina, R.W. Baird, A. Copeland, J.C. Drazen, R. Domokos, E. Oleson, Y. Jia, G.S. Schorr, D.L. Webster, and R.D. Andrews. 2015. Characterizing a foraging hotspot for short-finned pilot whales and Blainville's beaked whales located off the west side of Hawaiʻi Island by using tagging and oceanographic data. PLoS ONE 10(11):e0142628 doi:10.13371/journal.pone.0142628

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Bradford, A.L., E.M. Oleson, K.A. Forney, J.E. Moore, and J. Barlow. 2021 Line-transect abundance estimates of cetaceans in U.S. waters around the Hawaiian Islands in 2002, 2010, and 2017. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-PIFSC-115, 52pp. doi:10.25923/daz4-kw84

Caretta, J.V., E.M. Oleson, K.A. Forney, M.M. Muto, D.W. Weller, A.R. Lang, J. Baker, B. Hanson, A.J. Orr, J. Barlow, J.E. Moore, and R.L. Brownell Jr. 2021. U.S. Pacific Marine Mammal Stock Assessments: 2020. U.S. Department of Commerce, NOAA.

Duong, T., and M.L. Hazelton. 2003. Plug-in bandwidth matrices for bivariate kernel density estimation. Journal of Nonparametric Statistics 15:17-30.

Duong, T., and M.L. Hazelton. 2005. Cross-validation bandwidth matrices for multivariate kernel density estimation. Scandinavian Journal of Statistics 32:485-506.

Duong, T. 2007. Ks: Kernel density estimation and kernel discriminant analysis for multivariate data in R. Journal of Statistical Software 21:1-16.

Duong, T. 2021. Ks: Kernel smoothing. R package version 1.12.0 https://CRAN.R-project.org/package=ks

Hauser, D.D.W., K.L. Laidre, R.S. Suydam, and P.R. Richard. 2014. Population-specific home ranges and migration timing of Pacific Arctic beluga whales (Delphinapterus leucas). Polar Biology 37:1171-1183

Hill, M.C., A.R. Bendlin, A.M. Van Cise, A. Milette-Winfree, A.D., Ligon, A.C. Ü, M.H. Deakos, and E.M. Oleson. 2019. Short-finned pilot whales (Globicephala macrorhynchus) of the Mariana Archipelago: individual affiliations, movements, and spatial use. Marine Mammal Science 35(3):797-824 doi:10.1111/mms.12567

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Mahaffy, S.D., R.W. Baird, D.J. McSweeney, D.L. Webster, and G.S. Schorr. 2015. High site fidelity, strong associations, and long-term bonds: Short-finned pilot whales off the island of Hawaiʻi. Marine Mammal Science 31(4):1427-1451 doi:10.1111/mms.12234

Oleson, E.M., R.W. Baird, K.K. Martien, and B.L. Taylor. 2013. Island-associated stocks of odontocetes in the main Hawaiian Islands: a synthesis of available information to facilitate evaluation of stock structure. Document PSRG-2013-16 presented to the Pacific Scientific Review Group, Del Mar, April 2013.

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Van Cise, A.M., K.K. Martien, S.D. Mahaffy, R.W. Baird, D.L. Webster, J.H. Fowler, E.M. Oleson, and P.A. Morin. 2017. Familial social structure and socially driven genetic differentiation in Hawaiian short-finned pilot whales. Molecular Ecology 00:1-12 doi:10.1111/mec.14397

Worton, B.J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:164-168

Supplementary Description 6. 30. Short-finned pilot whale small and resident pop.

Species name: Short-finned pilot whale (*Globicephala macrorhynchus*)

Descriptive name: Main Hawaiian Islands - Child (Central Community Core Range)

BIA type: Small and Resident Pop.

BIA label: S-BIA3-s-b3-HI030-b

Transboundary across: None

Hierarchy: Hierarchical BIA; Child b

Importance score: 3 (Intensity: 3, Data support: 3)

Intensity matrix: Abundance: 3, Range: 3

Supporting notes for intensity score: The child BIAs for MHI short-finned pilot whales described here represent intensified use relative to the broader parent BIA, and account for varying spatial use by community. As such, it is appropriate here to score the child BIA the highest intensity score (3; proportion of broader insular population contained within core ranges is smaller and size of core areas much smaller than the population range described by the parent BIA). This child BIA also overlaps with concentrations of sightings and was identified by tag data where small boat survey effort coverage has been limited due to typically poor working conditions. The area of this child BIA is 2,427 km2.

Based on the number of distinct individuals in CRC's photo-identification catalog, the eastern community of short-finned pilot whales is likely larger than that of either the western or central communities (CRC unpublished). Therefore, we estimate that the central core range contains 25% of the MHI population, although recognize that there is uncertainty associated with this estimate.

Supporting notes for data support score: The child BIA described here was drawn using satellite tag data from 13 groups of tagged short-finned pilot whales, accounting for bias associated with varying deployment durations (KDE weighted by tag duration) and pseudoreplication (i.e., pairs of animals tagged together and acting in concert) for core range analysis, using a widely used approach for estimating core range (KDEs). Location data were collected over a period of 16 years and extend to areas where small boat survey efforts have been precluded due to typically poor working conditions.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: While variation in fine-scale foraging habits over lunar cycles has been identified (Owen et al., 2019), such variation occurs over a very short time scale during the lunar cycle and does not result in complete abandonment of suitable habitat or foraging effort. Therefore, we assign the spatiotemporal variability indicator for this BIA as static.

Boundary certainty: 3

Supporting notes for boundary certainty: We have high confidence in the boundary certainty for each short-finned pilot whale community child BIA, given the quantity and quality of both sighting and satellite tag data that were used to inform these boundaries. Although there are some caveats that come with kernel density analysis, estimated core ranges overlap with concentrations of sightings and satellite tag data and were used by all tagged individuals (by community), deployed during different years, seasons, etc. As noted above, we attempted to account for some potential sources of bias in this analysis, such as those that may arise from tag deployment locality (mitigated through weighting by deployment duration) and pseudoreplication (removal of one track per pseudoreplicate pair).

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 13

# of years in which supporting tagging data collected: 5 (2010-2017)

Supporting information: Location data from satellite tags were available for 18 deployments (13 excluding pseudoreplicates) on short-finned pilot whales thought or known to be from the Central community, from 2010-2017 (Baird, 2016). Individuals were assigned to the insular population and respective communities based on sighting histories and movements from satellite tag data (see Mahaffy et al. 2015; Baird 2016). Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk model using the package crawl implemented in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 4-hour interval and locations on land were re-routed around a polygon representing the 300-m isobath using the pathroutr package (London, 2020).

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 83

# of years in which supporting visual data collected: 9 (2000-2020)

Supporting information: Number of sightings entered here reflect the number of sightings in this particular community. General sightings information: Sighting and photographic data were collected from CRC non-systematic, dedicated small boat surveys conducted throughout the main Hawaiian Islands (MHI) from 2000-2021 (see Baird et al., 2013 for details on surveys). Surveys off these islands combined total 148,080 km of effort with a total of 837 short-finned pilot whale sightings (groups), 14 of which were of known or suspected to belong to a pelagic population and thus were not considered in this assessment (final sample size = 823 sightings of MHI short-finned pilot whales). In addition, photos taken by other researchers during localized research efforts (e.g., Pacific Whale Foundation off Maui Nui, Dan McSweeney off Hawaiʻi Island) or during large-scale ship surveys (e.g., NMFS cruises), and community science contributions total to an additional 571 encounters with individuals from this population since 2000 (22-year span). Contributed encounters comprise over 40% of all MHI short-finned pilot whale identifications in CRC's photo-identification catalog. Ship-based line-transect surveys were undertaken by NMFS through the Hawaiian Archipelago in 11 years between 2002 and 2020; of the 89 short-finned pilot whale sightings within the MHI region from these surveys, 13 sightings were of individuals with confirmed photographic assignment to the insular MHI population. Population assignment of individuals from the remaining 76 NMFS sightings was either to a pelagic population or is currently unknown.

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 1725

# of years of photo records to compare: 20 (2000-2021)

Maximum # of years same individual photographed in area: 17 (2003-2020)

Supporting information: Short-finned pilot whales photo-identified during small boat survey efforts have been resighted on up to 109 separate occasions (over a span of 15 years) and across a maximum of 18 years (on 79 separate occasions; CRC unpublished). Movements from over 100 satellite-tagged whales also support fidelity to insular waters of the main Hawaiian Islands (Baird, 2016). Additionally, genetics, satellite tagging, and photo-identification data suggest the existence of three overlapping regional communities of short-finned pilot whales around the main Hawaiian Islands that are largely socially isolated: a western community which generally ranges from Niʻihau to Oʻahu, a central community from Oʻahu to Kahoʻolawe, and an eastern community centered around Hawaiʻi Island (Baird, 2016; Van Cise et al., 2017, CRC unpublished). A total of 810 sightings from CRC effort, 571 encounters from other researchers and community scientists since 2000, with re-sightings of individuals up to 18 years (2003-2020, on 79 separate occasions) and up to 109 separate times (over 15-year span, 2005-2019). The number of distinct individuals (known or suspected to belong to the insular population) in CRC's photo-ID catalog is 1,725 (CRC unpublished).

Genetic analyses conducted supporting designation (Y/N): Y

Nature of supporting information: Strong

Supporting information: Only a single stock of short-finned pilot whale is recognized in Hawaiian waters (Caretta et al., 2021), but long-term re-sightings of individuals, movements from satellite tag deployments, and genetic analyses all support the existence of an insular population (Baird 2016; Mahaffy et al., 2015; Oleson et al., 2013; Van Cise et al. 2017). Additionally, all three lines of evidence suggest the existence of three overlapping insular communities of short-finned pilot whales around the main Hawaiian Islands that are largely socially isolated: a western community which generally ranges from Niʻihau to Oʻahu, a central community from Oʻahu to Kahoʻolawe, and an eastern community centered around Hawaiʻi Island (Baird 2016; Van Cise et al. 2017, CRC unpublished).

What factors justify the boundary selection?: Rather than attempt to describe the primary range of each short-finned pilot whale insular community (western, central, eastern), we delineated child BIAs with the intent to represent the core range (i.e., high-intensity areas) for each community relative to the overall range of the insular population. We applied the same kernel density analysis procedure used to derive the parent BIA. A UD was estimated for each community (locations pooled and weighted by community) and a 50% isopleth of the UD was used to represent the core range of each community.

Kernel density analysis
We used kernel density estimation (KDE) to generate a UD of the sample population (Worton, 1989) and used a 95% isopleth of the UD to represent the primary range of the population for the parent BIA. Prior to kernel density analyses, crawl positions during periods of large transmission gaps were removed from each individual's track (where applicable) such to avoid generation of artificially "dense" areas resulting from interpolation over long periods without any original Argos data; a 1-day gap threshold was used (i.e., interpolated crawl points removed during periods where Argos locations did not transmit for 1 or more days apart). Further, one of each pair of tagged individuals that acted in concert was removed (to reduce pseudoreplication). All tag locations were pooled together, and the contribution of each tag's location was weighted to the overall kernel density based on deployment length, and the KDE was re-scaled so it integrated to one (Hauser et al., 2014; Hill et al., 2019), such that locations from shorter deployments would have less weight than those with longer deployments. Kernel densities were estimated using the bivariate plug-in bandwidth (or smoothing parameter) matrix (Duong & Hazelton, 2003, 2005; Duong, 2007) accessed through the ks package for R (Duong, 2021). The location weighting was completed using the weights argument within the ks package (Duong, 2021).

Data sources: Cascadia Research Collective (unpub. data, 2000-2021); National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020; accessed 2021); Abecassis et al., 2015; Baird et al., 2013, 2015; Bradford et al., 2021; Mahaffy et al., 2015; Oleson et al., 2013; Van Cise et al., 2017

Approximate % of population that uses this area for the designated purpose (if known): 25

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Abecassis, M., J. Polovina, R.W. Baird, A. Copeland, J.C. Drazen, R. Domokos, E. Oleson, Y. Jia, G.S. Schorr, D.L. Webster, and R.D. Andrews. 2015. Characterizing a foraging hotspot for short-finned pilot whales and Blainville's beaked whales located off the west side of Hawaiʻi Island by using tagging and oceanographic data. PLoS ONE 10(11):e0142628 doi:10.13371/journal.pone.0142628

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Bradford, A.L., E.M. Oleson, K.A. Forney, J.E. Moore, and J. Barlow. 2021 Line-transect abundance estimates of cetaceans in U.S. waters around the Hawaiian Islands in 2002, 2010, and 2017. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-PIFSC-115, 52pp. doi:10.25923/daz4-kw84

Caretta, J.V., E.M. Oleson, K.A. Forney, M.M. Muto, D.W. Weller, A.R. Lang, J. Baker, B. Hanson, A.J. Orr, J. Barlow, J.E. Moore, and R.L. Brownell Jr. 2021. U.S. Pacific Marine Mammal Stock Assessments: 2020. U.S. Department of Commerce, NOAA.

Duong, T., and M.L. Hazelton. 2003. Plug-in bandwidth matrices for bivariate kernel density estimation. Journal of Nonparametric Statistics 15:17-30.

Duong, T., and M.L. Hazelton. 2005. Cross-validation bandwidth matrices for multivariate kernel density estimation. Scandinavian Journal of Statistics 32:485-506.

Duong, T. 2007. Ks: Kernel density estimation and kernel discriminant analysis for multivariate data in R. Journal of Statistical Software 21:1-16.

Duong, T. 2021. Ks: Kernel smoothing. R package version 1.12.0 https://CRAN.R-project.org/package=ks

Hauser, D.D.W., K.L. Laidre, R.S. Suydam, and P.R. Richard. 2014. Population-specific home ranges and migration timing of Pacific Arctic beluga whales (Delphinapterus leucas). Polar Biology 37:1171-1183

Hill, M.C., A.R. Bendlin, A.M. Van Cise, A. Milette-Winfree, A.D., Ligon, A.C. Ü, M.H. Deakos, and E.M. Oleson. 2019. Short-finned pilot whales (Globicephala macrorhynchus) of the Mariana Archipelago: individual affiliations, movements, and spatial use. Marine Mammal Science 35(3):797-824 doi:10.1111/mms.12567

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Mahaffy, S.D., R.W. Baird, D.J. McSweeney, D.L. Webster, and G.S. Schorr. 2015. High site fidelity, strong associations, and long-term bonds: Short-finned pilot whales off the island of Hawaiʻi. Marine Mammal Science 31(4):1427-1451 doi:10.1111/mms.12234

Oleson, E.M., R.W. Baird, K.K. Martien, and B.L. Taylor. 2013. Island-associated stocks of odontocetes in the main Hawaiian Islands: a synthesis of available information to facilitate evaluation of stock structure. Document PSRG-2013-16 presented to the Pacific Scientific Review Group, Del Mar, April 2013.

Owen, K., R.D. Andrews, R.W. Baird, G.S. Schorr, and D.L. Webster. 2019. Lunar cycles and day length influence the diving behavior and habitat use of short-finned pilot whales around the main Hawaiian Islands. Marine Ecology Press Series 629:193-206 doi:10.3354/meps13123

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Van Cise, A.M., K.K. Martien, S.D. Mahaffy, R.W. Baird, D.L. Webster, J.H. Fowler, E.M. Oleson, and P.A. Morin. 2017. Familial social structure and socially driven genetic differentiation in Hawaiian short-finned pilot whales. Molecular Ecology 00:1-12 doi:10.1111/mec.14397

Worton, B.J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:164-168

Supplementary Description 6. 31. Short-finned pilot whale small and resident pop.

Species name: Short-finned pilot whale (*Globicephala macrorhynchus*)

Descriptive name: Main Hawaiian Islands - Child (Eastern Community Core Range)

BIA type: Small and Resident Pop.

BIA label: S-BIA3-s-b3-HI030-a

Transboundary across: None

Hierarchy: Hierarchical BIA; Child a

Importance score: 3 (Intensity: 3, Data support: 3)

Intensity matrix: Abundance: 3, Range: 2

Supporting notes for intensity score: The child BIAs for MHI short-finned pilot whales described here represent intensified use relative to the broader parent BIA. As such, it is appropriate here to score the child BIAs the highest intensity score of 3 (proportion of population contained within core ranges is smaller and size of core area much smaller than the population range described by the parent BIA). The child BIAs also overlap with concentrations of sightings within each community's range, and for western and central communities, core areas were identified by tag data where small boat survey effort coverage has been limited due to typically poor working conditions. The area of this child BIA is 2,658 km2.

Based on the number of distinct individuals in CRC's photo-identification catalog, the eastern community of short-finned pilot whales is likely larger than that of either the western or central communities (CRC unpublished). Therefore, we estimate that the western, central, and eastern core ranges contain approximately 25%, 25%, and 50% of the MHI population, respectively, although recognize that there is uncertainty associated with these estimates.

Supporting notes for data support score: The child BIA described here was drawn using satellite tag data from 62 groups of tagged short-finned pilot whales, accounting for bias associated with varying deployment durations (density weighted by duration) and pseudoreplication (i.e., pairs of animals tagged together and acting in concert) for core range analysis, using a widely used approach for estimating core range (KDEs). Location data were collected over a period of 16 years and extend to areas where small boat survey efforts have been precluded due to typically poor working conditions. In addition, the child BIA described for the eastern community of short-finned pilot whales agrees with published findings on foraging hotspots for this species off the leeward coast of Hawaiʻi Island (Abecassis et al., 2015).

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: While variation in fine-scale foraging habits over lunar cycles has been identified (Owen et al., 2019), such variation occurs over a very short time scale during the lunar cycle and does not result in complete abandonment of suitable habitat or foraging effort. Therefore, we assign the spatiotemporal variability indicator for this BIA as static.

Boundary certainty: 3

Supporting notes for boundary certainty: We have high confidence in the boundary certainty for each short-finned pilot whale community core BIA, given the quantity and quality of both sighting and satellite tag data that were used to inform these boundaries. Although there are some caveats that come with kernel density analysis, estimated core feeding ranges (represented by child BIAs) overlap with concentrations of sightings and satellite tag data and were used by all tagged individuals (by community), deployed during different years, seasons, etc. As noted above, we attempted to account for some potential sources of bias in this analysis, such as those that may arise from tag deployment locality (mediated through weighting by deployment duration) and pseudoreplication (removal of one track per pseudoreplicate pair).

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 62

# of years in which supporting tagging data collected: 11 (2006-2019)

Supporting information: Location data from satellite tags were available for 86 deployments (62 excluding pseudoreplicates) on short-finned pilot whales thought or known to be from the Eastern community, from 2006-2019 (Baird, 2016). Individuals were assigned to the insular population and respective communities based on sighting histories and movements from satellite tag data (see Mahaffy et al. 2015; Baird 2016). Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk model using the package crawl implemented in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 4-hour interval and locations on land were re-routed around a polygon representing the 300-m isobath using the pathroutr package (London, 2020).

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 698

# of years in which supporting visual data collected: 20 (2002-2021)

Supporting information: Number of sightings entered here reflect the number of sightings in this particular community. General sightings information: Sighting and photographic data were collected from CRC non-systematic, dedicated small boat surveys conducted throughout the main Hawaiian Islands (MHI) from 2000-2021 (see Baird et al., 2013 for details on surveys).

Surveys off these islands combined total 148,080 km of effort with a total of 837 short-finned pilot whale sightings (groups), 14 of which were of known or suspected to belong to a pelagic population and thus were not considered in this assessment (final sample size = 823 sightings of MHI short-finned pilot whales). In addition, photos taken by other researchers during localized research efforts (e.g., Pacific Whale Foundation off Maui Nui, Dan McSweeney off Hawaiʻi Island) or during large-scale ship surveys (e.g., NMFS cruises), and community science contributions total to an additional 571 encounters with individuals from this population since 2000 (22-year span). Contributed encounters comprise over 40% of all MHI short-finned pilot whale identifications in CRC's photo-identification catalog. Ship-based line-transect surveys were undertaken by NMFS through the Hawaiian Archipelago in ten years between 2002 and 2020; of the 89 short-finned pilot whale sightings within the MHI region from these surveys, 13 sightings were of individuals with confirmed photographic assignment to the insular MHI population. Population assignment of individuals from the remaining 76 NMFS sightings was either to a pelagic population or is currently unknown.

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 1725

# of years of photo records to compare: 20 (2000-2021)

Maximum # of years same individual photographed in area: 17 (2003-2020)

Supporting information: Short-finned pilot whales photo-identified during small boat survey efforts have been resighted on up to 109 separate occasions (over a span of 15 years) and across a maximum of 18 years (on 79 separate occasions; CRC unpublished). Movements from over 100 satellite-tagged whales also support fidelity to insular waters of the main Hawaiian Islands (Baird, 2016). Additionally, genetics, satellite tagging, and photo-identification data suggest the existence of three overlapping regional communities of short-finned pilot whales around the main Hawaiian Islands that are largely socially isolated: a western community which generally ranges from Niʻihau to Oʻahu, a central community from Oʻahu to Kahoʻolawe, and an eastern community centered around Hawaiʻi Island (Baird, 2016; Van Cise et al., 2017, CRC unpublished). A total of 810 sightings from CRC effort, 571 encounters from other researchers and community scientists since 2000, with re-sightings of individuals up to 18 years (2003-2020, on 79 separate occasions) and up to 109 separate times (over 15-year span, 2005-2019). The number of distinct individuals (known or suspected to belong to the insular population) in CRC's photo-ID catalog is 1,725 (CRC unpublished).

Genetic analyses conducted supporting designation (Y/N): Y

Nature of supporting information: Strong

Supporting information: Only a single stock of short-finned pilot whale is recognized in Hawaiian waters (Caretta et al., 2021), but long-term re-sightings of individuals, movements from satellite tag deployments, and genetic analyses all support the existence of an insular population (Baird 2016; Mahaffy et al., 2015; Oleson et al., 2013; Van Cise et al. 2017). Additionally, all three lines of evidence suggest the existence of three overlapping insular communities of short-finned pilot whales around the main Hawaiian Islands that are largely socially isolated: a western community which generally ranges from Niʻihau to Oʻahu, a central community from Oʻahu to Kahoʻolawe, and an eastern community centered around Hawaiʻi Island (Baird 2016; Van Cise et al. 2017, CRC unpublished).

What factors justify the boundary selection?: Rather than attempt to describe the primary feeding range of each short-finned pilot whale insular community (western, central, eastern), we delineated child BIAs with the intent to represent the core feeding range (i.e., high-intensity areas) for each community relative to the overall feeding range of the insular population. We applied the same kernel density analysis procedure used to derive the parent BIA. A UD was estimated for each community (locations pooled and weighted by community) and a 50% isopleth of the UD was used to represent the core feeding range of each community.

We used kernel density estimation (KDE) to generate a UD of the sample population (Worton, 1989) and used a 95% isopleth of the UD to represent the primary range of the population for the parent BIA. Prior to kernel density analyses, crawl positions during periods of large transmission gaps were removed from each individual's track (where applicable) such to avoid generation of artificially "dense" areas resulting from interpolation over long periods without any original Argos data; a 1-day gap threshold was used (i.e., interpolated crawl points removed during periods where Argos locations did not transmit for 1 or more days apart). Further, one of each pair of tagged individuals that acted in concert was removed (to reduce pseudoreplication). All tag locations were pooled together, and the contribution of each tag's location was weighted to the overall kernel density based on deployment length, and the KDE was re-scaled so it integrated to one (Hauser et al., 2014; Hill et al., 2019), such that locations from shorter deployments would have less weight than those with longer deployments. Kernel densities were estimated using the bivariate plug-in bandwidth (or smoothing parameter) matrix (Duong & Hazelton, 2003, 2005; Duong, 2007) accessed through the ks package for R (Duong, 2021). The location weighting was completed using the weights argument within the ks package (Duong, 2021).

Data sources: Cascadia Research Collective (unpub. data, 2000-2021); National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020; accessed 2021); Abecassis et al., 2015; Baird et al., 2013, 2015; Bradford et al., 2021; Mahaffy et al., 2015; Oleson et al., 2013; Van Cise et al., 2017

Approximate % of population that uses this area for the designated purpose (if known): 50

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Abecassis, M., J. Polovina, R.W. Baird, A. Copeland, J.C. Drazen, R. Domokos, E. Oleson, Y. Jia, G.S. Schorr, D.L. Webster, and R.D. Andrews. 2015. Characterizing a foraging hotspot for short-finned pilot whales and Blainville's beaked whales located off the west side of Hawaiʻi Island by using tagging and oceanographic data. PLoS ONE 10(11):e0142628 doi:10.13371/journal.pone.0142628

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main

Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Bradford, A.L., E.M. Oleson, K.A. Forney, J.E. Moore, and J. Barlow. 2021 Line-transect abundance estimates of cetaceans in U.S. waters around the Hawaiian Islands in 2002, 2010, and 2017. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-PIFSC-115, 52pp. doi:10.25923/daz4-kw84

Caretta, J.V., E.M. Oleson, K.A. Forney, M.M. Muto, D.W. Weller, A.R. Lang, J. Baker, B. Hanson, A.J. Orr, J. Barlow, J.E. Moore, and R.L. Brownell Jr. 2021. U.S. Pacific Marine Mammal Stock Assessments: 2020. U.S. Department of Commerce, NOAA.

Duong, T., and M.L. Hazelton. 2003. Plug-in bandwidth matrices for bivariate kernel density estimation. Journal of Nonparametric Statistics 15:17-30.

Duong, T., and M.L. Hazelton. 2005. Cross-validation bandwidth matrices for multivariate kernel density estimation. Scandinavian Journal of Statistics 32:485-506.

Duong, T. 2007. Ks: Kernel density estimation and kernel discriminant analysis for multivariate data in R. Journal of Statistical Software 21:1-16.

Duong, T. 2021. Ks: Kernel smoothing. R package version 1.12.0 https://CRAN.R-project.org/package=ks

Hauser, D.D.W., K.L. Laidre, R.S. Suydam, and P.R. Richard. 2014. Population-specific home ranges and migration timing of Pacific Arctic beluga whales (Delphinapterus leucas). Polar Biology 37:1171-1183

Hill, M.C., A.R. Bendlin, A.M. Van Cise, A. Milette-Winfree, A.D., Ligon, A.C. Ü, M.H. Deakos, and E.M. Oleson. 2019. Short-finned pilot whales (Globicephala macrorhynchus) of the Mariana Archipelago: individual affiliations, movements, and spatial use. Marine Mammal Science 35(3):797-824 doi:10.1111/mms.12567

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Mahaffy, S.D., R.W. Baird, D.J. McSweeney, D.L. Webster, and G.S. Schorr. 2015. High site fidelity, strong associations, and long-term bonds: Short-finned pilot whales off the island of Hawaiʻi. Marine Mammal Science 31(4):1427-1451 doi:10.1111/mms.12234

Oleson, E.M., R.W. Baird, K.K. Martien, and B.L. Taylor. 2013. Island-associated stocks of odontocetes in the main Hawaiian Islands: a synthesis of available information to facilitate evaluation of stock structure. Document PSRG-2013-16 presented to the Pacific Scientific Review Group, Del Mar, April 2013.

Owen, K., R.D. Andrews, R.W. Baird, G.S. Schorr, and D.L. Webster. 2019. Lunar cycles and day length influence the diving behavior and habitat use of short-finned pilot whales around the main Hawaiian Islands. Marine Ecology Press Series 629:193-206 doi:10.3354/meps13123

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Van Cise, A.M., K.K. Martien, S.D. Mahaffy, R.W. Baird, D.L. Webster, J.H. Fowler, E.M. Oleson, and P.A. Morin. 2017. Familial social structure and socially driven genetic differentiation in Hawaiian short-finned pilot whales. Molecular Ecology 00:1-12 doi:10.1111/mec.14397

Worton, B.J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:164-168

Supplementary Description 6. 32. Short-finned pilot whale small and resident pop.

Species name: Short-finned pilot whale (*Globicephala macrorhynchus*)

Descriptive name: Main Hawaiian Islands - Child (Western Community Core Range)

BIA type: Small and Resident Pop.

BIA label: S-BIA3-s-b3-HI030-c

Transboundary across: None

Hierarchy: Hierarchical BIA; Child c

Importance score: 3 (Intensity: 3, Data support: 3)

Intensity matrix: Abundance: 3, Range: 3

Supporting notes for intensity score: The child BIAs for MHI short-finned pilot whales described here represent intensified use relative to the broader parent BIA. As such, it is appropriate here to score the child BIAs the highest Intensity score (3; proportion of population contained within core ranges is smaller and size of core area much smaller than the population range described by the parent BIA). The child BIAs also overlap with concentrations of sightings within each community's range, and for western and central communities, child BIAs were identified by tag data where small boat survey effort coverage has been limited due to typically poor working conditions. The area of this child BIA is 4,040 km2.

Based on the number of distinct individuals in CRC's photo-identification catalog, the eastern community of short-finned pilot whales is likely larger than that of either the western or central communities (CRC unpublished). Therefore, we estimate that the western, central, and eastern core ranges contain approximately 25%, 25%, and 50% of the MHI population, respectively, although recognize that there is uncertainty associated with these estimates.

Supporting notes for data support score: The child BIA described here was drawn using satellite tag data from 18 groups of tagged short-finned pilot whales, accounting for bias associated with varying deployment durations and pseudoreplication (i.e., pairs of animals tagged together and acting in concert) for core range analysis, using a widely used approach for estimating core range (KDEs). Location data were collected over a period of 16 years and extend to areas where small boat survey efforts have been precluded due to typically poor working conditions.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: While variation in fine-scale foraging habits over lunar cycles has been identified (Owen et al., 2019), such variation occurs over a very short time scale during the lunar cycle and does not result in complete abandonment of suitable habitat or foraging effort. Therefore, we assign the spatiotemporal variability indicator for this BIA as static.

Boundary certainty: 3

Supporting notes for boundary certainty: We have high confidence in the boundary certainty for each short-finned pilot whale community child BIA, given the quantity and quality of both sighting and satellite tag data that were used to inform these boundaries. Although there are some caveats that come with kernel density analysis, estimated core ranges overlap with concentrations of sightings and satellite tag data and were used by all tagged individuals (by community), deployed during different years, seasons, etc. As noted above, we attempted to account for some potential sources of bias in this analysis, such as those that may arise from tag deployment locality (mitigated through weighting by deployment duration) and pseudoreplication (removal of one track per pseudoreplicate pair).

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): Y

# of tags: 18

# of years in which supporting tagging data collected: 10 (2008-2021)

Supporting information: Location data from satellite tags were available for 24 deployments (18 excluding pseudoreplicates) on short-finned pilot whales thought or known to be from the Western community, from 2008-2021 (Baird, 2016). Individuals were assigned to the insular population and respective communities based on sighting histories and movements from satellite tag data (see Mahaffy et al. 2015; Baird 2016). Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered following CRC's protocol (see supplementary material) and subsequently fit to a continuous-time correlated random walk model using the package crawl implemented in R (Johnson et al., 2008; Johnson and London, 2018; R Core Team, 2021). Crawl fitted models were used to predict locations at a 4-hour interval and locations on land were re-routed around a polygon representing the 300-m isobath using the pathroutr package (London, 2020).

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 72

# of years in which supporting visual data collected: 14 (2003-2021)

Supporting information: Number of sightings entered here reflect the number of sightings in this particular community. General sightings information: Sighting and photographic data were collected from CRC non-systematic, dedicated small boat surveys conducted throughout the main Hawaiian Islands (MHI) from 2000-2021 (see Baird et al., 2013 for details on surveys). Surveys off these islands combined total 148,080 km of effort with a total of 837 short-finned pilot whale sightings (groups), 14 of which were of known or suspected to belong to a pelagic population and thus were not considered in this assessment (final sample size = 823 sightings of MHI short-finned pilot whales). In addition, photos taken by other researchers during localized research efforts (e.g., Pacific Whale Foundation off Maui Nui, Dan McSweeney off Hawaiʻi Island) or during large-scale ship surveys (e.g., NMFS cruises), and community science contributions total to an additional 571 encounters with individuals from this population since 2000 (22-year span). Contributed encounters comprise over 40% of all MHI short-finned pilot whale identifications in CRC's photo-identification catalog. Ship-based line-transect surveys were undertaken by NMFS through the Hawaiian Archipelago in 11 years between 2002 and 2020; of the 89 short-finned pilot whale sightings within the MHI region from these surveys, 13 sightings were of individuals with confirmed photographic assignment to the insular MHI population. Population assignment of individuals from the remaining 76 NMFS sightings was either to a pelagic population or is currently unknown.

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 1725

# of years of photo records to compare: 20 (2000-2021)

Maximum # of years same individual photographed in area: 17 (2003-2020)

Supporting information: Short-finned pilot whales photo-identified during small boat survey efforts have been resighted on up to 109 separate occasions (over a span of 15 years) and across a maximum of 18 years (on 79 separate occasions; CRC unpublished). Movements from over 100 satellite-tagged whales also support fidelity to insular waters of the main Hawaiian Islands (Baird, 2016). Additionally, genetics, satellite tagging, and photo-identification data suggest the existence of three overlapping regional communities of short-finned pilot whales around the main Hawaiian Islands that are largely socially isolated: a western community which generally ranges from Niʻihau to Oʻahu, a central community from Oʻahu to Kahoʻolawe, and an eastern community centered around Hawaiʻi Island (Baird, 2016; Van Cise et al., 2017, CRC unpublished). A total of 810 sightings from CRC effort, 571 encounters from other researchers and community scientists since 2000, with re-sightings of individuals up to 18 years (2003-2020, on 79 separate occasions) and up to 109 separate times (over 15-year span, 2005-2019). The number of distinct individuals (known or suspected to belong to the insular population) in CRC's photo-ID catalog is 1,725 (CRC unpublished).

Genetic analyses conducted supporting designation (Y/N): Y

Nature of supporting information: Strong

Supporting information: Only a single stock of short-finned pilot whale is recognized in Hawaiian waters (Caretta et al., 2021), but long-term re-sightings of individuals, movements from satellite tag deployments, and genetic analyses all support the existence of an insular population (Baird 2016; Mahaffy et al., 2015; Oleson et al., 2013; Van Cise et al. 2017). Additionally, all three lines of evidence suggest the existence of three overlapping insular communities of short-finned pilot whales around the main Hawaiian Islands that are largely socially isolated: a western community which generally ranges from Niʻihau to Oʻahu, a central community from Oʻahu to Kahoʻolawe, and an eastern community centered around Hawaiʻi Island (Baird 2016; Van Cise et al. 2017, CRC unpublished).

What factors justify the boundary selection?: Rather than attempt to describe the primary range of each short-finned pilot whale insular community (western, central, eastern), we delineated child BIAs with the intent to represent the core range (i.e., high-intensity areas) for each community relative to the overall range of the insular population. We applied the same kernel density analysis procedure used to derive the parent BIA. A UD was estimated for each community (locations pooled and weighted by community) and a 50% isopleth of the UD was used to represent the core range of each community.

Kernel density analysis
We used kernel density estimation (KDE) to generate a UD of the sample population (Worton, 1989) and used a 95% isopleth of the UD to represent the primary range of the population for the parent BIA. Prior to kernel density analyses, crawl positions during periods of large transmission gaps were removed from each individual's track (where applicable) such to avoid generation of artificially "dense" areas resulting from interpolation over long periods without any original Argos data; a 1-day gap threshold was used (i.e., interpolated crawl points removed during periods where Argos locations did not transmit for 1 or more days apart). Further, one of each pair of tagged individuals that acted in concert was removed (to reduce pseudoreplication). All tag locations were pooled together, and the contribution of each tag's location was weighted to the overall kernel density based on deployment length, and the KDE was re-scaled so it integrated to one (Hauser et al., 2014; Hill et al., 2019), such that locations from shorter deployments would have less weight than those with longer deployments. Kernel densities were estimated using the bivariate plug-in bandwidth (or smoothing parameter) matrix (Duong & Hazelton, 2003, 2005; Duong, 2007) accessed through the ks package for R (Duong, 2021). The location weighting was completed using the weights argument within the ks package (Duong, 2021).

Data sources: Cascadia Research Collective (unpub. data, 2000-2021); National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020; accessed 2021); Abecassis et al., 2015; Baird et al., 2013, 2015; Bradford et al., 2021; Mahaffy et al., 2015; Oleson et al., 2013; Van Cise et al., 2017

Approximate % of population that uses this area for the designated purpose (if known): 25

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Abecassis, M., J. Polovina, R.W. Baird, A. Copeland, J.C. Drazen, R. Domokos, E. Oleson, Y. Jia, G.S. Schorr, D.L. Webster, and R.D. Andrews. 2015. Characterizing a foraging hotspot for short-finned pilot whales and Blainville's beaked whales located off the west side of Hawaiʻi Island by using tagging and oceanographic data. PLoS ONE 10(11):e0142628 doi:10.13371/journal.pone.0142628

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Bradford, A.L., E.M. Oleson, K.A. Forney, J.E. Moore, and J. Barlow. 2021 Line-transect abundance estimates of cetaceans in U.S. waters around the Hawaiian Islands in 2002, 2010, and 2017. U.S. Department of Commerce, NOAA Technical Memorandum NMFS-PIFSC-115, 52pp. doi:10.25923/daz4-kw84

Caretta, J.V., E.M. Oleson, K.A. Forney, M.M. Muto, D.W. Weller, A.R. Lang, J. Baker, B. Hanson, A.J. Orr, J. Barlow, J.E. Moore, and R.L. Brownell Jr. 2021. U.S. Pacific Marine Mammal Stock Assessments: 2020. U.S. Department of Commerce, NOAA.

Duong, T., and M.L. Hazelton. 2003. Plug-in bandwidth matrices for bivariate kernel density estimation. Journal of Nonparametric Statistics 15:17-30.

Duong, T., and M.L. Hazelton. 2005. Cross-validation bandwidth matrices for multivariate kernel density estimation. Scandinavian Journal of Statistics 32:485-506.

Duong, T. 2007. Ks: Kernel density estimation and kernel discriminant analysis for multivariate data in R. Journal of Statistical Software 21:1-16.

Duong, T. 2021. Ks: Kernel smoothing. R package version 1.12.0 https://CRAN.R-project.org/package=ks

Hauser, D.D.W., K.L. Laidre, R.S. Suydam, and P.R. Richard. 2014. Population-specific home ranges and migration timing of Pacific Arctic beluga whales (Delphinapterus leucas). Polar Biology 37:1171-1183

Hill, M.C., A.R. Bendlin, A.M. Van Cise, A. Milette-Winfree, A.D., Ligon, A.C. Ü, M.H. Deakos, and E.M. Oleson. 2019. Short-finned pilot whales (Globicephala macrorhynchus) of the Mariana Archipelago: individual affiliations, movements, and spatial use. Marine Mammal Science 35(3):797-824 doi:10.1111/mms.12567

Johnson, D.S., J.M. London, M.-A. Lea, and J.W. Durban. 2008. Continuous-time correlated random walk model for animal telemetry data. Ecology 89:1208-1215 doi:10.1890/07-1032.1

Johnson, D.S., and J.M. London. 2018. Crawl: an R package for fitting continuous-time correlated random walk models to animal movement data. Zenodo https://doi.org/10.5281/zenodo.596464

London, J.M. 2020. Pathroutr: an R package for (re-)routing paths around barriers (version v0.1.1-beta). Zenodo http://doi.org/10.5281/zenodo.4321827

Mahaffy, S.D., R.W. Baird, D.J. McSweeney, D.L. Webster, and G.S. Schorr. 2015. High site fidelity, strong associations, and long-term bonds: Short-finned pilot whales off the island of Hawaiʻi. Marine Mammal Science 31(4):1427-1451 doi:10.1111/mms.12234

Oleson, E.M., R.W. Baird, K.K. Martien, and B.L. Taylor. 2013. Island-associated stocks of odontocetes in the main Hawaiian Islands: a synthesis of available information to facilitate evaluation of stock structure. Document PSRG-2013-16 presented to the Pacific Scientific Review Group, Del Mar, April 2013.

Owen, K., R.D. Andrews, R.W. Baird, G.S. Schorr, and D.L. Webster. 2019. Lunar cycles and day length influence the diving behavior and habitat use of short-finned pilot whales around the main Hawaiian Islands. Marine Ecology Press Series 629:193-206 doi:10.3354/meps13123

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Van Cise, A.M., K.K. Martien, S.D. Mahaffy, R.W. Baird, D.L. Webster, J.H. Fowler, E.M. Oleson, and P.A. Morin. 2017. Familial social structure and socially driven genetic differentiation in Hawaiian short-finned pilot whales. Molecular Ecology 00:1-12 doi:10.1111/mec.14397

Worton, B.J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:164-168

Supplementary Description 6. 33. Spinner dolphin small and resident pop.

Species name: Spinner dolphin (*Stenella longirostris*)

Stock or population: Hawai'i Island stock

Descriptive name: Hawai'i Island

BIA type: Small and Resident Pop.

BIA label: S-BIA1-s-b3-HI011-0

Transboundary across: None

Hierarchy: Non-hierarchical; single BIA

Importance score: 1 (Intensity: 1, Data support: 3)

Intensity matrix: Abundance: 1, Range: 2

Supporting notes for intensity score: Tyne et al. (2016) reported an abundance estimate for Hawaiʻi Island spinner dolphins of 665 (CV=0.09) individuals based on mark-recapture methods using photo-ID (2010-2012), with 235 distinct individuals (abundance score = 1) (Tyne et al., 2016). The range size (9,477 km2, score = 2), based on the NMFS recognized stock boundary, reflects their nearshore habitat use and extends as far as these animals have been known to move off these islands. Abundance estimates for each spinner dolphin stock are based on the most recently available published data, albeit most estimates are dated, with several over 10 years old. Without further information, it is difficult to estimate the true intensity level of each of these island-associated BIAs. The intensity ranges fall within the lower Intensity scores (1 and 2) reflecting uncertainty in the intensity score for each BIA. In addition, previous studies have indicated that spinner dolphins show site fidelity to one or more bays and that these bays serve as important resting areas, with waters outside of bays used for travelling offshore or to other bays (Thorne et al., 2012; Norris et al., 1994; Karczmarski et al., 2005; Lammers, 2004; Tyne et al., 2015). A more recent study indicated that spinner dolphins off Maui Nui do not exhibit site fidelity to particular bays, but instead move among areas using a wide variety of habitat for resting behavior (Stack et al., 2020). Collectively, use of and fidelity to localized areas for resting habitat within their broader range varies among island areas.

Supporting notes for data support score: Data Support score = 3.

A combination of photo-identification and genetics data support the distinction between island-associated stocks in the main Hawaiian Islands (Andrews et al., 2010; Hill et al. 2010). Sighting data from CRC further support the designated stock boundaries used to represent each stock's BIA here. Movement data from VHF satellite-tagged spinner dolphins support limited offshore movements of these animals and residency in nearshore waters, particularly during the day (Norris et al., 1994). While it is known that spinner dolphins in the Hawaiian Islands exhibit site fidelity to one or more bays for daytime resting behavior (Thorne et al., 2012; Norris et al., 1994; Karczmarski et al., 2005; Lammers, 2004; Tyne et al., 2015), and hence may have core areas, no detailed movements from satellite tag data are available to make such boundary determinations in this assessment. Further, evidence of variation in use of daytime resting habitat among island areas has been more recently documented (Stack et al., 2020). Most abundance estimates for these stocks are dated, with the Hawaiʻi Island stock having the most recent and robust abundance estimate. Therefore, we assigned Data Support scores of (2) for Kauaʻi/Niʻihau and Oʻahu/Maui Nui and (3) for Hawaiʻi Island.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: No information to suggest this area is used dynamically or ephemerally.

Boundary certainty: 3

Supporting notes for boundary certainty: We have high confidence in the boundary certainty for the Hawai'i Island spinner dolphin stock. Sightings from CRC survey efforts and previous studies have shown their nearshore habitat use with limited offshore movement that this boundary reflects (Norris et al., 1994; Benoit-Bird and Au, 2003).

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): N

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 132

# of years in which supporting visual data collected: 19 (2002-2021)

Supporting information: Although the BIA boundaries described in this assessment remain unchanged from Baird et al. (2015), we mapped sighting data collected from non-systematic, dedicated small boat surveys conducted by CRC to provide additional justification for the MHI boundaries. CRC non-systematic, dedicated small boat survey efforts were undertaken off Kauaʻi and Niʻihau, Oʻahu, Maui Nui, and Hawaiʻi Island in 12, six, nine, and 20 years, respectively, spanning 2000-2021 (see Baird et al., 2013 for details on surveys). CRC surveys off these islands combined total 148,080 km of effort with 303 sightings of spinner dolphin groups. Ship-based line-transect surveys throughout the Hawaiian Archipelago have been undertaken by National Marine Fisheries Service (NMFS) in 11 years between 2002 and 2020, but there was relatively little effort in nearshore waters where spinner dolphins occur in both the MHI and NWHI regions (Bradford et al., 2021). Within the MHI region, there were eight sightings within the known range of the three insular stocks and two sightings that were offshore and likely do not belong to the insular stocks. Although these large-scale surveys have covered the NWHI region, NMFS sightings of spinner dolphins in the NWHI region were not near Manawai (Pearl and Hermes Reef), Kuaihelani (Midway Atoll), nor Hōlanikū (Kure Atoll.

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 235

# of years of photo records to compare: 2010, 2011, 2012

Supporting information: Tyne et al., 2016

Genetic analyses conducted supporting designation (Y/N): Y

Weak/moderate/strong support for genetic differentiation: Strong

Nature of supporting information: Strong

Supporting information: Genetic studies have provided strong evidence for genetic differentiation among island-associated populations of spinner dolphins in Hawaii. This supporting evidence has led to the designation of five separate island-associated stocks recognized by NMFS (Andrews et al., 2006, 2010; Hill et al., 2010; Caretta et al., 2021).

What factors justify the boundary selection?: Baird et al. (2015) delineated five separate BIAs for insular spinner dolphins based on recognized stock boundaries (Caretta et al., 2021). The same boundaries were used for this assessment as no additional information to suggest revision of boundaries has been obtained since the 2015 report. Sighting locations were mapped as a line of supporting evidence for nearshore use by insular spinner dolphins and ultimately for the BIA boundaries. Island-associated stock boundaries, as reported in Caretta et al., (2021), served as the basis for each spinner dolphin BIA described here. The stock boundaries represent a 10 nautical mile offshore boundary based on anecdotal accounts of the distribution of spinner dolphins (Hill et al., 2010). For each spinner dolphin BIA, we defined the inner (shoreward) boundary by a 5-m distance from shore.

Data sources: Baird et al., (2013); CRC unpublished (2000-2021; accessed October 2021); National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020, accessed October 2021)

Approximate % of population that uses this area for the designated purpose (if known): 100

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Andrews, K.R., L. Karczmarski, W.W.L. Au, S.H. Rickards, C.A. Vanderlip, and R.J. Toonen. 2006. Patterns of genetic diversity of the Hawaiian spinner dolphin (Stenella longirostris). Atoll Research Bulletin 543:65-73

Andrews, K.R., L. Karczmarski, W.W.L. Au, S.H. Rickards, C.A. Vanderlip, B.W. Bowen, E.G. Grau, and R.J. Toonen. 2010. Rolling stones and stable homes: social structure, habitat diversity and population genetics of the Hawaiian spinner dolphin (Stenella longirostris). Molecular Ecology 19:732-748

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013b. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Benoit-Bird, K.J., and W.W.L. Au. 2003. Prey dynamics affect foraging by a pelagic predator (Stenella longirostris) over a range of spatial and temporal scales. Behavioral Ecology and Sociobiology 53:364-373.

Caretta, J.V., K.A. Forney, E.M. Oleson, D.W. Weller, A.R. Lang, J. Baker, M.M. Muto, B. Hanson, A.J. Orr, H. Huber, M.S. Lowry, J. Barlow, J.E. Moore, D. Lynch, L. Carswell, and R.L. Brownwell Jr. 2019. U.S. Pacific Marine Mammal Stock Assessments: 2018. U.S. Department of Commerce, NOAA.

Hill, M.C., E.M. Oleson, and K.R. Andrews. 2010. New island-associated stocks for Hawaiian spinner dolphins (Stenella longirostris longirostris): Rationale and new stock boundaries. Pacific Islands Fisheries Science Center Admin Report H-10-04

Hill, M.C., A.L. Bradford, K.R. Andrews, R.W. Baird, M.H. Deakos, D.W. Johnston, S.D. Mahaffy, A.J. Milette, E.M. Oleson, J. Ostman-Lind, A.A. Pack, S.H. Rickards, and S. Yin. 2011. Abundance and movements of spinner dolphins off the main Hawaiian Islands. Pacific Islands Fisheries Science Center Working Paper WP-11-013

Karczmarski, L., B. Wursing, and B. Winning. 1998. Socio-ecology and population biology of spinner dolphins Stenella longirostris in Midway Atoll, Northwest Hawaiian Chain, Central Pacific. Unpublished report to U.S. Fish and Wildlife Service and National Marine Fisheries Service. 41 pp.

Karczmarski, L., B. Wursig, G. Gailey, K.W. Larson, and C. Vanderlip. 2005. Spinner dolphins in a remote Hawaiian atoll: Social grouping and population structure. Behavioral Ecology 16(4):675-685.

Lammers, M.O. 2004. Occurrence and behavior of Hawaiian spinner dolphins (Stenella longirostris) along Oahu's leeward and south shores. Aquatic Mammals 30:237-250.

Norris, K.S., B. Würsing, R.S. Wells, and M. Würsig. 1994. The Hawaiian Spinner Dolphin. University of California Press, 408 pp.

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Stack, S.H., G.L. Olson, V. Neamtu, A.F. Machernis, R.W. Baird, and J.J. Currie. 2020. Identifying spinner dolphin Stenella longirostris longirostris movement and behavioral patterns to inform conservation strategies in Maui Nui, Hawaiʻi. Marine Ecology Progress Series 644:187-197 doi:10.3354/meps13347

Thorne, L.H., D.W. Johnston, D.L. Urban, J. Tyne, L. Bejder, R.W. Baird, S. Yin, S.H. Rickards, M.H. Deakos, J.R. Mobley, A.A. Pack, and M.C. Hill. 2012. Predictive modeling of spinner dolphin (Stenella longirostris) resting habitat in the main Hawaiian Islands. PLoS ONE 7(8):e43167

Tyne, J.A., D.W. Johnston, R. Rankin, N.R. Loneragan, and L. Bejder. 2015. The importance of spinner dolphin (Stenella longirostris) resting habitat: implications for management. Journal of Applied Ecology 52:621-630 doi:10.1111/1365-2664.12434

Tyne, J.A., N.R. Longergan, D.W. Johnston, K.H. Pollock, R. Williams, and L. Bejder. 2016. Evaluating monitoring methods for cetaceans. Biological Conservation 201:252-260.

Supplementary Description 6. 34. Spinner dolphin small and resident pop.

Species name: Spinner dolphin (*Stenella longirostris*)

Stock or population: Kaua'i/Ni'ihau stock

Descriptive name: Kaua'i and Ni'ihau

BIA type: Small and Resident Pop.

BIA label: S-BIA1-s-b3-HI013-0

Transboundary across: None

Hierarchy: Non-hierarchical; single BIA

Importance score: 1 (Intensity: 1, Data support: 2)

Intensity matrix: Abundance: 1, Range: 2

Supporting notes for intensity score: The most recent estimate (from mark recapture methods based on photo-ID data) was 601 individuals (CV=0.20) during the survey period from October to November 2005, although this estimate only accounts for individuals encountered off the leeward side of Kauaʻi and thus is likely an underestimate of the true population size (Hill et al., 2011); abundance score = 1. The area of the BIA is 7,233 km2 (score = 2). Abundance estimates for each spinner dolphin stock are based on the most recently available published data, albeit most estimates are dated, with several over 10 years old. Without further information it is difficult to estimate the true intensity level of each of these island-associated BIAs. The intensity ranges fall within the lower intensity scores and as such capture uncertainty in the intensity score for each BIA. In addition, previous studies have indicated that spinner dolphins show site fidelity to one or more bays and that these bays serve as important resting areas, with waters outside of bays used for travelling offshore or to other bays (Thorne et al., 2012; Norris et al., 1994; Karczmarski et al., 2005; Lammers, 2004; Tyne et al., 2015). A more recent study indicated that spinner dolphins off Maui Nui do not exhibit site fidelity to particular bays, but instead move among areas using a wide variety of habitat for resting behavior (Stack et al., 2020). Collectively, use of and fidelity to localized areas for resting habitat within their broader range varies among island areas.

Supporting notes for data support score: Score = 2; A combination of photo-identification and genetics data support the distinction between island-associated stocks (Andrews et al., 2010; Hill et al. 2010). Sighting data from CRC further support the designated stock boundaries used to represent each stock's BIA here (Figure 1). Movement data from VHF satellite tagged spinner dolphins support limited offshore movements of these animals and residency to nearshore waters, particularly during the day (Norris et al., 1994). While it is known that spinner dolphins in the Hawaiian Islands exhibit site fidelity to one or more bays for daytime resting behavior (Thorne et al., 2012; Norris et al., 1994; Karczmarski et al., 2005; Lammers, 2004; Tyne et al., 2015), and hence may have core areas, no detailed movements from satellite tag data are available to make such boundary determinations in this assessment. Further, evidence for variation in use of daytime resting habitat among island areas has been more recently documented (Stack et al., 2020). Most abundance estimates for these stocks are dated, with the Hawaiʻi Island stock having the most recent and robust abundance estimate.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: No information to suggest the area is used dynamically or ephemerally.

Boundary certainty: 3

Supporting notes for boundary certainty: We have high confidence in the boundary certainty for the Kauaʻi/Niʻihau spinner dolphin stock. Sightings from CRC survey efforts and previous studies have shown their nearshore habitat use with limited offshore movement that these boundaries reflect (Norris et al., 1994; Benoit-Bird and Au, 2003).

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): N

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 121

# of years in which supporting visual data collected: 12 (2003-2021)

Supporting information: Although the BIA boundaries described in this assessment remain unchanged from Baird et al. (2015), we mapped sighting data collected from non-systematic, dedicated small boat surveys conducted by CRC to provide additional justification for the MHI boundaries. CRC non-systematic, dedicated small boat survey efforts were undertaken off Kauaʻi and Niʻihau, Oʻahu, Maui Nui, and Hawaiʻi Island in 12, six, nine, and 20 years, respectively, spanning 2000-2021 (see Baird et al., 2013 for details on surveys). CRC surveys off these islands combined total 148,080 km of effort with 303 sightings of spinner dolphin groups. Ship-based line-transect surveys throughout the Hawaiian Archipelago have been undertaken by National Marine Fisheries Service (NMFS) in 11 years between 2002 and 2020, but there was relatively little effort in nearshore waters where spinner dolphins occur in both the MHI and NWHI regions (Bradford et al., 2021). Within the MHI region, there were eight sightings within the known range of the three insular stocks and two sightings that were offshore and likely do not belong to the insular stocks. Although these large-scale surveys have covered the NWHI region, NMFS sightings of spinner dolphins in the NWHI region were not near Manawai (Pearl and Hermes Reef), Kuaihelani (Midway Atoll), nor Hōlanikū (Kure Atoll).

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of years of photo records to compare: 2005

Supporting information: Hill et al., 2011

Genetic analyses conducted supporting designation (Y/N): Y

Nature of supporting information: Strong

Supporting information: Genetic studies have provided strong evidence for genetic differentiation among island-associated populations of spinner dolphins in Hawaii. This supporting evidence has led to the designation of five separate island-associated stocks recognized by NMFS (Andrews et al., 2006, 2010; Hill et al., 2010; Caretta et al., 2021).

What factors justify the boundary selection?: Baird et al. (2015) delineated five separate BIAs for insular spinner dolphins based on recognized stock boundaries (Caretta et al., 2021). The same boundaries were used for this assessment as no additional information to suggest revision of boundaries has been obtained since the 2015 report. Sighting locations were mapped as a line of supporting evidence for nearshore use by insular spinner dolphins and ultimately for the BIA boundaries. Island-associated stock boundaries, as reported in Caretta et al., (2021), served as the basis for each spinner dolphin BIA described here. The stock boundaries represent a 10 nautical mile offshore boundary based on anecdotal accounts of the distribution of spinner dolphins (Hill et al., 2010). For each spinner dolphin BIA, we defined the inner (shoreward) boundary by a 50 m distance buffer from shore.

Data sources: Baird et al., (2013); CRC unpublished (accessed October 2021); National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020, accessed October 2021).

Approximate % of population that uses this area for the designated purpose (if known): 100

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Andrews, K.R., L. Karczmarski, W.W.L. Au, S.H. Rickards, C.A. Vanderlip, and R.J. Toonen. 2006. Patterns of genetic diversity of the Hawaiian spinner dolphin (Stenella longirostris). Atoll Research Bulletin 543:65-73

Andrews, K.R., L. Karczmarski, W.W.L. Au, S.H. Rickards, C.A. Vanderlip, B.W. Bowen, E.G. Grau, and R.J. Toonen. 2010. Rolling stones and stable homes: social structure, habitat diversity and population genetics of the Hawaiian spinner dolphin (Stenella longirostris). Molecular Ecology 19:732-748

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013b. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Benoit-Bird, K.J., and W.W.L. Au. 2003. Prey dynamics affect foraging by a pelagic predator (Stenella longirostris) over a range of spatial and temporal scales. Behavioral Ecology and Sociobiology 53:364-373.

Caretta, J.V., K.A. Forney, E.M. Oleson, D.W. Weller, A.R. Lang, J. Baker, M.M. Muto, B. Hanson, A.J. Orr, H. Huber, M.S. Lowry, J. Barlow, J.E. Moore, D. Lynch, L. Carswell, and R.L. Brownwell Jr. 2019. U.S. Pacific Marine Mammal Stock Assessments: 2018. U.S. Department of Commerce, NOAA.

Hill, M.C., E.M. Oleson, and K.R. Andrews. 2010. New island-associated stocks for Hawaiian spinner dolphins (Stenella longirostris longirostris): Rationale and new stock boundaries. Pacific Islands Fisheries Science Center Admin Report H-10-04

Hill, M.C., A.L. Bradford, K.R. Andrews, R.W. Baird, M.H. Deakos, D.W. Johnston, S.D. Mahaffy, A.J. Milette, E.M. Oleson, J. Ostman-Lind, A.A. Pack, S.H. Rickards, and S. Yin. 2011. Abundance and movements of spinner dolphins off the main Hawaiian Islands. Pacific Islands Fisheries Science Center Working Paper WP-11-013

Karczmarski, L., B. Wursing, and B. Winning. 1998. Socio-ecology and population biology of spinner dolphins Stenella longirostris in Midway Atoll, Northwest Hawaiian Chain, Central Pacific. Unpublished report to U.S. Fish and Wildlife Service and National Marine Fisheries Service. 41 pp.

Karczmarski, L., B. Wursig, G. Gailey, K.W. Larson, and C. Vanderlip. 2005. Spinner dolphins in a remote Hawaiian atoll: Social grouping and population structure. Behavioral Ecology 16(4):675-685.

Lammers, M.O. 2004. Occurrence and behavior of Hawaiian spinner dolphins (Stenella longirostris) along Oahu's leeward and south shores. Aquatic Mammals 30:237-250.

Norris, K.S., B. Würsing, R.S. Wells, and M. Würsig. 1994. The Hawaiian Spinner Dolphin. University of California Press, 408 pp.

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Stack, S.H., G.L. Olson, V. Neamtu, A.F. Machernis, R.W. Baird, and J.J. Currie. 2020. Identifying spinner dolphin Stenella longirostris longirostris movement and behavioral patterns to inform conservation strategies in Maui Nui, Hawaiʻi. Marine Ecology Progress Series 644:187-197 doi:10.3354/meps13347

Thorne, L.H., D.W. Johnston, D.L. Urban, J. Tyne, L. Bejder, R.W. Baird, S. Yin, S.H. Rickards, M.H. Deakos, J.R. Mobley, A.A. Pack, and M.C. Hill. 2012. Predictive modeling of spinner dolphin (Stenella longirostris) resting habitat in the main Hawaiian Islands. PLoS ONE 7(8):e43167

Tyne, J.A., D.W. Johnston, R. Rankin, N.R. Loneragan, and L. Bejder. 2015. The importance of spinner dolphin (Stenella longirostris) resting habitat: implications for management. Journal of Applied Ecology 52:621-630 doi:10.1111/1365-2664.12434

Tyne, J.A., N.R. Longergan, D.W. Johnston, K.H. Pollock, R. Williams, and L. Bejder. 2016. Evaluating monitoring methods for cetaceans. Biological Conservation 201:252-260.

Supplementary Description 6. 35. Spinner dolphin small and resident pop.

Species name: Spinner dolphin (*Stenella longirostris*)

Stock or population: Midway Atoll/Kure stock

Descriptive name: Kuaihelani/Hōlanikū (Midway/Kure Atolls)

BIA type: Small and Resident Pop.

BIA label: S-BIA1-s-b2-HI015-0

Transboundary across: None

Hierarchy: Non-hierarchical; single BIA

Importance score: 1 (Intensity: 2, Data support: 1)

Intensity matrix: Abundance: 2, Range: 2

Supporting notes for intensity score: The most recent abundance estimate for this spinner dolphin stock was 260 individuals based on 139 photo-identified spinner dolphins during dedicated surveys in 1998 (Karczmarski et al., 1998). However, this estimate is dated. For the purposes of this assessment we will assume the abundance is within the 126 to 500 individual range (score = 2) of the BIA Intensity scoring criteria. The area of the BIA is 4,841 km2 (range size score = 2).

Abundance estimates for each spinner dolphin stock are based on the most recently available published data, albeit most estimates are dated, with several over 10 years old. Without further information it is difficult to estimate the true intensity level of each of these island-associated BIAs. The intensity ranges fall within the lower intensity scores (1 and 2) and as such capture uncertainty in the intensity score for each BIA. In addition, previous studies have indicated that spinner dolphins show site fidelity to one or more bays and that these bays serve as important resting areas, with waters outside of bays used for travelling offshore or to other bays (Thorne et al., 2012; Norris et al., 1994; Karczmarski et al., 2005; Lammers, 2004; Tyne et al., 2015). A more recent study indicated that spinner dolphins off Maui Nui do not exhibit site fidelity to particular bays, but instead move among areas using a wide variety of habitat for resting behavior (Stack et al., 2020). Collectively, use of and fidelity to localized areas for resting habitat within their broader range varies among island areas.

Supporting notes for data support score: Score = 1; Although we do not have a comprehensive sighting dataset to map here in support of the NWHI spinner dolphin stocks, previous studies on photo-identification, social structure, and genetic structure support their designation as small and resident populations (Andrews et al., 2006, 2010; Hill et al., 2010; Karczmarski et al., 2005). The Kuaihelani/Hōlanikū (Midway/Kure Atolls) stock is the only NWHI stock that has an abundance estimate and this estimate is over 20 years old (Karczmarski et al., 1998). No abundance estimates are available for the Manawai (Pearl and Hermes Reef) stock and the abundance score derived here was based on photo-identification data and expert elicitation. Provided the quality and quantity of available information and their limitations, we assign a data support score of 1 for both NWHI stocks.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: No information to suggest the area is used dynamically or ephemerally.

Boundary certainty: 2

Supporting notes for boundary certainty: We have intermediate confidence in the boundary certainty for the NWHI spinner dolphin stocks. Previous studies have indicated high gene flow between Kuaihelani (Midway Atoll) and Hōlanikū (Kure Atoll) populations but genetic differentiation of these spinner dolphins from those found at Manawai (Pearl & Hermes Reef), suggesting that movements over large distances of deep-water habitat are unlikely to occur (Andrews et al, 2010; Hill et al., 2010; Karczmarski et al., 2005). Despite this, there is limited information on longer-term movements on these populations that may better inform their BIA boundaries.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): N

Visual observations/records supporting designation (Y/N): Y

Supporting information: Although the BIA boundaries described in this assessment remain unchanged from Baird et al. (2015), we mapped sighting data collected from non-systematic, dedicated small boat surveys conducted by CRC to provide additional justification for the MHI boundaries. CRC non-systematic, dedicated small boat survey efforts were undertaken off Kauaʻi and Niʻihau, Oʻahu, Maui Nui, and Hawaiʻi Island in 12, six, nine, and 20 years, respectively, spanning 2000-2021 (see Baird et al., 2013 for details on surveys). CRC surveys off these islands combined total 148,080 km of effort with 303 sightings of spinner dolphin groups. Ship-based line-transect surveys throughout the Hawaiian Archipelago have been undertaken by National Marine Fisheries Service (NMFS) in 11 years between 2002 and 2020, but there was relatively little effort in nearshore waters where spinner dolphins occur in both the MHI and NWHI regions (Bradford et al., 2021). Within the MHI region, there were eight sightings within the known range of the three insular stocks and two sightings that were offshore and likely do not belong to the insular stocks. Although these large-scale surveys have covered the NWHI region, NMFS sightings of spinner dolphins in the NWHI region were not near Manawai (Pearl and Hermes Reef), Kuaihelani (Midway Atoll), nor Hōlanikū (Kure Atoll).

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 139

Supporting information: Karczmarski et al., 1998

Genetic analyses conducted supporting designation (Y/N): Y

Nature of supporting information: Strong

Supporting information: Genetic studies have provided strong evidence for genetic differentiation among island-associated populations of spinner dolphins in Hawaii. This supporting evidence has led to the designation of five separate island-associated stocks recognized by NMFS (Andrews et al., 2006, 2010; Hill et al., 2010; Caretta et al., 2021).

What factors justify the boundary selection?: Baird et al. (2015) delineated five separate BIAs for insular spinner dolphins based on recognized stock boundaries (Caretta et al., 2021). The same boundaries were used for this assessment as no additional information to suggest revision of boundaries has been obtained since the 2015 report. Sighting locations were mapped as a line of supporting evidence for nearshore use by insular spinner dolphins and ultimately for the BIA boundaries. Island-associated stock boundaries, as reported in Caretta et al., (2021), served as the basis for each spinner dolphin BIA described here. The stock boundaries represent a 10 nautical mile offshore boundary based on anecdotal accounts of the distribution of spinner dolphins (Hill et al., 2010). For each spinner dolphin BIA, we defined the inner (shoreward) boundary by a 5-m distance from shore.

Data sources: Andrews et al., (2006, 2010). National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020; accessed 2021).

Approximate % of population that uses this area for the designated purpose (if known): 100

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Andrews, K.R., L. Karczmarski, W.W.L. Au, S.H. Rickards, C.A. Vanderlip, and R.J. Toonen. 2006. Patterns of genetic diversity of the Hawaiian spinner dolphin (Stenella longirostris). Atoll Research Bulletin 543:65-73

Andrews, K.R., L. Karczmarski, W.W.L. Au, S.H. Rickards, C.A. Vanderlip, B.W. Bowen, E.G. Grau, and R.J. Toonen. 2010. Rolling stones and stable homes: social structure, habitat diversity and population genetics of the Hawaiian spinner dolphin (Stenella longirostris). Molecular Ecology 19:732-748

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013b. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Benoit-Bird, K.J., and W.W.L. Au. 2003. Prey dynamics affect foraging by a pelagic predator (Stenella longirostris) over a range of spatial and temporal scales. Behavioral Ecology and Sociobiology 53:364-373.

Caretta, J.V., K.A. Forney, E.M. Oleson, D.W. Weller, A.R. Lang, J. Baker, M.M. Muto, B. Hanson, A.J. Orr, H. Huber, M.S. Lowry, J. Barlow, J.E. Moore, D. Lynch, L. Carswell, and R.L. Brownwell Jr. 2019. U.S. Pacific Marine Mammal Stock Assessments: 2018. U.S. Department of Commerce, NOAA.

Hill, M.C., E.M. Oleson, and K.R. Andrews. 2010. New island-associated stocks for Hawaiian spinner dolphins (Stenella longirostris longirostris): Rationale and new stock boundaries. Pacific Islands Fisheries Science Center Admin Report H-10-04

Hill, M.C., A.L. Bradford, K.R. Andrews, R.W. Baird, M.H. Deakos, D.W. Johnston, S.D. Mahaffy, A.J. Milette, E.M. Oleson, J. Ostman-Lind, A.A. Pack, S.H. Rickards, and S. Yin. 2011. Abundance and movements of spinner dolphins off the main Hawaiian Islands. Pacific Islands Fisheries Science Center Working Paper WP-11-013

Karczmarski, L., B. Wursing, and B. Winning. 1998. Socio-ecology and population biology of spinner dolphins Stenella longirostris in Midway Atoll, Northwest Hawaiian Chain, Central Pacific. Unpublished report to U.S. Fish and Wildlife Service and National Marine Fisheries Service. 41 pp.

Karczmarski, L., B. Wursig, G. Gailey, K.W. Larson, and C. Vanderlip. 2005. Spinner dolphins in a remote Hawaiian atoll: Social grouping and population structure. Behavioral Ecology 16(4):675-685.

Lammers, M.O. 2004. Occurrence and behavior of Hawaiian spinner dolphins (Stenella longirostris) along Oahu's leeward and south shores. Aquatic Mammals 30:237-250.

Norris, K.S., B. Würsing, R.S. Wells, and M. Würsig. 1994. The Hawaiian Spinner Dolphin. University of California Press, 408 pp.

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Stack, S.H., G.L. Olson, V. Neamtu, A.F. Machernis, R.W. Baird, and J.J. Currie. 2020. Identifying spinner dolphin Stenella longirostris longirostris movement and behavioral patterns to inform conservation strategies in Maui Nui, Hawaiʻi. Marine Ecology Progress Series 644:187-197 doi:10.3354/meps13347

Thorne, L.H., D.W. Johnston, D.L. Urban, J. Tyne, L. Bejder, R.W. Baird, S. Yin, S.H. Rickards, M.H. Deakos, J.R. Mobley, A.A. Pack, and M.C. Hill. 2012. Predictive modeling of spinner dolphin (Stenella longirostris) resting habitat in the main Hawaiian Islands. PLoS ONE 7(8):e43167

Tyne, J.A., D.W. Johnston, R. Rankin, N.R. Loneragan, and L. Bejder. 2015. The importance of spinner dolphin (Stenella longirostris) resting habitat: implications for management. Journal of Applied Ecology 52:621-630 doi:10.1111/1365-2664.12434

Tyne, J.A., N.R. Longergan, D.W. Johnston, K.H. Pollock, R. Williams, and L. Bejder. 2016. Evaluating monitoring methods for cetaceans. Biological Conservation 201:252-260.

Supplementary Description 6. 36. Spinner dolphin small and resident pop.

Species name: Spinner dolphin (*Stenella longirostris*)

Stock or population: Pearl & Hermes Reef stock

Descriptive name: Manawai (Pearl and Hermes Reef)

BIA type: Small and Resident Pop.

BIA label: S-BIA1-s-b2-HI014-0

Transboundary across: None

Hierarchy: Non-hierarchical; single BIA

Importance score: 1 (Intensity: 2, Data support: 1)

Intensity matrix: Abundance: 2, Range: 2

Supporting notes for intensity score: There is no abundance estimate available for this stock. A photo-identification catalog for this stock exists; however, inadequate survey effort and low re-sighting rates preclude a comprehensive estimate of abundance, per Caretta et al. (2021). The photo-identification catalog includes 80 identified individuals (S. Rickards, pers. comm.). Andrews et al. (2006) reported that although the population size of spinner dolphins off this reef was unknown, over 300 individuals have been observed at this location. Provided these sources and input from experts on this population, we assumed the abundance is in the 126 to 500 individuals range category of the BIA Intensity scoring criteria. The area of the BIA is 2,094 km2 (score = 2).

Abundance estimates for each spinner dolphin stock are based on the most recently available published data, albeit most estimates are dated, with several over 10 years old. Without further information it is difficult to estimate the true intensity level of each of these island-associated BIAs. The intensity ranges fall within the lower intensity scores (1 and 2) and as such capture uncertainty in the intensity score for each BIA. In addition, previous studies have indicated that spinner dolphins show site fidelity to one or more bays and that these bays serve as important resting areas, with waters outside of bays used for travelling offshore or to other bays (Thorne et al., 2012; Norris et al., 1994; Karczmarski et al., 2005; Lammers, 2004; Tyne et al., 2015). A more recent study indicated that spinner dolphins off Maui Nui do not exhibit site fidelity to particular bays, but instead move among areas using a wide variety of habitat for resting behavior (Stack et al., 2020). Collectively, use of and fidelity to localized areas for resting habitat within their broader range varies among island areas.

Supporting notes for data support score: Score = 1; Although we do not have a comprehensive sighting dataset to map here in support of the NWHI spinner dolphin stocks, previous studies on photo-identification, social structure, and genetic structure support their designation as small and resident populations (Andrews et al., 2006, 2010; Hill et al., 2010; Karczmarski et al., 2005). The Kuaihelani/Hōlanikū (Midway/Kure Atolls) stock is the only NWHI stock that has an abundance estimate and this estimate is over 20 years old (Karczmarski et al., 1998). No abundance estimates are available for the Manawai (Pearl and Hermes Reef) stock and the abundance score derived here was based on photo-identification data and expert elicitation. Given the quality and quantity of available information and their limitations, we assigned a Data Support score of 1 for both NWHI stocks.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: No information to suggest the area is used dynamically or ephemerally.

Boundary certainty: 2

Supporting notes for boundary certainty: We have intermediate confidence in the Boundary Certainty for the NWHI spinner dolphin stocks. Previous studies have indicated high gene flow between Kuaihelani (Midway Atoll) and Hōlanikū (Kure Atoll) populations but genetic differentiation of these spinner dolphins from those found at Manawai (Pearl & Hermes Reef), suggesting that movements over large distances of deep-water habitat are unlikely to occur (Andrews et al, 2010; Hill et al., 2010; Karczmarski et al., 2005). Despite this, there is limited information on longer-term movements on these populations that may better inform their BIA boundaries.

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): N

Visual observations/records supporting designation (Y/N): Y

Supporting information: Although the BIA boundaries described in this assessment remain unchanged from Baird et al. (2015), we mapped sighting data collected from non-systematic, dedicated small boat surveys conducted by CRC to provide additional justification for the MHI boundaries. CRC non-systematic, dedicated small boat survey efforts were undertaken off Kauaʻi and Niʻihau, Oʻahu, Maui Nui, and Hawaiʻi Island in 12, six, nine, and 20 years, respectively, spanning 2000-2021 (see Baird et al., 2013 for details on surveys). CRC surveys off these islands combined total 148,080 km of effort with 303 sightings of spinner dolphin groups. Ship-based line-transect surveys throughout the Hawaiian Archipelago have been undertaken by National Marine Fisheries Service (NMFS) in 11 years between 2002 and 2020, but there was relatively little effort in nearshore waters where spinner dolphins occur in both the MHI and NWHI regions (Bradford et al., 2021). Within the MHI region, there were eight sightings within the known range of the three insular stocks and two sightings that were offshore and likely do not belong to the insular stocks. Although these large-scale surveys have covered the NWHI region, NMFS sightings of spinner dolphins in the NWHI region were not near Manawai (Pearl and Hermes Reef), Kuaihelani (Midway Atoll), nor Hōlanikū (Kure Atoll)

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of individuals photographed: 80

Supporting information: Andrews et al. (2006)

Genetic analyses conducted supporting designation (Y/N): Y

Nature of supporting information: Strong

Supporting information: Genetic studies have provided strong evidence for genetic differentiation among island-associated populations of spinner dolphins in Hawaii. This supporting evidence has led to the designation of five separate island-associated stocks recognized by NMFS (Andrews et al., 2006, 2010; Hill et al., 2010; Caretta et al., 2021).

What factors justify the boundary selection?: Baird et al. (2015) delineated five separate BIAs for insular spinner dolphins based on recognized stock boundaries (Caretta et al., 2021). The same boundaries were used for this assessment as no additional information to suggest revision of boundaries has been obtained since the 2015 report. Sighting locations were mapped as a line of supporting evidence for nearshore use by insular spinner dolphins and ultimately for the BIA boundaries. Island-associated stock boundaries, as reported in Caretta et al., (2021), served as the basis for each spinner dolphin BIA described here. The stock boundaries represent a 10 nautical mile offshore boundary based on anecdotal accounts of the distribution of spinner dolphins. For each spinner dolphin BIA, we defined the inner (shoreward) boundary by a 5-m distance from shore.

Data sources: S. Rickards (Pers. communication, October 2021); Andrews et al., (2006, 2010). National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020, accessed 2021).

Approximate % of population that uses this area for the designated purpose (if known): 100

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Andrews, K.R., L. Karczmarski, W.W.L. Au, S.H. Rickards, C.A. Vanderlip, and R.J. Toonen. 2006. Patterns of genetic diversity of the Hawaiian spinner dolphin (Stenella longirostris). Atoll Research Bulletin 543:65-73

Andrews, K.R., L. Karczmarski, W.W.L. Au, S.H. Rickards, C.A. Vanderlip, B.W. Bowen, E.G. Grau, and R.J. Toonen. 2010. Rolling stones and stable homes: social structure, habitat diversity and population genetics of the Hawaiian spinner dolphin (Stenella longirostris). Molecular Ecology 19:732-748

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013b. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Benoit-Bird, K.J., and W.W.L. Au. 2003. Prey dynamics affect foraging by a pelagic predator (Stenella longirostris) over a range of spatial and temporal scales. Behavioral Ecology and Sociobiology 53:364-373.

Caretta, J.V., K.A. Forney, E.M. Oleson, D.W. Weller, A.R. Lang, J. Baker, M.M. Muto, B. Hanson, A.J. Orr, H. Huber, M.S. Lowry, J. Barlow, J.E. Moore, D. Lynch, L. Carswell, and R.L. Brownwell Jr. 2019. U.S. Pacific Marine Mammal Stock Assessments: 2018. U.S. Department of Commerce, NOAA.

Hill, M.C., E.M. Oleson, and K.R. Andrews. 2010. New island-associated stocks for Hawaiian spinner dolphins (Stenella longirostris longirostris): Rationale and new stock boundaries. Pacific Islands Fisheries Science Center Admin Report H-10-04

Hill, M.C., A.L. Bradford, K.R. Andrews, R.W. Baird, M.H. Deakos, D.W. Johnston, S.D. Mahaffy, A.J. Milette, E.M. Oleson, J. Ostman-Lind, A.A. Pack, S.H. Rickards, and S. Yin. 2011. Abundance and movements of spinner dolphins off the main Hawaiian Islands. Pacific Islands Fisheries Science Center Working Paper WP-11-013

Karczmarski, L., B. Wursing, and B. Winning. 1998. Socio-ecology and population biology of spinner dolphins Stenella longirostris in Midway Atoll, Northwest Hawaiian Chain, Central Pacific. Unpublished report to U.S. Fish and Wildlife Service and National Marine Fisheries Service. 41 pp.

Karczmarski, L., B. Wursig, G. Gailey, K.W. Larson, and C. Vanderlip. 2005. Spinner dolphins in a remote Hawaiian atoll: Social grouping and population structure. Behavioral Ecology 16(4):675-685.

Lammers, M.O. 2004. Occurrence and behavior of Hawaiian spinner dolphins (Stenella longirostris) along Oahu's leeward and south shores. Aquatic Mammals 30:237-250.

Norris, K.S., B. Würsing, R.S. Wells, and M. Würsig. 1994. The Hawaiian Spinner Dolphin. University of California Press, 408 pp.

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Stack, S.H., G.L. Olson, V. Neamtu, A.F. Machernis, R.W. Baird, and J.J. Currie. 2020. Identifying spinner dolphin Stenella longirostris longirostris movement and behavioral patterns to inform conservation strategies in Maui Nui, Hawaiʻi. Marine Ecology Progress Series 644:187-197 doi:10.3354/meps13347

Thorne, L.H., D.W. Johnston, D.L. Urban, J. Tyne, L. Bejder, R.W. Baird, S. Yin, S.H. Rickards, M.H. Deakos, J.R. Mobley, A.A. Pack, and M.C. Hill. 2012. Predictive modeling of spinner dolphin (Stenella longirostris) resting habitat in the main Hawaiian Islands. PLoS ONE 7(8):e43167

Tyne, J.A., D.W. Johnston, R. Rankin, N.R. Loneragan, and L. Bejder. 2015. The importance of spinner dolphin (Stenella longirostris) resting habitat: implications for management. Journal of Applied Ecology 52:621-630 doi:10.1111/1365-2664.12434

Tyne, J.A., N.R. Longergan, D.W. Johnston, K.H. Pollock, R. Williams, and L. Bejder. 2016. Evaluating monitoring methods for cetaceans. Biological Conservation 201:252-260.

Supplementary Description 6. 37. Spinner dolphin small and resident pop.

Species name: Spinner dolphin (*Stenella longirostris*)

Stock or population: O'ahu/Maui Nui stock

Descriptive name: O'ahu and Maui Nui

BIA type: Small and Resident Pop.

BIA label: S-BIA1-s-b3-HI012-0

Transboundary across: None

Hierarchy: Non-hierarchical; single BIA

Importance score: 1 (Intensity: 1, Data support: 2)

Intensity matrix: Abundance: 2, Range: 1

Supporting notes for intensity score: The most recent estimate from photo-ID mark-recapture analysis of data collected from July to September 2007 off the leeward side of Oʻahu was n=355 (CV=0.09; Hill et al., 2011); the abundance score = 2. The area of the BIA is 14,651 km2 (score = 1). However, this abundance estimate is dated and did not account for animals occupying other areas of Oʻahu nor those found off Maui Nui. Abundance estimates for each spinner dolphin stock are based on the most recently available published data, albeit most estimates are dated, with several over 10 years old. Without further information, it is difficult to estimate the true intensity level of each of these island-associated BIAs. The intensity ranges fall within the lower Intensity scores (1 and 2) reflecting uncertainty in the intensity score for each BIA. In addition, previous studies have indicated that spinner dolphins show site fidelity to one or more bays and that these bays serve as important resting areas, with waters outside of bays used for travelling offshore or to other bays (Thorne et al., 2012; Norris et al., 1994; Karczmarski et al., 2005; Lammers, 2004; Tyne et al., 2015). A more recent study indicated that spinner dolphins off Maui Nui do not exhibit site fidelity to particular bays, but instead move among areas using a wide variety of habitat for resting behavior (Stack et al., 2020). Collectively, use of and fidelity to localized areas for resting habitat within their broader range varies among island areas.

Supporting notes for data support score: Score = 2; A combination of photo-identification and genetics data support the distinction between island-associated stocks (Andrews et al., 2010; Hill et al. 2010). Sighting data from CRC further support the designated stock boundaries used to represent each stock's BIA here. Movement data from VHF satellite tagged spinner dolphins support limited offshore movements of these animals and residency to nearshore waters, particularly during the day (Norris et al., 1994). While it is known that spinner dolphins in the Hawaiian Islands exhibit site fidelity to one or more bays for daytime resting behavior (Thorne et al., 2012; Norris et al., 1994; Karczmarski et al., 2005; Lammers, 2004; Tyne et al., 2015), and hence may have core areas, no detailed movements from satellite tag data are available to make such boundary determinations in this assessment. Further, evidence for variation in use of daytime resting habitat among island areas has been more recently documented (Stack et al., 2020). Most abundance estimates for these stocks are dated, with the Hawaiʻi Island stock having the most recent and robust abundance estimate.

Spatiotemporal variability: s

Supporting notes for spatiotemporal variability: No information to suggest area is used dynamically or ephemerally.

Boundary certainty: 3

Supporting notes for boundary certainty: We have high confidence in the boundary certainty for the Oʻahu/Maui Nui spinner dolphin stock. Sightings from CRC survey efforts and previous studies have shown their nearshore habitat use with limited offshore movement that these boundaries reflect (Norris et al., 1994; Benoit-Bird and Au, 2003).

Months of year designation is applicable: Year-round

Tagging data supporting designation (Y/N): N

Visual observations/records supporting designation (Y/N): Y

# of observations/records: 50

# of years in which supporting visual data collected: 10 (2000-2020)

Supporting information: Although the BIA boundaries described in this assessment remain unchanged from Baird et al. (2015), we mapped sighting data collected from non-systematic, dedicated small boat surveys conducted by CRC to provide additional justification for the MHI boundaries. CRC non-systematic, dedicated small boat survey efforts were undertaken off Kauaʻi and Niʻihau, Oʻahu, Maui Nui, and Hawaiʻi Island in 12, six, nine, and 20 years, respectively, spanning 2000-2021 (see Baird et al., 2013 for details on surveys). CRC surveys off these islands combined total 148,080 km of effort with 303 sightings of spinner dolphin groups. Ship-based line-transect surveys throughout the Hawaiian Archipelago have been undertaken by National Marine Fisheries Service (NMFS) in 11 years between 2002 and 2020, but there was relatively little effort in nearshore waters where spinner dolphins occur in both the MHI and NWHI regions (Bradford et al., 2021). Within the MHI region, there were eight sightings within the known range of the three insular stocks and two sightings that were offshore and likely do not belong to the insular stocks. Although these large-scale surveys have covered the NWHI region, NMFS sightings of spinner dolphins in the NWHI region were not near Manawai (Pearl and Hermes Reef), Kuaihelani (Midway Atoll), nor Hōlanikū (Kure Atoll).

Acoustic detections/records supporting designation (Y/N): N

Photo-ID evidence supporting designation (Y/N): Y

# of years of photo records to compare: 2007

Supporting information: Hill et al., 2011

Genetic analyses conducted supporting designation (Y/N): Y

Nature of supporting information: Strong

Supporting information: Genetic studies have provided strong evidence for genetic differentiation among island-associated populations of spinner dolphins in Hawaii. This supporting evidence has led to the designation of five separate island-associated stocks recognized by NMFS (Andrews et al., 2006, 2010; Hill et al., 2010; Caretta et al., 2021).

What factors justify the boundary selection?: Baird et al. (2015) delineated five separate BIAs for insular spinner dolphins based on recognized stock boundaries (Caretta et al., 2021). The same boundaries were used for this assessment as no additional information to suggest revision of boundaries has been obtained since the 2015 report. Sighting locations were mapped as a line of supporting evidence for nearshore use by insular spinner dolphins and ultimately for the BIA boundaries. Island-associated stock boundaries, as reported in Caretta et al., (2021), served as the basis for each spinner dolphin BIA described here. The stock boundaries represent a 10 nautical mile offshore boundary based on anecdotal accounts of the distribution of spinner dolphins (Hill et al., 2010). For each BIA, we defined the inner (shoreward) boundary by a 5-m distance from shore.

Data sources: Baird et al., (2013); CRC unpublished (accessed October 2021); National Marine Fisheries Service, Pacific Islands Fisheries Science Center (2002-2020; accessed October 2021).

Approximate % of population that uses this area for the designated purpose (if known): 100

Approximate # of areas known specifically for this behavior (if feeding/cow-calf/mating/migratory) for this population: 1

References: Andrews, K.R., L. Karczmarski, W.W.L. Au, S.H. Rickards, C.A. Vanderlip, and R.J. Toonen. 2006. Patterns of genetic diversity of the Hawaiian spinner dolphin (Stenella longirostris). Atoll Research Bulletin 543:65-73

Andrews, K.R., L. Karczmarski, W.W.L. Au, S.H. Rickards, C.A. Vanderlip, B.W. Bowen, E.G. Grau, and R.J. Toonen. 2010. Rolling stones and stable homes: social structure, habitat diversity and population genetics of the Hawaiian spinner dolphin (Stenella longirostris). Molecular Ecology 19:732-748

Baird, R.W., D.L. Webster, J.M. Aschettino, G.S. Schorr, and D.J. McSweeney. 2013b. Odontocete cetaceans around the main Hawaiian Islands: habitat use and relative abundance from small-boat sighting surveys. Aquatic Mammals 39:253-269.

Baird, R.W., D. Cholewiak, D.L. Webster, G.S. Schorr, S.D. Mahaffy, C. Curtice, J. Harrison, and S.M. Van Paris. 2015. Biologically important areas for cetaceans within U.S. waters – Hawaiʻi Region. Aquatic Mammals 41(1):54-64 doi:10.1578/AM.41.1.2015.54

Baird, R.W. 2016. The lives of Hawaiʻi's dolphins and whales: natural history and conservation. University of Hawaiʻi Press, Honolulu, HI.

Benoit-Bird, K.J., and W.W.L. Au. 2003. Prey dynamics affect foraging by a pelagic predator (Stenella longirostris) over a range of spatial and temporal scales. Behavioral Ecology and Sociobiology 53:364-373.

Caretta, J.V., K.A. Forney, E.M. Oleson, D.W. Weller, A.R. Lang, J. Baker, M.M. Muto, B. Hanson, A.J. Orr, H. Huber, M.S. Lowry, J. Barlow, J.E. Moore, D. Lynch, L. Carswell, and R.L. Brownwell Jr. 2019. U.S. Pacific Marine Mammal Stock Assessments: 2018. U.S. Department of Commerce, NOAA.

Hill, M.C., E.M. Oleson, and K.R. Andrews. 2010. New island-associated stocks for Hawaiian spinner dolphins (Stenella longirostris longirostris): Rationale and new stock boundaries. Pacific Islands Fisheries Science Center Admin Report H-10-04

Hill, M.C., A.L. Bradford, K.R. Andrews, R.W. Baird, M.H. Deakos, D.W. Johnston, S.D. Mahaffy, A.J. Milette, E.M. Oleson, J. Ostman-Lind, A.A. Pack, S.H. Rickards, and S. Yin. 2011. Abundance and movements of spinner dolphins off the main Hawaiian Islands. Pacific Islands Fisheries Science Center Working Paper WP-11-013

Karczmarski, L., B. Wursing, and B. Winning. 1998. Socio-ecology and population biology of spinner dolphins Stenella longirostris in Midway Atoll, Northwest Hawaiian Chain, Central Pacific. Unpublished report to U.S. Fish and Wildlife Service and National Marine Fisheries Service. 41 pp.

Karczmarski, L., B. Wursig, G. Gailey, K.W. Larson, and C. Vanderlip. 2005. Spinner dolphins in a remote Hawaiian atoll: Social grouping and population structure. Behavioral Ecology 16(4):675-685.

Lammers, M.O. 2004. Occurrence and behavior of Hawaiian spinner dolphins (Stenella longirostris) along Oahu's leeward and south shores. Aquatic Mammals 30:237-250.

Norris, K.S., B. Würsing, R.S. Wells, and M. Würsig. 1994. The Hawaiian Spinner Dolphin. University of California Press, 408 pp.

R Core Team (2021). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/

Stack, S.H., G.L. Olson, V. Neamtu, A.F. Machernis, R.W. Baird, and J.J. Currie. 2020. Identifying spinner dolphin Stenella longirostris longirostris movement and behavioral patterns to inform conservation strategies in Maui Nui, Hawaiʻi. Marine Ecology Progress Series 644:187-197 doi:10.3354/meps13347

Thorne, L.H., D.W. Johnston, D.L. Urban, J. Tyne, L. Bejder, R.W. Baird, S. Yin, S.H. Rickards, M.H. Deakos, J.R. Mobley, A.A. Pack, and M.C. Hill. 2012. Predictive modeling of spinner dolphin (Stenella longirostris) resting habitat in the main Hawaiian Islands. PLoS ONE 7(8):e43167

Tyne, J.A., D.W. Johnston, R. Rankin, N.R. Loneragan, and L. Bejder. 2015. The importance of spinner dolphin (Stenella longirostris) resting habitat: implications for management. Journal of Applied Ecology 52:621-630 doi:10.1111/1365-2664.12434

Tyne, J.A., N.R. Longergan, D.W. Johnston, K.H. Pollock, R. Williams, and L. Bejder. 2016. Evaluating monitoring methods for cetaceans. Biological Conservation 201:252-260.