Supplementary File A:
Detailed summaries of all Hawai‘i BIAs

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)

Acronyms

BIA	Biologically Important Area
S-BIA	Small and resident BIA
R-BIA	Reproductive BIA
F-BIA	Feeding BIA
MHI	Main Hawaiian Islands (Niʻihau, Kauaʻi, Oʻahu, Maui, Molokaʻi, Lānaʻi, Kahoʻolawe, Hawaiʻi Island)
MN	Maui Nui (Maui, Molokaʻi, Lānaʻi, Kahoʻolawe)
HI	Hawaiʻi Island
O	Oʻahu
KN	Kauaʻi/Niʻihau
NWHI	Northwestern Hawaiian Islands
NOAA	National Oceanographic and Atmospheric Administration
NMFS	National Marine Fisheries Service, NOAA Fisheries
CRC	Cascadia Research Collective
OSU	Oregon State University
NIWC	Naval Information Warfare Center
PMRF	Pacific Missile Range Facility
EEZ	Exclusive Economic Zone
MMPA	Marine Mammal Protection Act

BIA Methods Summary

BIAs for all seven regions around the U.S. were consistently delineated, scored, and labeled using the methodology described in the Introductory chapter included in this special edition, Harrison et al. (in review). Additionally, Harrison et al. (in review) highlights the changes in BIA II since Vans Parijs et al. (2015), describes the intended use of the BIAs, and specifically addresses common mischaracterizations of the BIA I products to try to reduce inappropriate use of BIAs in the future. Fundamentally, BIAs are compilations of the best available science and have no inherent or direct regulatory power. We provide a brief overview of the methods outlined in Harrison et al. (in review) below.

The BIA II effort applied principles of expert elicitation in a more structured manner to identify, delineate, and score BIAs to ensure that information that was not incorporated during BIA I (e.g., Indigenous knowledge, local knowledge, or community science) was included. Expert elicitation is a formal, structured process for obtaining experts' opinions and knowledge to help inform decision-making, particularly in an information-limited situation. The BIA II expert elicitation process included wide-ranging information solicitation; extensive communication of purpose, intention, and protocols; clear documentation of methods; and extensive consistency review. Additional details on expert elicitation are included in Harrison et al. (in review).

A regional lead with cetacean expertise oversaw the identification, delineation, and scoring of the Hawaiʻi BIAs, engaging with additional subject matter experts (SMEs) as needed to ensure all available data and necessary expertise were included for all cetacean taxa. Four types of BIAs were defined (Table A): feeding areas (F-BIAs), reproductive areas (R-BIAs), migratory routes (M-BIAs), and small and resident populations (S-BIAs). Each BIA was delineated only for the times and areas for which direct information exists on a particular cetacean species, population, or stock. Any reliable published or unpublished information from scientific research, Indigenous or local knowledge, or community science, including both data and personal observations, were considered valid. F-BIAs, R-BIAs, or M-BIAs indicate where a substantial portion of a species "*preferentially* feeds"; "*selectively* mates, gives birth, or is found with neonates or calves"; or within which "a *substantial* portion" is known to migrate, respectively, and likely include less than 100% of the area and time in which the associated activity occurs. In contrast, BIA boundaries for small resident populations aim to include 100% of the population. Intentional "buffers" or other "precautionary" additions of area or time were not allowed. Similarly, predictions of potential habitat alone were insufficient to support a BIA delineation. BIAs were delineated within or adjacent to the U.S. Exclusive Economic Zone; however, the BIA was not truncated if it extended past the U.S. Exclusive Economic Zone (EEZ). When a BIA spanned more than one region, region leads worked together to delineate and score the BIA as a "transboundary" BIA. Transboundary BIAs are included in only one region's metadata, generally the region containing the larger area of the BIA.

All candidate BIAs were scored and labeled using five metrics: Intensity, Data Support, Importance, Boundary Certainty, and Spatiotemporal Variability (Table B). All scoring metrics except Spatiotemporal Variability were assigned an integer value ranging from 1 (“low”) to 3 (“high”). For each candidate BIA, Intensity and Data Support were independently scored using scoring rules specific to each BIA type. Then, Intensity and Support scores were combined to determine an overall Importance score using a single Importance Score matrix (Figure A) for all BIA types. Candidate BIAs with an Importance score of 0 were added to a list of watch list areas for future consideration. Some S-BIAs with an Importance score of 1 were also included in the watch list; this was necessary because the quantitative Intensity scoring protocols produce an Intensity score of 3 for a species with a small abundance and range, precluding an Importance score of 0 even when the supporting data are insufficient. Boundary Certainty and Spatiotemporal Variability (dynamic, ephemeral, or static) were assigned to each BIA, using the same rules across BIA types, and independent of the Intensity and Data Support scores.

Reproductive Areas (**R-BIA**)	Areas and times within which a particular species selectively mates, gives birth, or is found with neonates or calves.
Feeding Areas (**F-BIA**)	Areas and times within which aggregations of a particular species preferentially feed. These either may be persistent in space and time or associated with ephemeral features that are less predictable but are located within a larger area that can be delineated.
Migratory Routes (**M-BIA**):	Areas and times within which a substantial portion of a species is known to migrate; the route is spatially restricted.
Small and Resident Population (**S-BIA**)	Areas and times within which small and resident populations occupy a limited geographic extent.

Table A. Definitions of BIA types.

Score/Metric	Description	Possible scores/indicators
Intensity	Comparative significance of an area to the species in the context of the species’ range and size, and the definition of the BIA type. Considers the strength and type of characteristics that underlie an area’s identification as a BIA.	**1, 2, or 3**. Higher number = more intense characteristics
Data Support	Distinguishes meaningful differences in the information used to support the identification and scoring of a BIA. Considers the quantity, quality, and type of information, and associated uncertainties, upon which the BIA delineation depends.	**1, 2, or 3**. Higher number = more/higher quality supporting information
IMPORTANCE	Combines the Intensity and Support scores as depicted in Importance Matrix.	**1, 2, or 3**. Higher number = higher overall importance
Boundary Certainty	Characterizes the degree of certainty in the location and timing of the boundary.	**1, 2, or or 3**. Higher number = more certainty
Spatiotemporal Variability	Characterizes spatiotemporal variability of the BIA using one of three descriptors.	(**s**)tatic, (**e**)phemeral, or (**d**)ynamic.

Table B. Descriptions of the five metrics used to score and label BIAs.

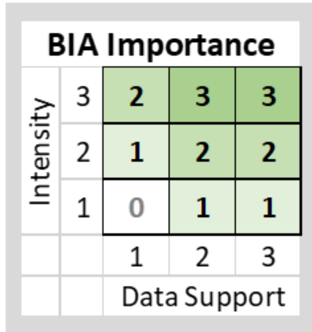

Figure A. Matrix used to combine Intensity and Support to score Importance.

The definition of a BIA unit was expanded for this BIA II process. In the simplest case, a BIA unit corresponds to a single polygon and one continuous period within which a species engages in a particular biologically important activity, or it corresponds to the range of a small resident population. However, it is possible that multiple polygons of the same type of BIA for a species could exist in a single region and period. In that case, a cluster of BIA polygons could be delineated, scored, and labeled as a single unit, regardless of whether they share common boundaries, as long as the scores for all metrics were identical across all polygons in the cluster. Another new feature of this BIA II process was the option to identify "hierarchical" BIAs for cases in which high-resolution information are available and it is appropriate and helpful to identify a gradation in animal use (Intensity), available information (Data Support), Boundary Certainty, or ecological characteristics (Spatiotemporal Variability) across a broader area. For example, in some cases data may support a single core area (a "child" BIA) identified within the larger "parent" BIA. In other cases, one or more clusters of identically scored polygons may appropriately be identified as a child BIAs within a larger parent BIA. For R-, F-, and M-BIAs, the Intensity score for the parent BIA must be less than the highest Intensity score among the child BIAs. For S-BIAs, when hierarchical scoring is used to identify core habitat within the population's range, the Intensity score may be the same for the core habitat (the child BIA) and the overall range (the parent BIA), as S-BIAs have quantitative scoring protocols and the parent BIA could score a 3. Potential child BIAs could not be added to the watch list, as any potential child BIA would inherently qualify as a BIA since it is within the parent BIA.

A label was generated for each individual BIA unit for metadata purposes. Labels were generated using information on the BIA type (S-, R-, F-, or M-BIA); Importance, Spatiotemporal Variability, and Boundary Certainty scores; region code (EC = East Coast, GOM = Gulf of Mexico, WC = West Coast, HI = Hawai‘i, GOA = Gulf of Alaska, ABS = Aleutian Islands and Bering Sea, ARC = Arctic); identification number; and suffix that indicates hierarchical (0 followed by alphabetical index of child BIAs, e.g., -0ab for parent and -a and -b for child BIAs, respectively) or non-hierarchical structure (0).

References

Harrison, J., Ferguson, M.C., New, L., Cleary, J., Curtice, C. DeLand, S. et al. Biologically important areas for cetaceans within U.S. and adjacent waters: Updates and the application of a new scoring system. Front. Mar. Sci. (in review).

Van Parijs, S.M., Curtice, C., and Ferguson, M. (Eds.). (2015). Biologically Important Areas for Cetaceans within U.S. waters. Aquatic Mammals (Special Issue) 41(1). Doi: 10.1578/AM.41.1.2015.1

Hawai‘i BIA Definitions for Species/Stock/Population/Community

Below we define the terms *species*, *stock*, and *population* with respect to our application of them in the Hawai‘i BIA delineation process. Because nearly all BIAs delineated in Hawai‘i were S-BIAs, we define *species*, *stock*, and *population* in specific regards to species with small and resident populations in Hawai‘i.

Species: Species of cetacean.

Stock: population that is formally recognized as a management unit by NOAA, and as such, meets a set of identifying criteria (e.g., genetics, geographic range, morphology, life history, acoustic call types) that concomitantly provides strong support for the delineation of a small and resident BIA. More specifically, “a stock is recognized as being a management unit that identifies a demographically independent biological population” by the U.S. Marine mammal Protection Act (MMPA). Examples: Hawai‘i Island common bottlenose dolphins, MHI insular false killer whales.

Population: generally, an interacting group of individuals of a particular species inhabiting the same space. In the context of odontocetes in Hawai‘i and the BIAs, these refer to populations of resident odontocetes that may not be formally recognized as stocks/management units but for whom there exist several lines of evidence to support their identity as a small and resident population (e.g., movement, genetics, site fidelity, associations from photo-ID), thus warranting S-BIA delineation. These populations may not be formally recognized as stocks due to lack of strength of information required for stock designation under the objectives of the MMPA (e.g., proof of demographic independence). This may also relate to the fact that the pace at which information on population structure is accrued through time varies among species in Hawai‘i, which is largely associated with the behavior of each species (e.g., cryptic/elusive; Oleson et al., 2013). Examples: Blainville’s beaked whales, Cuvier’s beaked whales.

Community: largely behaviorally self-contained group of animals belonging to one population that may inhabit a localized region within the population’s overall range, but we do not have evidence to suggest the group represents its own entire population differentiated from other groups within the population’s range. Examples: MHI short-finned pilot whale regional communities, rough-toothed dolphin Kaua‘i/Ni‘ihau and O‘ahu communities (KNO).

General explanation of how we approached S-BIA delineation for stocks and populations

Some Hawai‘i S-BIAs were delineated for specific stocks. However, for some species in Hawai‘i, there is enough information supporting the existence of small, resident populations that may be differentiated from other populations of the same species occurring in the Hawaiian Islands (e.g., pelagic or other distinct island-associated populations), but these populations are not yet formally recognized as a stock. Therefore, based on all available supporting evidence, we also delineated S-BIAs for populations that are not formally stocks. Throughout the manuscript and each individual account included in this document, “stock” will only be used in reference to populations that are formally recognized as such. We use the term “population” in both specific cases (e.g., for island-associated populations not recognized as stocks, or a breeding population of baleen whales) and more generally, as all Hawaiʻi BIAs were delineated for some focal population regardless of whether they are recognized as a formal management unit by NOAA or not. For each population unit with a BIA (i.e., whether recognized as a stock or not), we refer to them as a BIA population.

The use of the term “community” was only relevant to populations in which we have evidence suggesting the existence of said communities.

References

Caretta, J.V., Oleson, E.M., Forney, K.A., Muto, M.M., Weller, D.W., Lang, A.R., et al. (2021). U.S. Pacific Marine Mammal Stock Assessments: 2020. NOAA Technical Memorandum, NOAA-TM-SWFSC-646. (U.S. Department of Commerce)

Oleson, E.M., Baird, R.W., Martien, K.K., and Taylor, B.L. (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 submitted to the Pacific Scientific Review Group, Del Mar, April 2013.

Note on maps presented in each section following:

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BIAs: Table of Contents

Rough-toothed dolphin (*Steno bredanensis*)

Background

Although NMFS recognizes only a single stock of rough-toothed dolphins (*Steno bredanensis*) within the Exclusive Economic Zone (EEZ) around the Hawaiian archipelago, there is evidence for considerable population structure within the archipelago, indicating the existence of several island-associated populations (Albertson et al., 2016; Baird et al., 2008, 2021; Baird, 2016; Oleson et al., 2013). Genetic analysis of biopsy samples collected from rough-toothed dolphins revealed no significant differences in mtDNA or nuclear DNA for individuals off Kaua‘i/Ni‘ihau versus off O‘ahu, but did reveal differentiation from individuals sampled off Hawai‘i Island (Albertson et al., 2016). Analyses of photo-identified individuals also indicate associations of individuals from Kaua‘i/Ni‘ihau and O‘ahu, although the degree of association appears to be limited; each island area has a well-defined social cluster of regularly associating individuals with only a single, mutual individual connecting them (Baird et al., 2021). One satellite-tagged rough-toothed dolphin from Kaua‘i/Ni‘ihau moved to waters off west O‘ahu for a brief period, further supporting the existence of some association between the two island-associated communities (Baird, 2016; Baird et al., 2019). Although satellite tags have never been deployed on rough-toothed dolphins off O‘ahu, photo-identification analyses indicate high site fidelity to the island, and movements to Kaua‘i/Ni‘ihau only rarely occur (CRC unpublished). Two rough-toothed dolphins have been documented moving from Kaua‘i to Hawai‘i Island; however, those individuals were not associated with rough-toothed dolphins from the Hawai‘i Island population (Baird et al., 2008) and were later documented back off Kaua‘i (Baird 2016). In addition, a few inter-island movements between Hawai‘i Island and Lāna‘i and Moloka‘i have been documented through photo-identification data, providing evidence for some degree of movement between these island areas (CRC unpublished). The degree of association between travelling dolphins and residents from each island community is unclear due to limited information on this species off Maui Nui. Limited satellite tag-derived movement data preclude a better understanding of movements between Maui Nui and Hawai‘i Island. Based on these independent lines of evidence, rough-toothed dolphins off Kaua‘i, Ni‘ihau, and O‘ahu meet the criteria of S-BIA and are assessed as a single population (KNO hereafter) for the purposes of this BIA assessment, while recognizing each island-associated population may have different core ranges. Rough-toothed dolphins associated with Hawai‘i Island and Maui Nui (MNHI hereafter) are assigned a separate BIA. Here we detail the BIA for the KNO population.

KNO: BIA boundary delineation

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 O‘ahu and some individuals off O‘ahu have associated with those off Kaua‘i/Ni‘ihau, all Kaua‘i, Ni‘ihau, and O‘ahu 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 O‘ahu and Kaua‘i/Ni‘ihau dolphins, in addition to the O‘ahu community’s high site fidelity, there is likely a second core area for the KNO population off O‘ahu that we do not have sufficient information to delineate a child BIA for at this time.

KNO: Sighting and photographic data

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 (Table 1, Figure 1; see Baird et al., 2013 and Baird et al., 2019 for details on surveys). Surveys off Kauaʻi, Niʻihau, and Oʻahu total 33,850 km of effort with a total of 295 rough-toothed dolphin sightings (Table 1, Figure 1). 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. For example, non-CRC contributions identified over 65% of the individuals included in CRC's photo-identification catalog of the Oʻahu cluster of rough-toothed dolphins. 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 insular population or within the known range of the insular population were used in boundary determinations (n=17; Figure 1, 3); effort from these surveys in the area shown in Figure 1 total 7,238 km (9 individual surveys between 2002-2020).

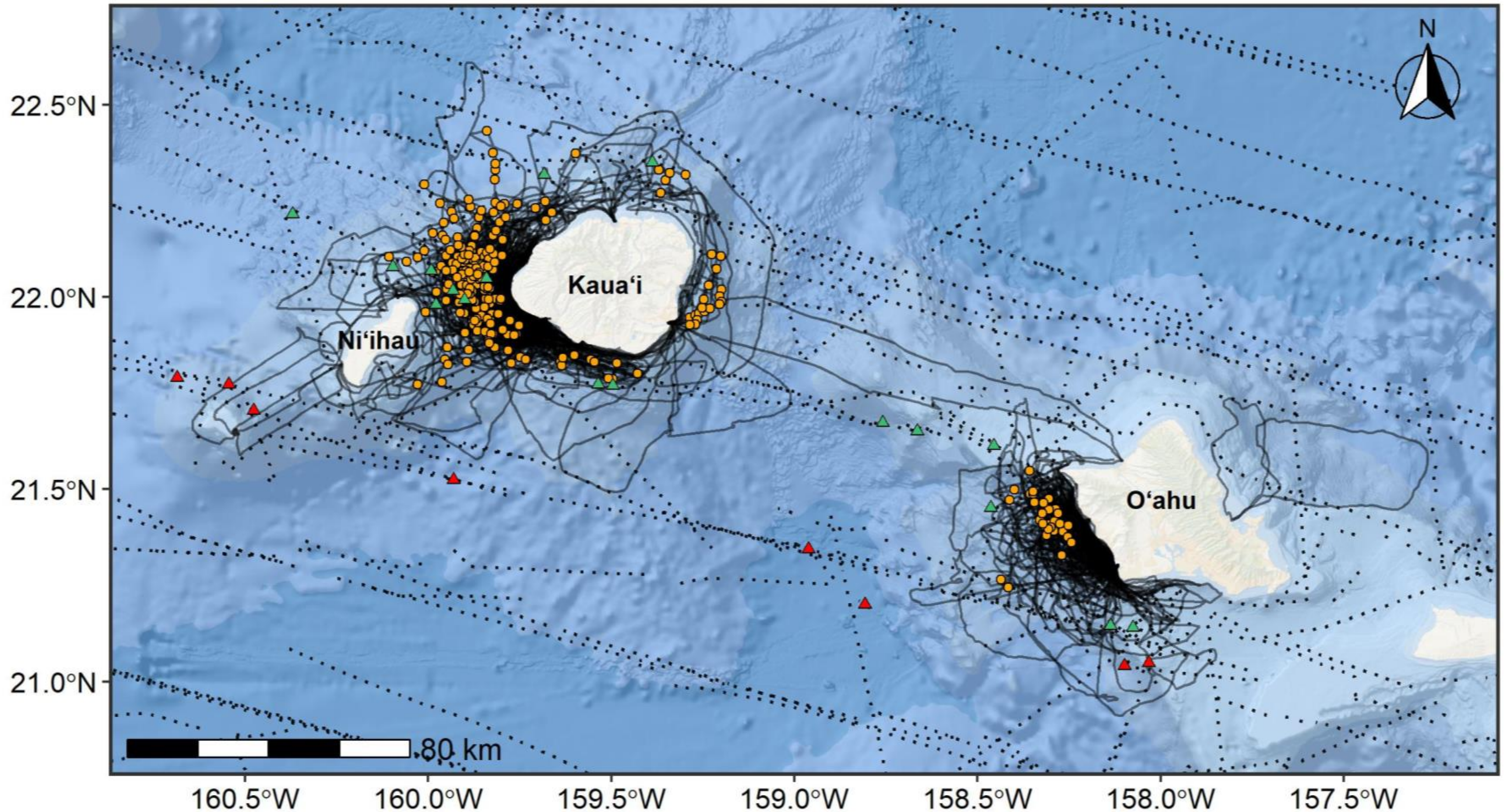

Figure 1. Rough-toothed dolphin sighting locations (circles = CRC, triangles = NMFS) off Kauaʻi and Niʻihau (n=274) and Oʻahu (n=38) overlaid on CRC small-boat survey research vessel tracklines (solid lines) from efforts conducted during 2002-2021 (33,850 km of effort) and NMFS ship-based line-transect surveys (dotted lines) conducted during 2002-2020 (7,238 km of effort in the area mapped here). Red NMFS sighting locations (n=8) indicate sightings where population assignment is currently unknown and/or sightings are outside the known range of the insular population. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Table 1. KNO rough-toothed dolphin sighting data used in boundary determinations

Source	Island area	Study duration (first sighting – last sighting)	# unique years with sightings	Total # sightings	Median group size (range)
CRC	Kauaʻi/Niʻihau	2003-2021	13	263	5 (1-140)
CRC	Oʻahu	2003-2017	5	32	7 (1-46)
NMFS	Kauaʻi/Niʻihau	2002-2020	5	11	14 (3-62)
NMFS	Oʻahu	2002-2020	5	6	29 (13-73)
	Total	2003-2021	15	312	11 (1-140)

KNO: Satellite tag data

Satellite tags were deployed on a total of 19 rough-toothed dolphins during dedicated survey efforts off Kauaʻi and Niʻihau from 2011-2018 (Table 2, Figure 2; Shaff and Baird, 2021). Detailed methods on satellite tag data processing methods are provided in Supplementary File B. 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 1-hour intervals. 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, 2021).

Table 2. KNO rough-toothed dolphin satellite tag data summary

# deployments	Study duration (first tag – last tag)	# unique years with deployments	Median deployment duration (min-max) days	Total # Argos locations*	Total # hourly *crawl* locations
19	2011-2018	8	12.5 (3.7-27.7)	3,642	5,566

*Value represents Douglas-filtered Argos locations used to generate *crawl* tracks. See supplementary material for details on satellite tag processing methods.

KNO Parent BIA boundary: Range size

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) (Figure 3). 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* (Figure 3); 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 km^2.

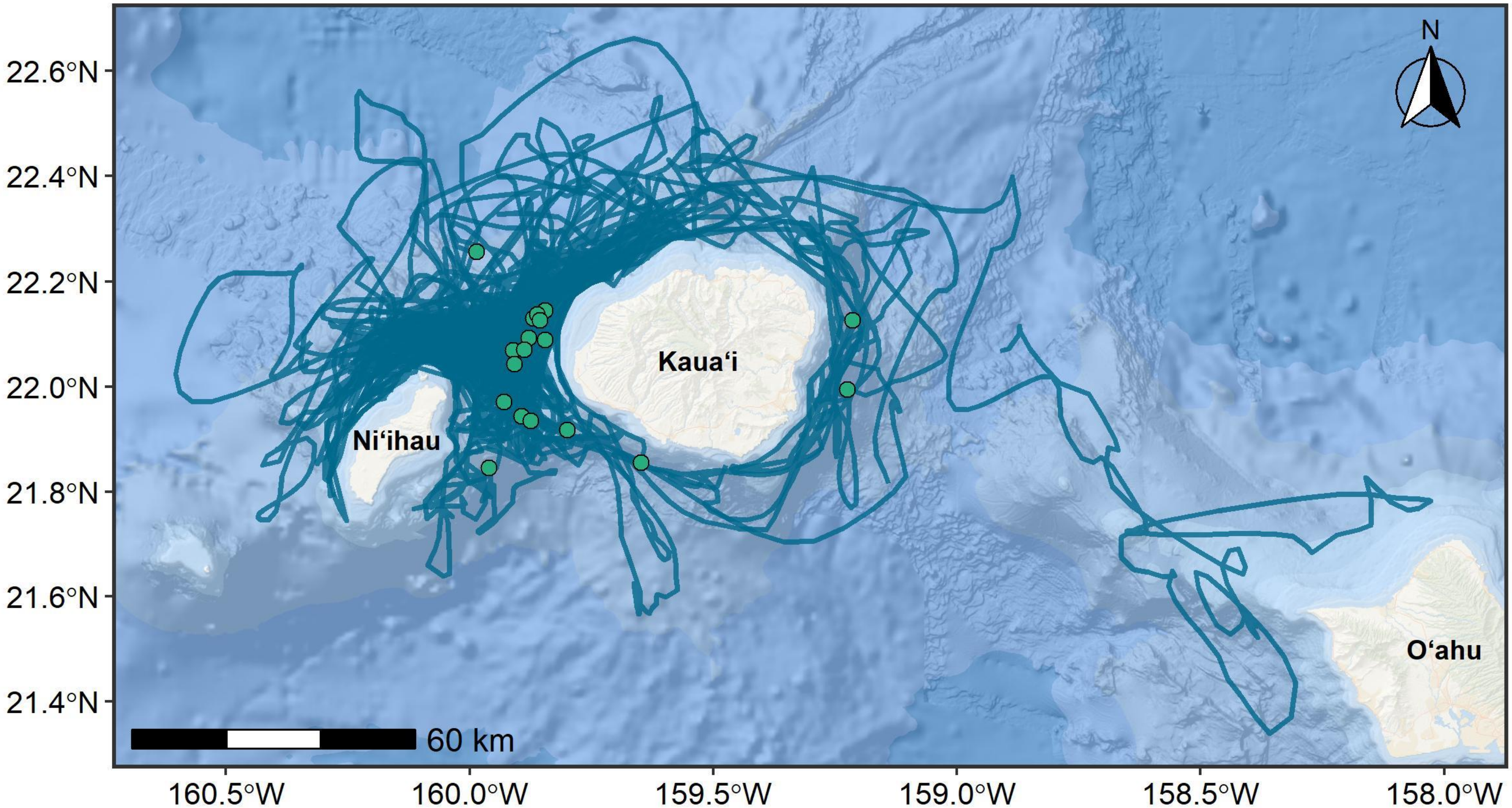

Figure 2. Tracklines of hourly *crawl* positions of satellite-tagged rough-toothed dolphins (n=19), re-routed around the 200-m isobath where necessary to avoid tracks crossing land. Tag deployment locations are shown as green circles. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

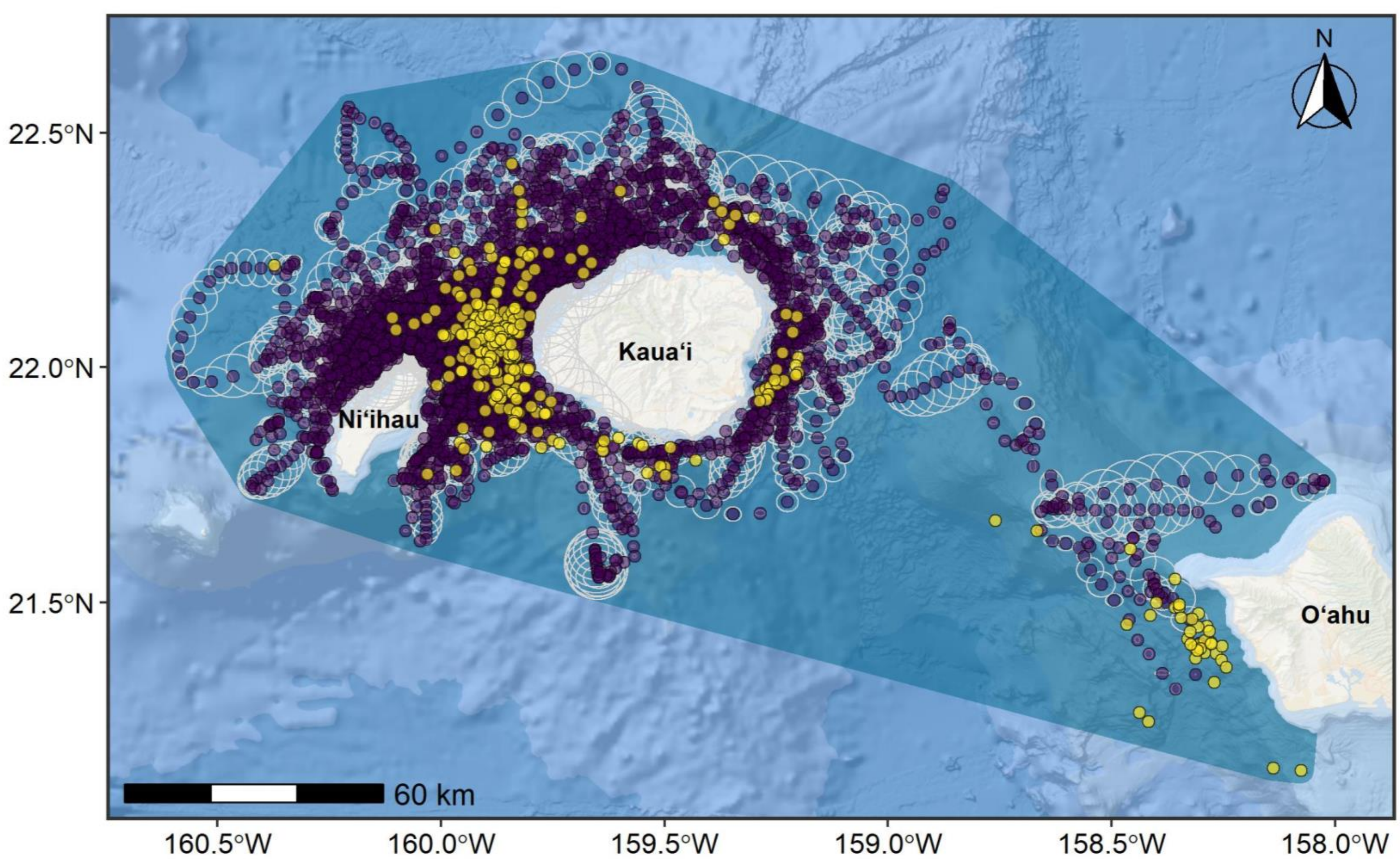

Figure 3. Parent BIA boundary (blue polygon) for the KNO rough-toothed dolphin population represented as a minimum convex polygon (MCP) encompassing all *crawl*-predicted satellite tag locations (purple circles) and sighting locations (yellow circles), extended by 3-km to the outer boundary to capture *crawl* standard error (68% confidence interval) ellipses (light grey ellipses). The inner (shoreward) boundary was defined as the 200-m isobath. Points are partially transparent to highlight high-density areas (i.e., where multiple points overlap). Total area of the BIA = 25,083 km^2. Note: not all error ellipses are visible, as their size may be smaller than that of the mapped point. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

KNO Parent BIA: Scoring
Intensity
Abundance:
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 U.S. 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.

Range size:
The size of the modified MCP representing the parent BIA is **25,083 km^2.**

Scoring criteria:
Intensity scoring: First, abundance and range size are scored independently as follows for each population based on the best available information:

Abundance: **(3)** = 125 or fewer individuals; **(2)** = 126 to 500 individuals; **(1)** = 501 to 2000 individuals.

Range size: **(3)** = less than 2,000 km^2; **(2)** = 2,001-10,000 km^2; **(1)** = greater than 10,001 km^2

Abundance and range size scores are combined to generate an overall Intensity score using the matrix below:

S-BIA Intensity				
Range	3	2	3	3
	2	1	2	3
	1	1	1	2
		1	2	3
		Abundance		

Abundance = 501-2,000; **score = 1**
Range size = 25,083 km^2; **score = 1**
<u>Overall Intensity score = 1</u>

Rationale
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.

Data Support:
Amount and quality of information used to delineate BIA; justified in the narrative.

(3) = high confidence in both the fact that the population is small and resident and the abundance and range size estimates of population
(1) = notably lower confidence
(2) = represents the remainder of situations that are not notably high or low confidence

Data Support notes:

- 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 small-boat survey 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/Maui Nui 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

Data Support score = 2 (in between low and high confidence)
Rationale
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.

Importance score

Importance Score Matrix

Intensity	3	**2**	**3**	**3**
	2	**1**	**2**	**2**
	1	0	**1**	**1**
		1	2	3
		Data Support		

Intensity = 1
Data Support = 2
<u>Importance score = 1</u>

Boundary Certainty:
Describe the factors used in the boundary delineation.

- **(3)** = high confidence in boundary location
- **(1)** = notably lower confidence
- **(2)** = represents the remainder of situations that are not notably high or low confidence

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.
<u>Boundary Certainty score = 2</u>

Spatiotemporal Variability indicator:
Dynamic (d), ephemeral (e), or static (s). If the area is dynamic or ephemeral, describe the factor(s) that drive the change in location or timing.
Spatiotemporal Variability indicator **is static**. No information to suggest the area is used dynamically or ephemerally.

KNO Rough-toothed dolphin child BIA

Satellite tag locations are concentrated in the Kaulakahi Channel between Kaua‘i and Ni‘ihau (Figure 2,3). To estimate this population’s core area(s) of use, 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 (Figure 4) 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.

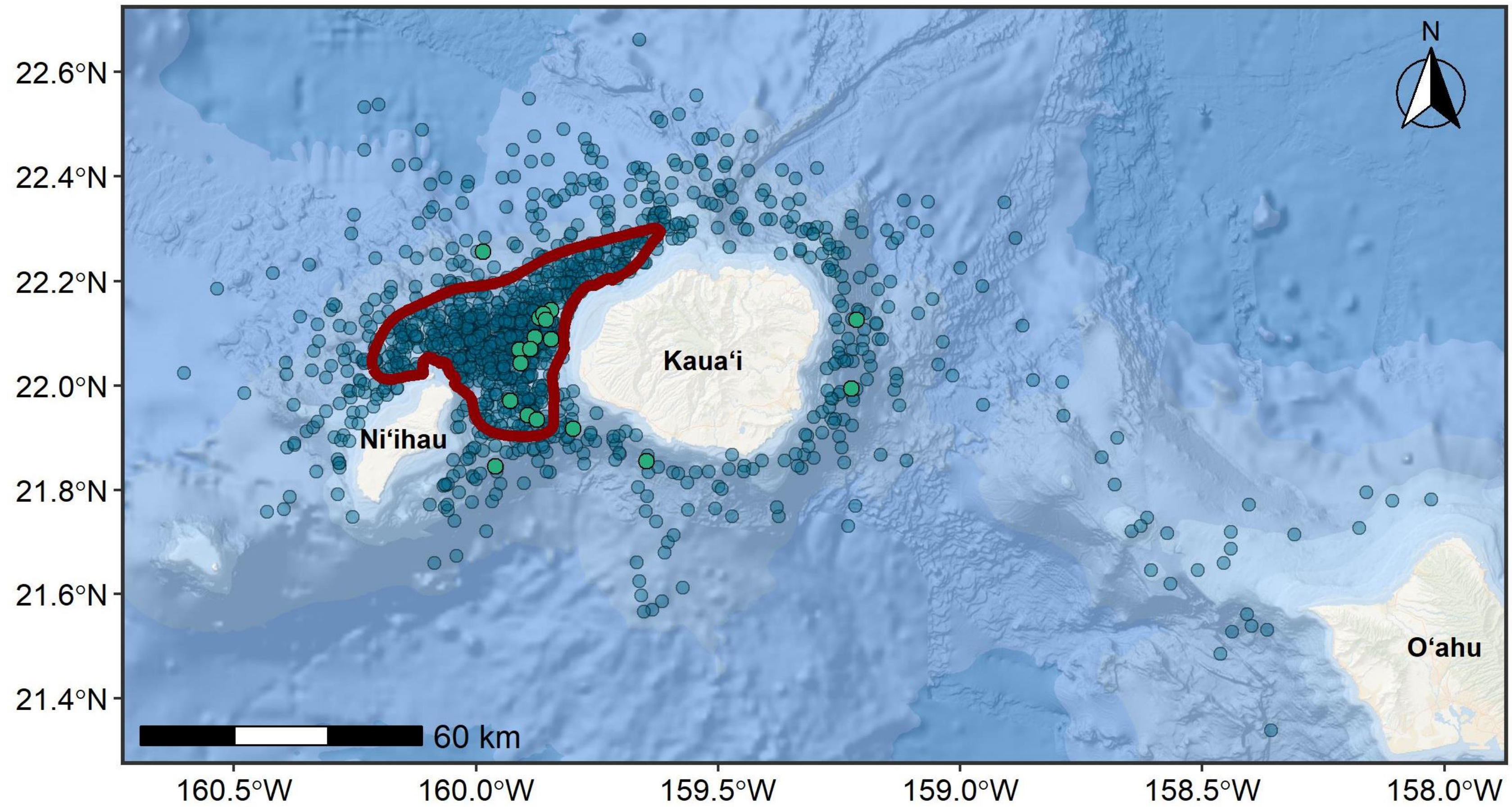

Figure 4. Four-hour *crawl* locations of satellite-tagged rough-toothed dolphins (pseudoreplicates excluded, n=1,324 *crawl* locations) shown as shaded blue points and dark red outline represents the core range of the sample population (50% isopleth of UD estimated from kernel density analysis), modified to exclude areas within the 200-m isobath. Tag deployment locations are shown as green circles. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

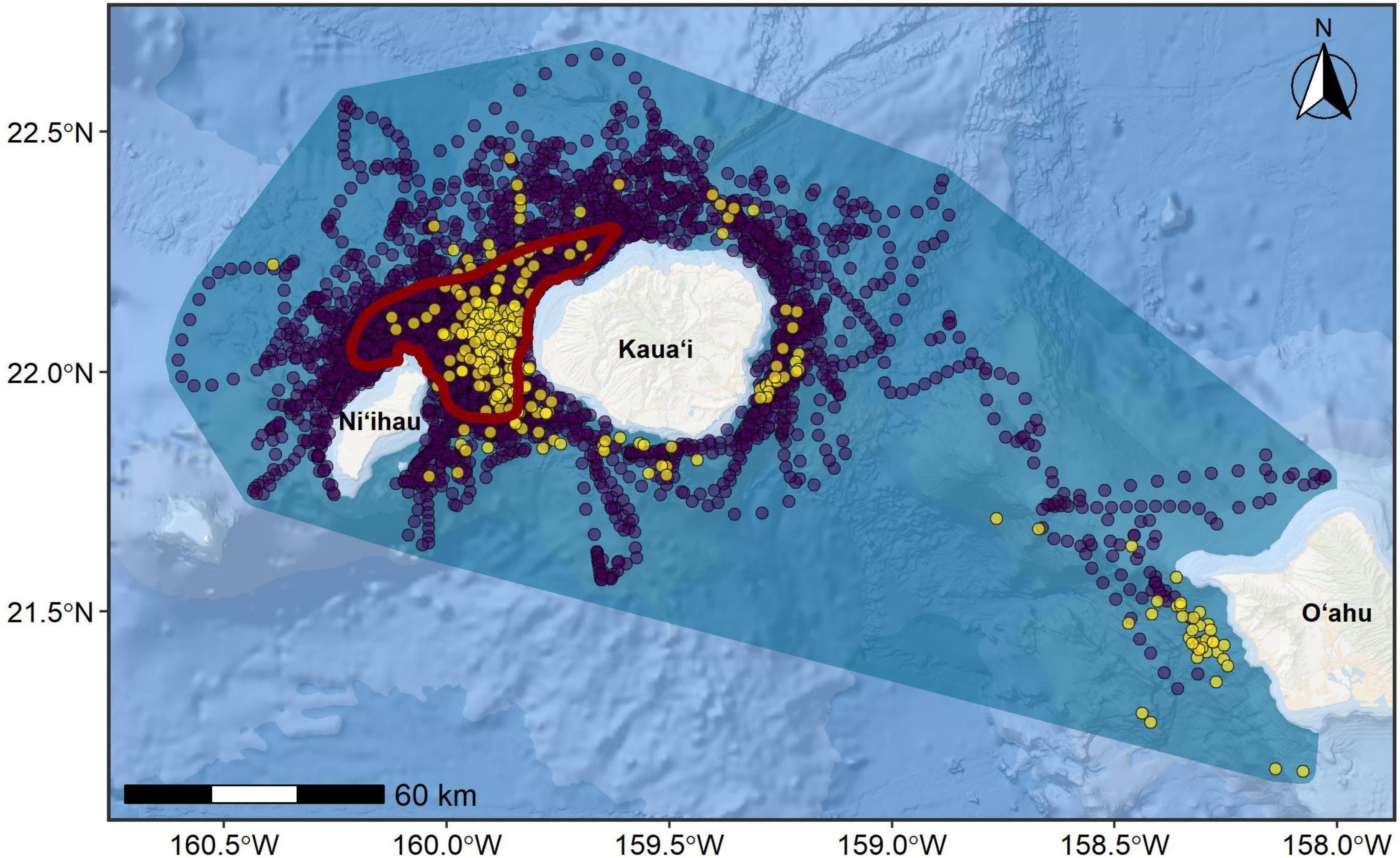

Figure 5. Parent BIA boundary (blue polygon) and child BIA (core range; dark red polygon) for the KNO rough-toothed dolphin population, shown with all sighting locations (yellow circles) and hourly *crawl*-predicted tag locations (purple circles). Points are partially transparent to highlight high-density areas (i.e., where multiple points overlap). The total area of the parent BIA = 25,083 km^2 and child BIA = 1,098 km^2. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

KNO Child BIA scoring
Intensity
Abundance:
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 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 child BIA 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.

Range size:
Area of core range (50% isopleth of UD) excluding land is **1,098 km^2**

<u>**Overall Intensity score = 2**</u>

Data Support
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).
<u>**Data support score = 2**</u>

Importance Score Matrix

Intensity	3	2	3	3
	2	1	2	2
	1	0	1	1
		1	2	3
		Data Support		

Importance score:
<u>**Importance score = 2**</u>
Rationale:
Individuals were tagged in different years and seasons, and some were tagged outside of the core range, yet all tagged individuals used the core range. The majority (61%) of sighting locations are also within the child BIA (estimated core range). It is hard to approximate the proportion of the population that would be included in the core range.

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.
Boundary Certainty score = 2

Spatiotemporal Variability indicator:
No information to suggest their core range varies over space or time (static).

Summary of BIA scoring for KNO rough-toothed dolphins (see Figure 5)

		Scoring				
	S-BIA	**Intensity**	**Data Support**	**Importance**	**Boundary Certainty**	**Spatiotemporal Variability**
Parent BIA	MCP	1	2	1	2	s
Child BIA	50% isopleth of UD	2	2	2	2	s

KNO rough-toothed dolphin BIA labels
Parent: **S-BIA1-s-b2-HI026-0a**
Child: **S-BIA2-s-b2-HI026-a**

MNHI: BIA boundary delineation

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.

MNHI: Sighting and photographic data

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 (Table 3, Figure 6, 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 and Maui Nui (near and offshore, as mapped in Figure 6) total 8,636 km of effort with 26 sightings of rough-toothed dolphins. Two CRC sightings and three NMFS sightings (four 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; Figure 6). An additional seven offshore NMFS sightings were excluded from this process as 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 (Figure 6, Table 3). 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 MNHI 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 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.

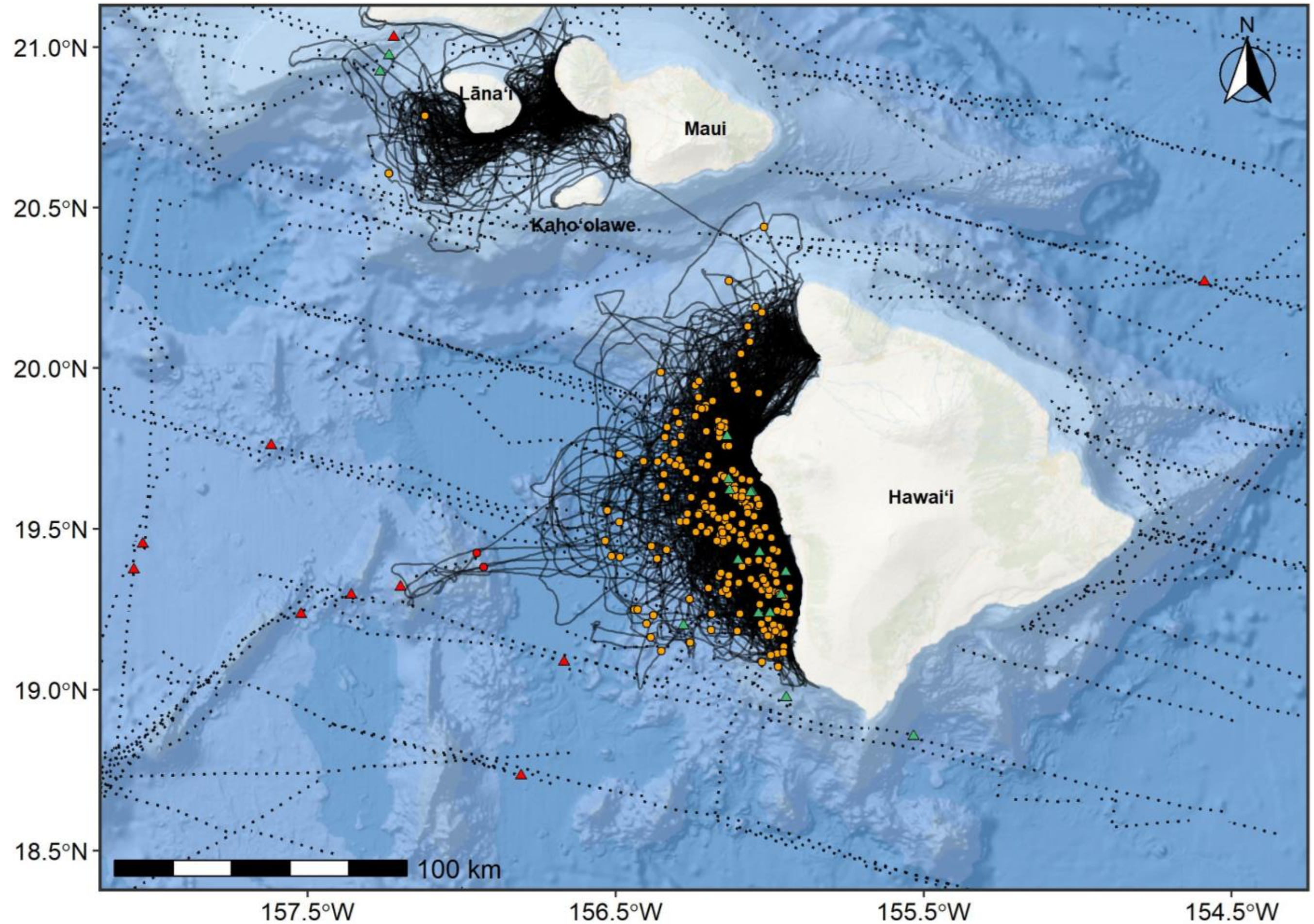

Figure 6. Resident rough-toothed dolphin sighting locations off Hawaiʻi Island and Maui Nui (CRC (orange circles), n=213; NMFS (green triangles), n=16) overlaid on research vessel tracklines from efforts conducted by CRC (solid lines) and NMFS (dotted lines) during 2000-2021 (122,866 km of effort combined). Two CRC sightings (red circles) and ten NMFS sightings (red triangles) shown here were excluded from the BIA boundary determination process as the population assignment of individuals encountered remains uncertain at this time. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Table 3. Maui Nui- Hawaiʻi Island (MNHI) rough-toothed dolphin sighting data used in boundary determinations

Source-Island area*	Study duration (first sighting – last sighting)	# unique years with sightings	Total # sightings	Median group size (range)
CRC-LN	2012, 2017	2	2	20 (12-28)
CRC-HI	2002-2021	20	211	6 (1-80)
NMFS-LN	2017, 2020	2	2	20 (16-24)
NMFS-HI	2002-2020	6	14	10 (3-34)
Total	2002-2021	20	229	6 (1-80)

MNHI: Satellite tag data

One satellite tag was deployed on a rough-toothed dolphin during a dedicated survey effort off Hawaiʻi Island in 2018 (Table 4, Figure 7). Detailed methods on satellite tag data processing methods are provided in Supplementary File B. 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 1-hour intervals.

Table 4. MNHI rough-toothed dolphin satellite tag data summary

# deployments	Deployment year	# unique years with deployments	Deployment duration (days)	Total # Argos locations*	Total # hourly *crawl* locations
1	2018	1	7.5 days	93	180

*Value represents Douglas-filtered Argos locations used to generate *crawl* tracks. See supplementary material for details on satellite tag processing methods.

MNHI BIA boundary: Range size

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) (Figure 8). 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 km^2.

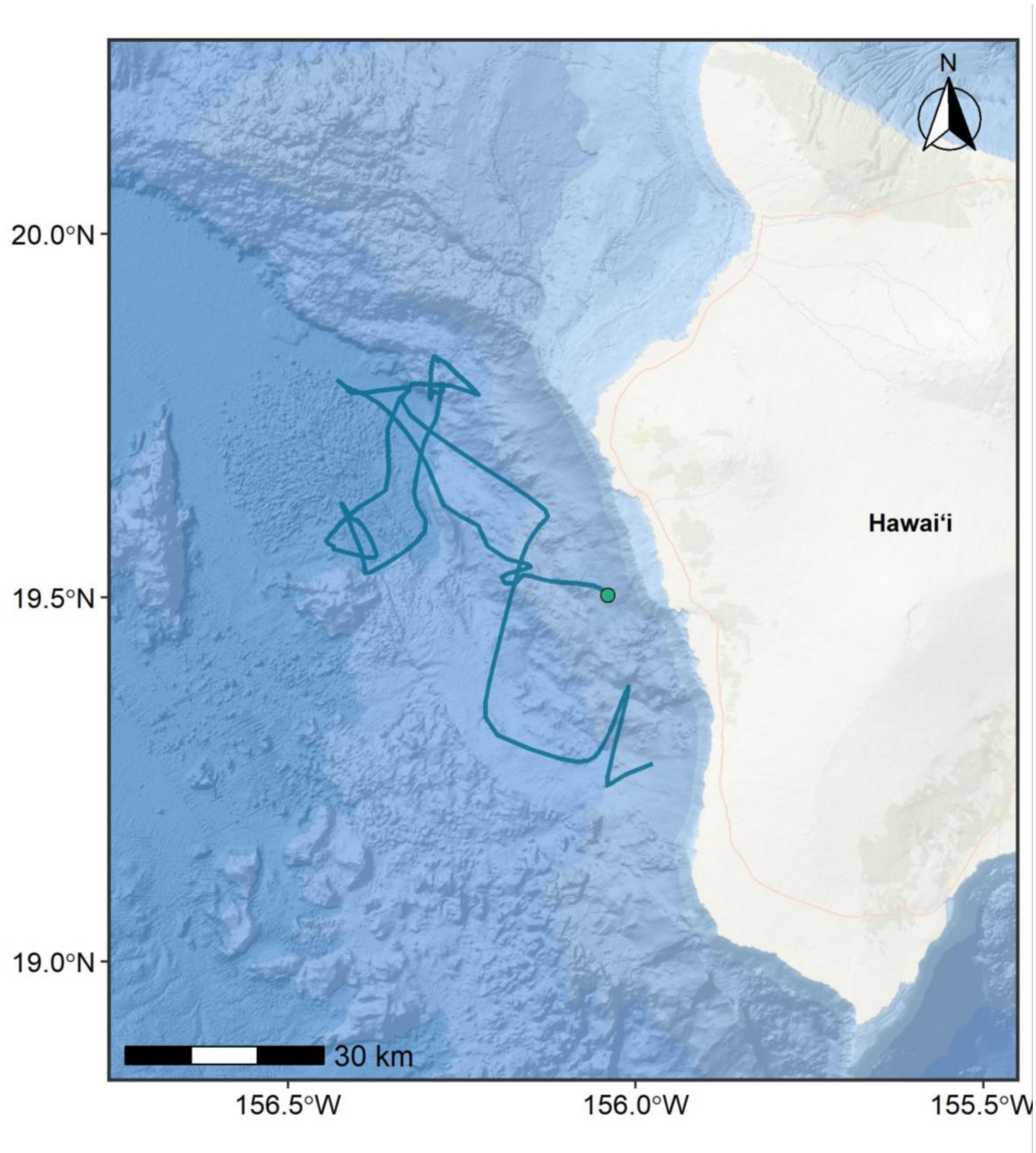

Figure 7. Trackline of hourly *crawl* positions of a single satellite-tagged rough-toothed dolphin. Tag deployment location is shown as a green circle. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

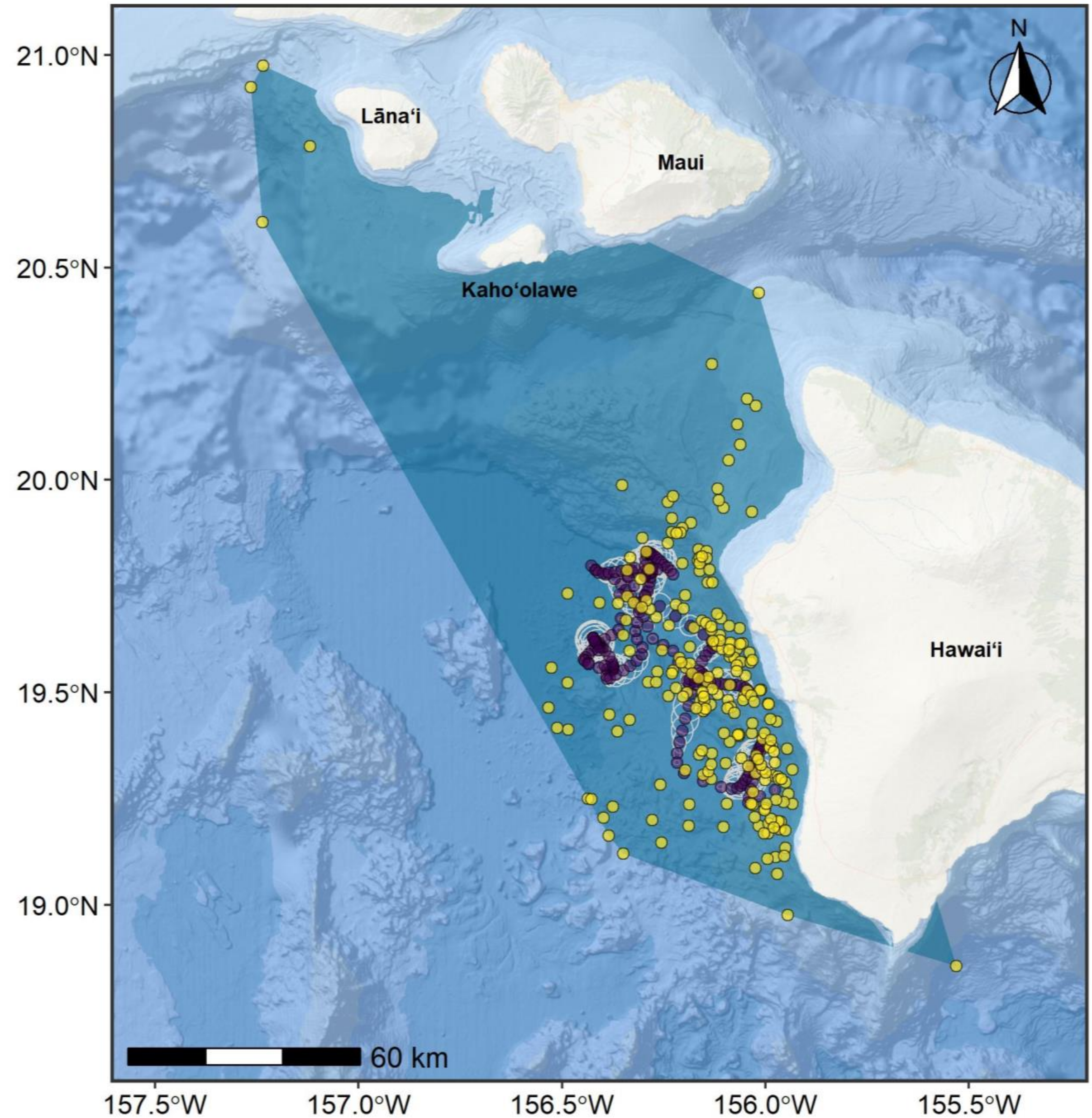

Figure 8. BIA boundary (blue polygon) for the MNHI rough-toothed dolphin population represented as a minimum convex polygon (MCP) encompassing all *crawl*-predicted satellite tag locations (purple circles) with associated standard error (68% confidence interval) ellipses (light grey ellipses) and sighting locations (yellow circles). The inner (shoreward) boundary was defined by the 300-m isobath. Points are partially transparent to highlight high-density areas (i.e., where multiple points overlap). Total area of the BIA = 15,112 km^2. Note: not all error ellipses are visible, as their size may be smaller than that of the mapped point. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

MNHI BIA: Scoring

Intensity

Abundance:

This population has not been formally recognized as a stock within the U.S. Hawaiian EEZ, and there is no specific abundance estimate for the Hawai‘i Island rough-toothed dolphin population. The latest abundance estimate for the entire Hawai‘i stock of rough-toothed dolphins, derived from a line-transect survey within the U.S. 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 Hawai‘i 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 Hawai‘i 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, although it is also possible that the population size is less than 500 individuals, given the Baird et al. (2008) estimate.

Range size:

The size of the MCP representing the BIA is 15,112 km^2.

Scoring criteria:

Intensity scoring: First, abundance and range size are scored independently as follows for each population based on the best available information:

Abundance: **(3)** = 125 or fewer individuals; **(2)** = 126 to 500 individuals; **(1)** = 501 to 2000 individuals.

Range size: **(3)** = less than 2,000 km^2; **(2)** = 2,001-10,000 km^2; **(1)** = greater than 10,001 km^2

Abundance and range size scores are combined to generate an overall Intensity score using the matrix below:

S-BIA Intensity				
Range	3	2	3	3
	2	1	2	3
	1	1	1	2
		1	2	3
		Abundance		

Abundance = 501-2,000; **score = 1**

Range size = 15,112 km^2; **score = 1**
<u>Overall Intensity score = 1</u>

Rationale
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.

Data Support:
Amount and quality of information used to delineate BIA; justified in the narrative.

- **(3)** = high confidence in both the fact that the population is small and resident and the abundance and range size estimates of population
- **(1)** = notably lower confidence
- **(2)** = represents the remainder of situations that are not notably high or low confidence

Data Support notes:

- 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 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

<u>Data Support score = 2 (intermediate confidence)</u>
Rationale
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.

Importance score

Importance Score Matrix

Intensity	3	2	3	3
	2	1	2	2
	1	0	1	1
		1	2	3
		Data Support		

Intensity = 1
Data Support = 2
<u>**Importance score = 1**</u>

Boundary Certainty:
Describe the factors used in the boundary delineation.

- **(3)** = high confidence in boundary location
- **(1)** = notably lower confidence
- **(2)** = represents the remainder of situations that are not notably high or low confidence

We have intermediate confidence in Boundary Certainty for the S-BIA for 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 (Figure 8). 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.
<u>**Boundary Certainty score = 2**</u>

Spatiotemporal Variability indicator:
Dynamic (d), ephemeral (e), or static (s). If the area is dynamic or ephemeral, describe the factor(s) that drive the change in location or timing.
Spatiotemporal variability indicator **is static**. No information to suggest the area is used dynamically or ephemerally.

Summary of BIA scoring for MNHI rough-toothed dolphins (see Figure 8)

	Scoring

	S-BIA	Intensity	Data Support	Importance	Boundary Certainty	Spatiotemporal Variability
BIA	MCP	1	2	1	2	s

BIA label for MNHI rough-toothed dolphin S-BIA:
S-BIA1-s-b2-HI016-0

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Common bottlenose dolphin (*Tursiops truncatus*)

Background

There are four island-associated stocks of common bottlenose dolphins (*Tursiops truncatus*; bottlenose dolphin, hereafter) recognized by NMFS within the U.S. Exclusive Economic Zone (EEZ) around the Hawaiian Islands. Each stock is defined by insular regions around Kaua‘i/Ni‘ihau, O‘ahu, Maui Nui, and Hawai‘i Island (Caretta et al., 2021). These stocks are considered demographically independent from one another based on genetic differentiation (Martien et al., 2011) and resighting rates within island areas from long-term photo-identification studies (Baird et al., 2009; Baird, 2016; CRC unpublished). Information from both satellite tag data and photo-identification analyses indicate that individual bottlenose dolphins rarely move outside of their respective island areas (Baird et al., 2009; Baird et al., 2013a; Baird, 2016; Baird et al., 2021; Harnish, 2021; CRC unpublished). Despite this, recent studies have documented occasional movements between some island-associated stocks (Baird et al., 2021; Baird, 2016; Harnish, 2021). For example, one individual satellite tagged off Kaua‘i moved to waters off the leeward side of O‘ahu and remained there through the end of the tag’s deployment (8 days; Baird et al., 2021; Baird, 2016). Photo-identification analyses, supported by over two decades of data, have also identified a limited number of individuals moving between O‘ahu and Maui Nui, and movement data from satellite tagged dolphins off these areas indicate some degree of range overlap (Harnish, 2021; CRC unpublished). In contrast, no movements between Hawai‘i Island and other island areas have been observed (Baird, 2016; CRC unpublished). In the initial BIA assessment, single BIAs were delineated for each island-associated stock using their respective stock boundaries (Baird et al., 2015). However, with a more recent understanding of inter-island movements, bottlenose dolphins off Hawai‘i Island and the rest of the main Hawaiian Islands (Kaua‘i/Ni‘ihau/O‘ahu/Maui Nui, KNOMN hereafter) will be assessed as separate BIA entities for the purposes of this revised assessment.

KNOMN: Parent BIA boundary delineation

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 O‘ahu 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 (Kaua‘i/Ni‘ihau, O‘ahu 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.

KNOMN: Sighting and photographic data

Sighting data were collected from non-systematic, dedicated small-boat surveys conducted off Kaua‘i/Ni‘ihau, O‘ahu, and Maui Nui in 13, six, and nine years, respectively, spanning 2000-2021 (Table 1, Figure 1; 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 Ka‘ula and not considered to be part of the Kaua‘i/Ni‘ihau 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; Figure 1, 3); effort from these surveys in the area shown in Figure 1 total 12,732 km.

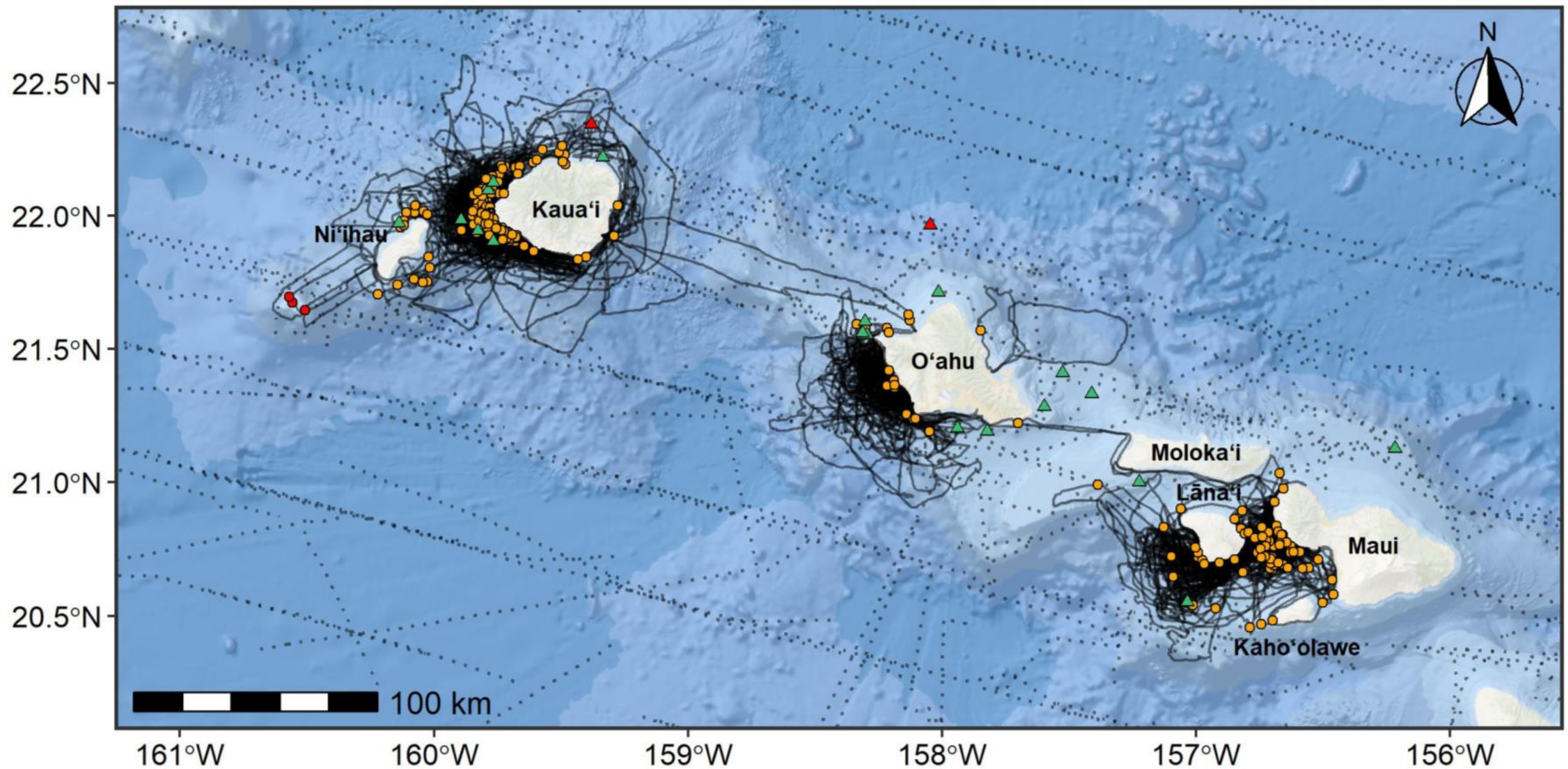

Figure 1. Bottlenose dolphin sighting locations (circles = CRC, triangles = NMFS) off Kaua'i/Ni'ihau (n=152), O'ahu (n=29), and Maui Nui (n=75) overlaid on CRC small-boat survey research vessel tracklines (solid lines) from efforts conducted during 2000-2021 (50,642 km of effort) and NMFS ship-based line-transect surveys (dotted lines) conducted during 2002-2020 (12,732 effort in the area mapped here). Red sighting points (circles and triangles, n=5) indicate sightings of individuals outside of the KNOM insular population and/or outside of the known range of the KNOMN population. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Table 1. KNOMN bottlenose dolphin sighting data used in BIA boundary determinations

Island area-Source	Study duration (first sighting – last sighting)	# unique years with sightings	Total # sightings	Median group size (range)
Kaua'i/Ni'ihau- CRC	2003-2021	13	141	7 (1-45)
O'ahu-CRC	2002-2017	6	18	7 (1-40)
Maui Nui-CRC	2000-2020	8	72	5 (1-50)
Kaua'i/Ni'ihau-NMFS	2009-2020	4	7	15 (3-26)
O'ahu-NMFS	2002-2020	4	10	7 (2-63)
Maui Nui-NMFS	2002-2017	3	3	7 (6-15)
Total	2000-2021	17	251	7 (1-63)

KNOMN: Satellite tag data

Satellite tags were deployed on 21 bottlenose dolphins during dedicated survey efforts off Kaua'i/Ni'hau from 2011-2020 (n=15), O'ahu in 2016 (n=1), and Maui Nui from 2012-2020 (n=5) (Table 2, Figure 2). Three of the tag deployments off Maui Nui were on individuals considered to be part of the O'ahu stock (Harnish, 2021). Detailed methods on satellite tag data processing methods are provided in Supplementary File B. 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 1-hour intervals and locations on land were re-routed around a polygon representing the islands with an added 50-m distance band using the *pathroutr* package (London, 2021).

Table 2. Bottlenose dolphin KNOMN satellite tag data summary

# deployments	Study duration (first tag – last tag)	# unique years with deployments	Median deployment duration (min-max) days	Total # Argos locations	Total # hourly *crawl* locations
21	2011-2020	8	14.8 (5.9-34.3)	6,358	8,023

KNOMN Parent BIA boundary: Range size

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* (Figure 3); 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 (Figure 3). 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 km^2.

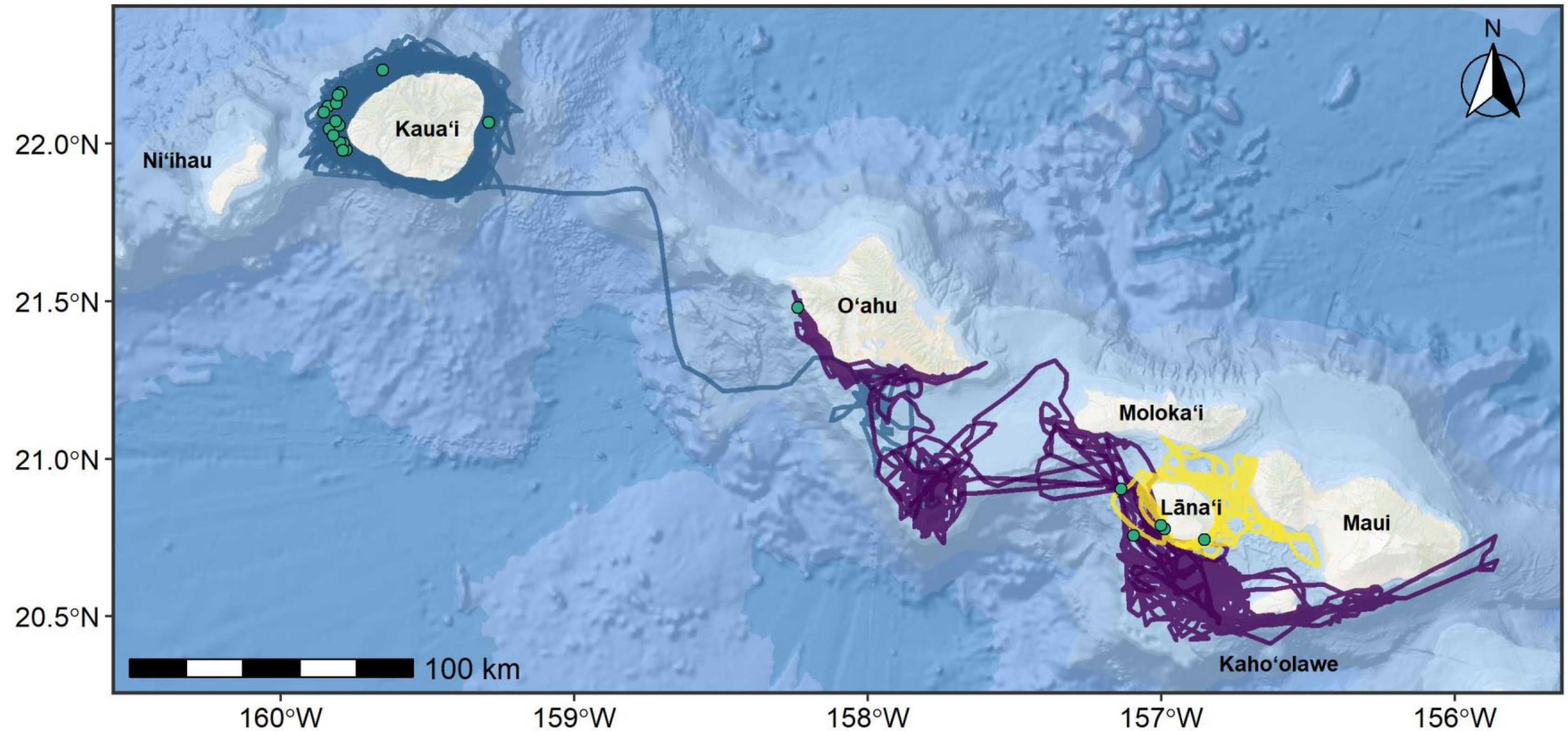

Figure 2. Tracklines of hourly *crawl* positions of satellite tagged bottlenose dolphins from the Kaua‘i/Ni‘ihau (n=15), O‘ahu (n=4), and Maui Nui (n=2) stocks, rerouted around land (with 50-m distance band) where necessary to avoid tracks crossing land. Trackline color corresponds to stock assignment as determined by photo-identification analyses (Kaua‘i/Ni‘ihau = blue; O‘ahu = purple; Maui Nui = yellow). Tag deployment locations are shown as green circles. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

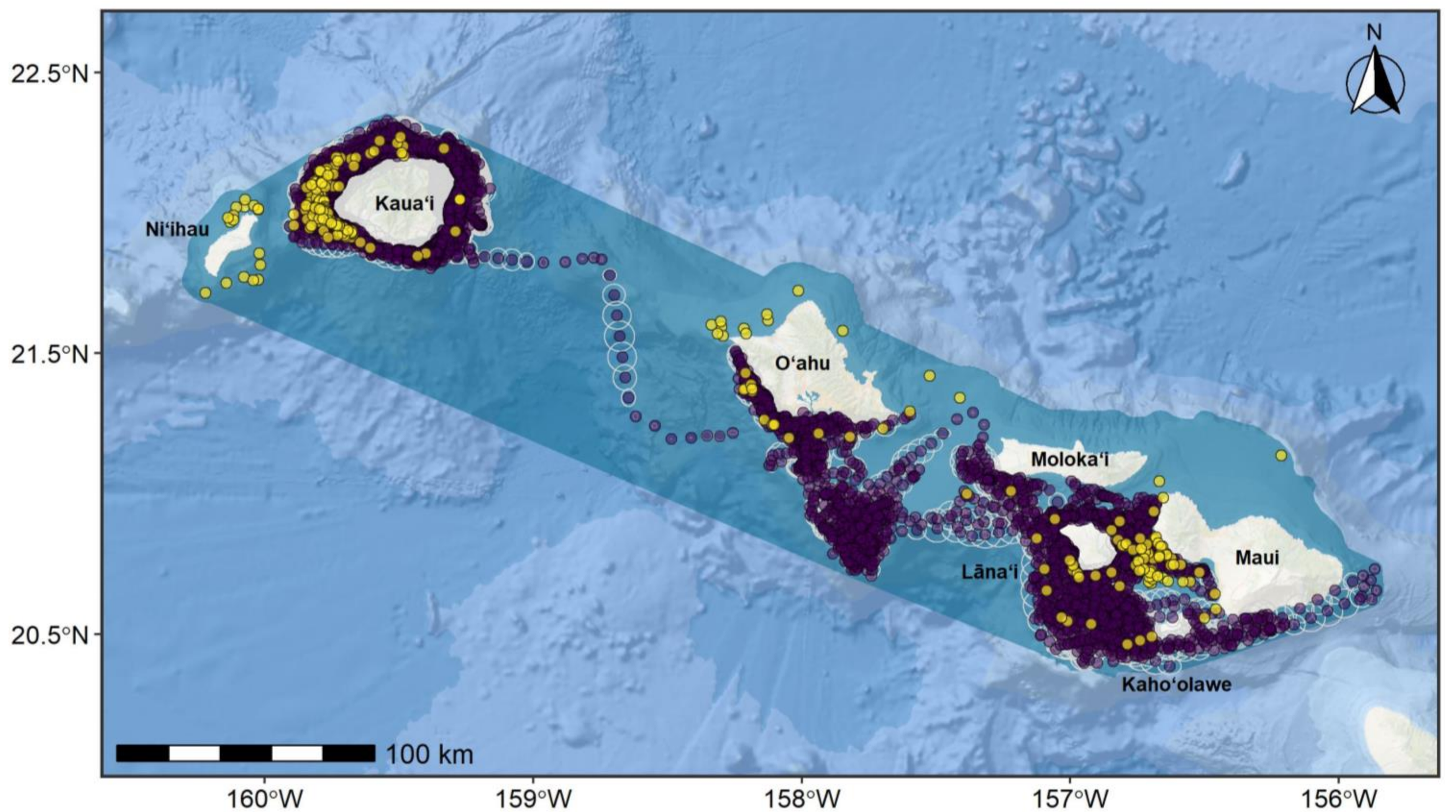

Figure 3. Parent BIA boundary (blue polygon) for the KNOMN population of bottlenose dolphins (encompassing the three island-associated stocks here). The parent BIA is represented as a minimum convex polygon (MCP) encompassing all *crawl*-predicted satellite tag locations (purple circles) and sighting locations (yellow circles), extended by 3-km to the outer boundary to capture positional uncertainty estimated by the *crawl* model (standard error ellipses (68% confidence interval) shown as light grey ellipses), and merged with the stock boundary (1,000-m isobath). Points are partially transparent to highlight high-density areas (i.e., where multiple points overlap). The inner (shoreward) boundary is defined as a 50-m distance band from the coast. Total area of the BIA = 36,634 km^2. Note: not all error ellipses are visible, as their size may be smaller than that of the mapped point. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

KNOMN Parent BIA: Scoring
Intensity
Abundance:
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.

Range size:
The size of the modified MCP representing the BIA is 36,634 km^2.

Scoring criteria:
Intensity scoring: First, abundance and range size are scored independently as follows for each population based on the best available information:

Abundance: **(3)** = 125 or fewer individuals; **(2)** = 126 to 500 individuals; **(1)** = 501 to 2000 individuals.

Range size: **(3)** = less than 2,000 km^2; **(2)** = 2,001-10,000 km^2; **(1)** = greater than 10,001 km^2

Abundance and range size scores are combined to generate an overall Intensity score using the matrix below:

S-BIA Intensity				
Range	3	2	3	3
	2	1	2	3
	1	1	1	2
		1	2	3
		Abundance		

Abundance = 126-500; **score = 2**
Range size = 36,634 km^2; **score = 1**
<u>**Overall Intensity score = 1**</u>

Rationale
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.

Data Support:
Amount and quality of information used to delineate BIA; justified in the narrative.

(3) = high confidence both in the fact that the population is small and resident and in the abundance and range size estimates of population

(1) = notably lower confidence

(2) = represents the remainder of situations that are not notably high or low confidence

Data support notes:

- 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

Data Support score = 3 (high confidence)

Rationale

The existence of small, resident, island-associated stocks of bottlenose dolphins around Kaua‘i/Ni‘ihau, O‘ahu, 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 KNOMN population-wide parent BIA (Baird, 2016; Baird et al., 2021; Harnish, 2021). Out of the 15 satellite tags deployed on bottlenose dolphins off Kaua‘i from 2011-2020, only one tagged individual left nearshore waters of Kaua‘i and moved to O‘ahu, and has not been documented associating with the O‘ahu resident population (Baird, 2016; Baird et al., 2021; Figure 2). This Kaua‘i/Ni‘ihau individual has only been encountered once (when it was tagged off Kaua‘i). As of May 2021 CRC’s photo-identification catalog does not include any inter-island individuals sighted at both Kaua‘i/Ni‘ihau and other island areas (CRC unpublished).

Importance score

Importance Score Matrix				
Intensity	3	2	3	3
	2	1	2	2
	1	0	1	1
		1	2	3
		Data Support		

Intensity = 1
Data Support = 3
Importance score = 1

Boundary Certainty:
Describe the factors used in the boundary delineation.

- **(3)** = high confidence in boundary location
- **(1)** = notably lower confidence
- **(2)** = represents the remainder of situations that are not notably high or low confidence

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 Kaua‘i/Ni‘ihau and O‘ahu where there are no data points, primarily driven by the movement of a single individual between these island areas (Figure 2); however, the spatial extents of the boundary is supported by the MCP methods and objective estimates of uncertainty in tag locations.

Boundary Certainty score = 2

Spatiotemporal Variability indicator:
Dynamic (d), ephemeral (e), or static (s). If the area is dynamic or ephemeral, describe the factor(s) that drive the change in location or timing.
Spatiotemporal variability indicator **is static**. No information to suggest the area is used dynamically or ephemerally.

KNOMN: Child BIA boundary delineation
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 (Figure 1, 2). 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

(Figure 4). The O‘ahu child BIA was modified to include an area ranging from Penguin Bank to south Lāna‘i, 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 O‘ahu bottlenose dolphins (termed "inter-island travelers"; Figure 2; CRC unpublished; Harnish, 2021). As a result, the Maui Nui and O‘ahu child BIAs share a common, overlapping region covering Penguin Bank to south Lāna‘i, reflecting the demographic independence of these two island-associated stocks while also highlighting their overlapping ranges based on available data.

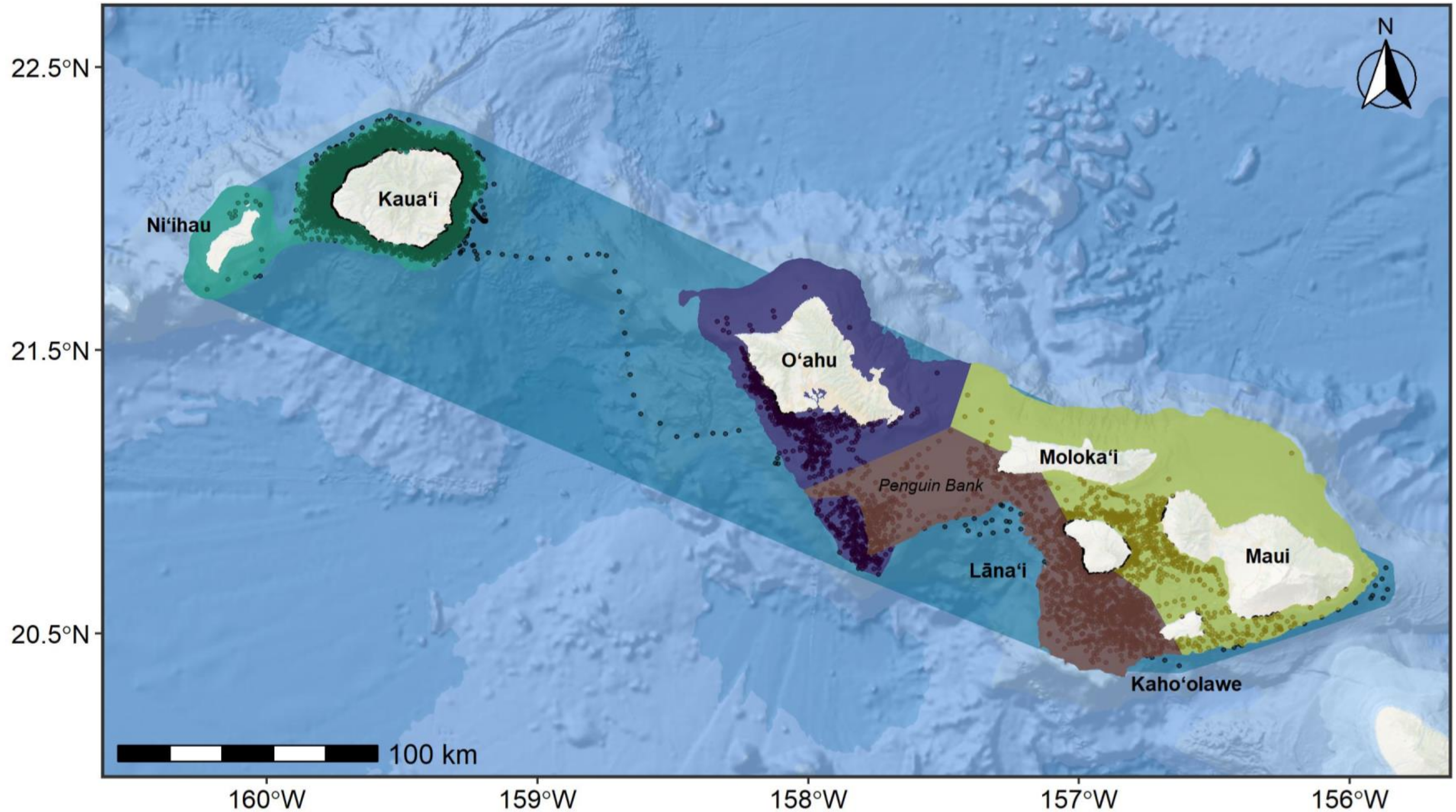

Figure 4. Parent BIA for the KNOMN population of bottlenose dolphins (light blue polygon, 36,634 km^2). Child BIAs represented as each island-associated stock's boundary (Kaua'i/Ni'ihau = green, 2,772 km^2; O'ahu = purple, 8,487 km^2; Maui Nui = yellow, 10,622 km^2), with the extension of the O'ahu boundary that overlaps with the range of the Maui Nui BIA represented by the red-brown polygon. Sighting locations and hourly *crawl* locations of satellite tagged bottlenose dolphins are shown as points under the polygons. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

KNOMN Child BIA: Scoring
Intensity
Abundance:
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.

Range size:
Area of Kauaʻi/Niʻihau child BIA: 2,772 km^2
Area of Oʻahu child BIA: 8,487 km^2
Area of Maui Nui child BIA: 10,622 km^2

Overall Intensity scores:
Kauaʻi/Niʻihau = 3
Oʻahu = 3
Maui Nui = 2

Rationale
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.

Data support
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 (Figure 2, 4; CRC unpublished; Harnish, 2021). More satellite tags have been deployed on bottlenose dolphins off Kauaʻi compared to the other island areas (Table 2). 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 KNOMN 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.

Data Support scores:
Kauaʻi/Niʻihau = 3
Oʻahu = 2
Maui Nui = 2

Importance score:

Importance Score Matrix

Intensity	3	2	3	3
	2	1	2	2
	1	0	1	1
		1	2	3
		Data Support		

Importance scores:
Kauaʻi/Niʻihau = 3
Oʻahu = 3
Maui Nui = 2

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 stock. 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 (Figure 2). 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 (Figure 1, 4).

Boundary Certainty scores:
Kauaʻi/Niʻihau = 3 (high certainty)
Oʻahu = 2 (intermediate certainty)
Maui Nui = 2 (intermediate certainty)

Spatiotemporal dynamic indicator: static for all.
No information to suggest their use of these ranges varies over space or time.

Summary of hierarchical BIA scoring for KNOMN bottlenose dolphins (see Figure 4)

		Scoring				
	S-BIA	**Intensity**	**Data Support**	**Importance**	**Boundary Certainty**	**Spatiotemporal Variability**
Parent BIA	MCP + stock boundaries	1	3	1	2	s
Child BIA	Kaua‘i/Ni‘ihau	3	3	3	3	s
Child BIA	O‘ahu	3	2	3	2	s
Child BIA	Maui Nui	2	2	2	2	s

KNOM BIA labels:
Parent: **S-BIA1-s-b2-HI018-0abc**
Kaua‘i/Ni‘ihau: **S-BIA3-s-b3-HI018-a**
O‘ahu: **S-BIA3-s-b2-HI018-b**
Maui Nui: **S-BIA2-s-b2-HI018-c**

Hawai‘i Island: BIA boundary delineation

Baird et al. (2015) delineated the BIA for Hawai‘i 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.

Hawai‘i Island: Sighting and photographic data

Sighting data were collected from non-systematic, dedicated small-boat surveys conducted off Hawai‘i Island from 2002-2021 (Table 3, Figure 5; see Baird et al., 2013b for details on surveys). Surveys off Hawai‘i 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 Hawai‘i Island over a period of 34 years (1987-2020), comprising over 40% of all individuals in CRC's photo-identification catalog of Hawai‘i 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 Hawai‘i 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 Hawai‘i Island insular stock or within the known range of this stock were used in boundary determinations (n=8; Figure 3, 7); effort from these surveys in the area shown in Figure 5 total 4,906 km.

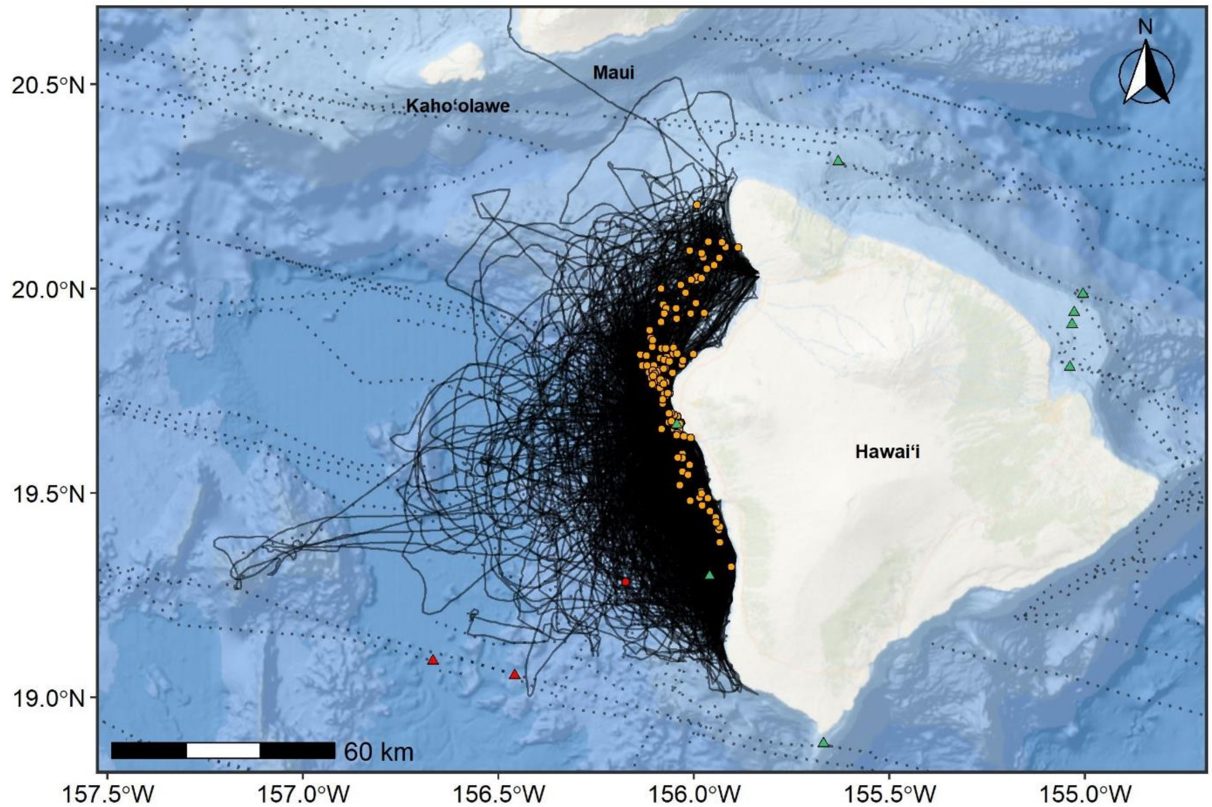

Figure 5. Bottlenose dolphin sighting locations off Hawaiʻi Island (circle = CRC, triangle = NMFS) overlaid on CRC small boat research vessel tracklines (solid lines) from efforts conducted during 2002-2021 (97,438 km of effort) and NMFS shipboard line-transect tracklines (dotted lines) from surveys conducted during 2002-202 (4,906 km of effort as mapped in the area shown). One CRC sighting of bottlenose dolphins in 3,750 m of water (red circle) and thought to be from the pelagic population is excluded from the BIA boundary determination. Two offshore sightings from NMFS shipboard line-transect surveys were also excluded (red triangles) as the population or stock assignment of the individuals encountered is currently unknown, and the sighting occurred outside of the known range of the insular stock (final sample size = 141). Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Table 3. Hawai'i Island bottlenose dolphin stock sighting data used in boundary determinations

Island area-Source	Study duration (first sighting – last sighting)	# unique years with sightings	Total # sightings	Median group size (range)
Hawai'i Island-CRC	2002-2021	20	133	7 (1-90)
Hawai'i Island-NMFS	2002-2020	5	8	11 (6-72)
Total	2002-2021	20	141	8 (1-90)

Hawai'i Island: Satellite tag data

Satellite tags were deployed on five bottlenose dolphins off the west side of Hawai'i Island during dedicated survey efforts from 2012-2021 (Table 4, Figure 6). Detailed methods on satellite tag data processing methods are provided as supplementary material. Briefly, location data were filtered following CRC's protocol (see Supplementary File B) 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 1-hour intervals and locations on land were re-routed around a polygon representing the islands with an added 50-m distance using the *pathroutr* package (London, 2021).

Table 4. Bottlenose dolphin Hawai'i Island satellite tag data summary

# deployments	Study duration (first tag – last tag)	# unique years with deployments	Median (range) deployment duration (days)	Total # Argos locations	Total # hourly *crawl* locations
5	2012-2021	5	17.2 (15.1-30.0)	1,749	2,324

Hawai'i Island BIA boundary: Range size

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* (Figure 7); 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 Hawai'i = 25-m; Figure 7). The resulting area of the BIA (i.e., population range size) is 8,299 km^2.

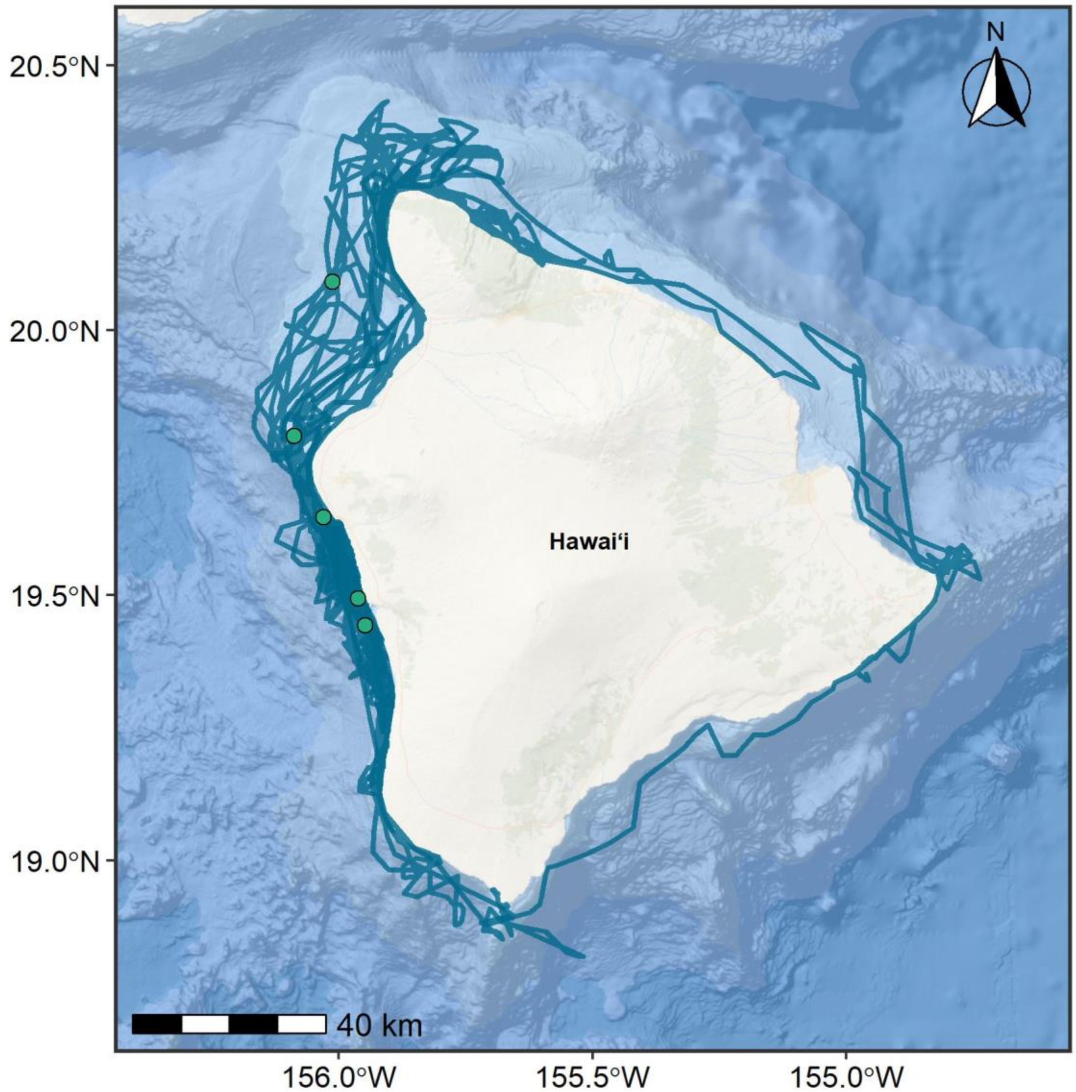

Figure 6. Tracklines of hourly *crawl* positions of satellite tagged bottlenose dolphins (n=5), re-routed around land (with 50-m distance band) where necessary to avoid tracks crossing land. Tag deployment locations are shown as green circles. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

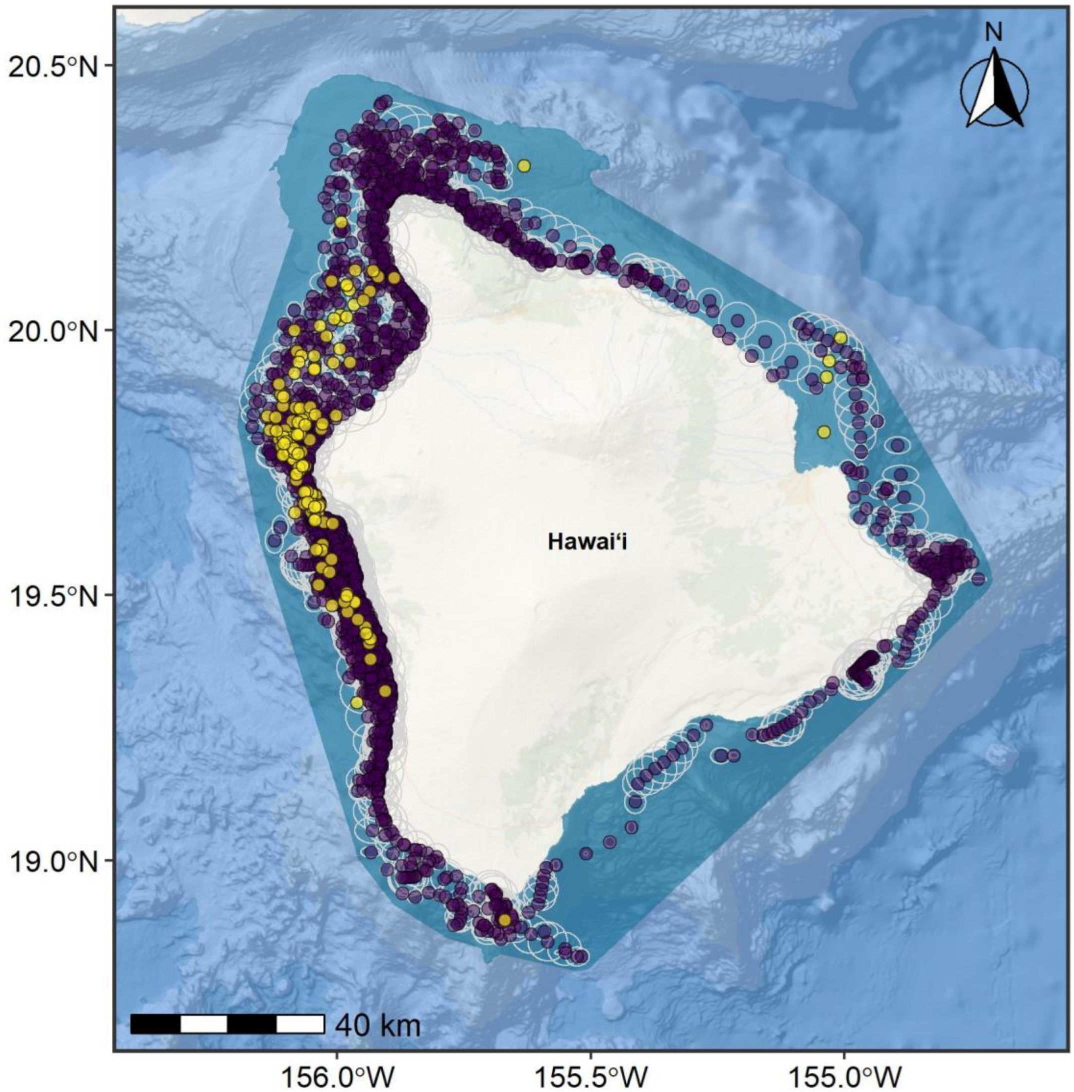

Figure 7. BIA boundary (blue polygon) for the Hawai‘i Island insular bottlenose dolphin stock, represented as a minimum convex polygon (MCP) encompassing all *crawl*-predicted satellite tag locations (purple circles) and sighting locations (yellow circles), extended by 3-km on the outer boundary to include the *crawl* standard error (68% confidence interval) error ellipses (light grey ellipses), and merged with the stock boundary (1,000-m isobath). Points are partially transparent to highlight high density areas (i.e., where multiple points overlap). The inner (shoreward) boundary is defined as a 50-m distance band from the coast. Total area of the BIA = 8,299 km^2. Note: not all error ellipses are visible, as their size may be smaller than that of the mapped point. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Hawai‘i Island BIA: Scoring
Intensity
Abundance:
Abundance estimates specific to each island-associated stock of bottlenose dolphins in Hawai‘i 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 Hawai‘i 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 (Figure 6), we assume the population is within the 126 to 500 range of the BIA Intensity scoring criteria.

Range size:
The size of the modified MCP representing the BIA is 8,299 km^2.

Scoring criteria:
Intensity scoring: First, abundance and range size are scored independently as follows for each population based on the best available information:
Abundance: **(3)** = 125 or fewer individuals; **(2)** = 126 to 500 individuals; **(1)** = 501 to 2,000 individuals.
Range size: **(3)** = less than 2,000 km^2; **(2)** = 2,001-10,000 km^2; **(1)** = greater than 10,001 km^2

Abundance and range size scores are combined to generate an overall Intensity score using the matrix below:

S-BIA Intensity

Range		Abundance 1	Abundance 2	Abundance 3
	3	2	3	3
	2	1	2	3
	1	1	1	2

Abundance = 126-500; **score = 2**
Range size = 8,299 km^2; **score = 2**
<u>Overall Intensity score = 2</u>

Rationale
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.

Data Support:
Amount and quality of information used to delineate BIA; justified in the narrative.

> **(3)** = high confidence in both the fact that the population is small and resident and the abundance and range size estimates of population
> **(1)** = notably lower confidence
> **(2)** = represents the remainder of situations that are not notably high or low confidence

Data Support notes:

- 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

Data Support score = 3 (high confidence)

Rationale

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.

Importance score

Importance Score Matrix

Intensity				
	3	2	3	3
	2	1	2	2
	1	0	1	1
		1	2	3
		Data Support		

Intensity = 2
Data Support = 3
Importance score = 2

Boundary Certainty:
Describe the factors used in the boundary delineation.

- **(3)** = high confidence in boundary location
- **(1)** = notably lower confidence
- **(2)** = represents the remainder of situations that are not notably high or low confidence

We have high confidence in boundary certainty for the S-BIA for Hawai‘i 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 (Figure 5, Figure 7).

Boundary Certainty score = 3

Spatiotemporal Variability indicator:
Dynamic (d), ephemeral (e), or static (s). If the area is dynamic or ephemeral, describe the factor(s) that drive the change in location or timing.
Spatiotemporal variability indicator **is static**. No information to suggest the area is used dynamically or ephemerally.

Summary of BIA scoring for Hawai‘i Island bottlenose dolphin stock (see Figure 7)

		Scoring				
	S-BIA	**Intensity**	**Data Support**	**Importance**	**Boundary Certainty**	**Spatiotemporal Variability**
BIA	MCP-stock boundary	2	3	2	3	s

BIA label for Hawaiʻi Island bottlenose dolphin S-BIA:
S-BIA2-s-b3-HI017-0

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Pantropical spotted dolphin (*Stenella attenuata*)

Background

NMFS recognizes four stocks of pantropical spotted dolphins (*Stenella attenuata*) 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 stocks are considered demographically independent from one another based on genetic differentiation (Courbis et al., 2014). 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 et al., 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). Limited information is available on their movements; however, a recent study reported that tagged insular dolphins generally remained associated with the island area they were tagged, but that movements outside of stock boundaries occur, including one individual that moved across all three insular stock boundaries (Baird and Webster, 2019; Kratofil et al., 2022). Pantropical spotted dolphins also occur in offshore waters and off Kauaʻi and Niʻihau, however they are thought to be part of a pelagic population (Baird et al., 2013; Baird, 2016; Baird and Webster, 2019; Courbis et al., 2014; Kratofil et al., 2022; Oleson et al., 2013). In the initial BIA assessment, separate BIAs were delineated for each island-associated pantropical spotted dolphin stock based on the distribution of sightings off each island area from CRC surveys (Baird et al., 2015). However, with a more recent understanding of inter-island movements and spatial use, in this revised assessment we delineated a single parent BIA encompassing spotted dolphin stocks off Oʻahu, Maui Nui, and Hawaiʻi Island (OMNHI, hereafter) and highlighted stock-specific ranges through hierarchical BIAs.

Parent BIA boundary delineation

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 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.

Sighting and photographic data

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 (Table 1, Figure 1, see Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020 for details on surveys). CRC surveys off these islands combined total 123,856 km of effort with 604 sightings of pantropical spotted dolphins. NMFS surveys around these three island areas (near and offshore, as mapped in Figure 1) total 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 stocks described in this assessment).

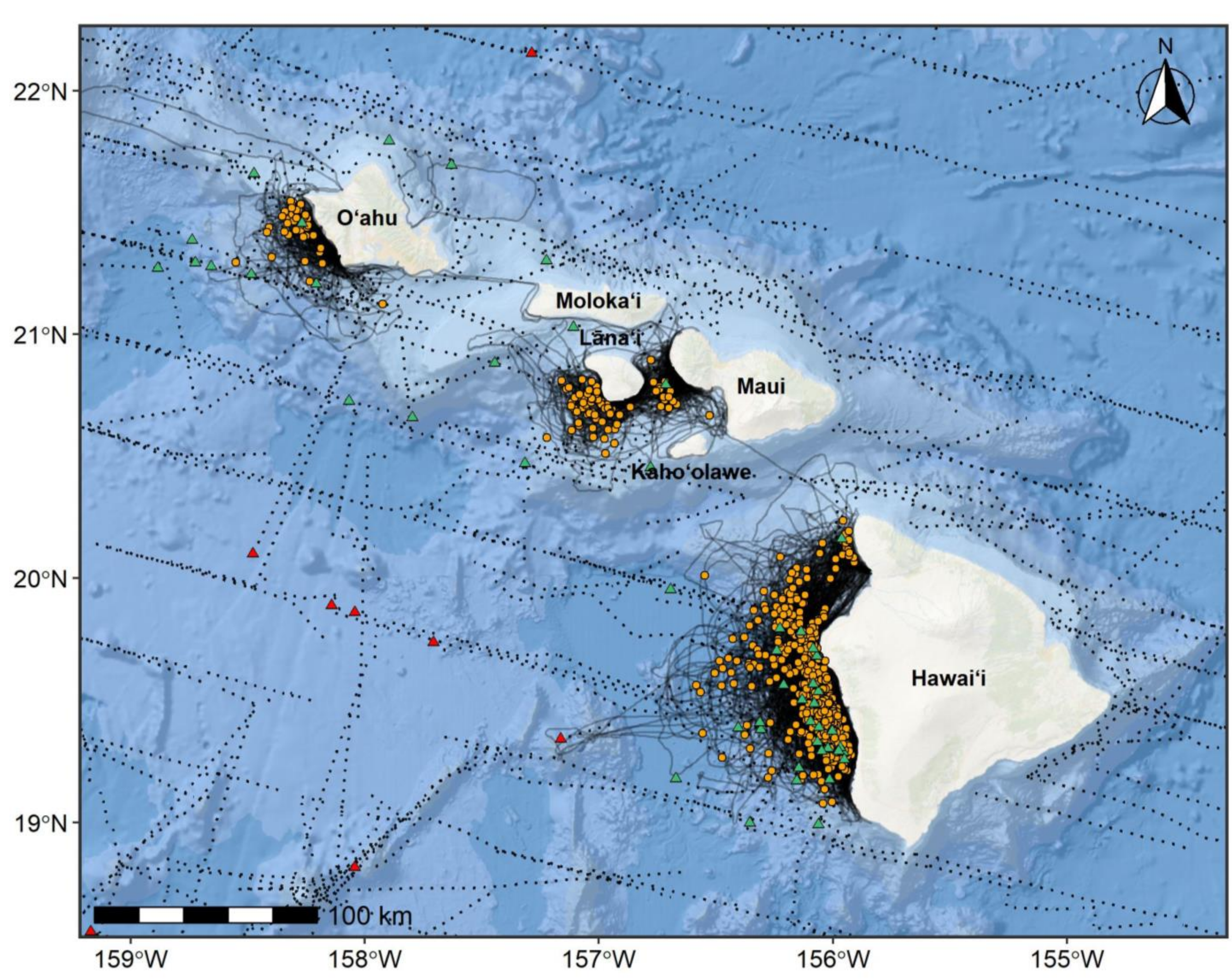

Figure 1. Pantropical spotted dolphin sighting locations collected by CRC (orange circles; n=604) and NMFS (green triangles; n=49) overlaid on research vessel tracklines from efforts conducted by CRC (solid lines) and NMFS (dotted lines) during 2000-2021 (139,067 km effort combined). Eight NMFS sightings (red triangles) were excluded from the BIA boundary determination process as these were far offshore and were likely part of the broader pelagic stock of pantropical spotted dolphins. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Table 1. Pantropical spotted dolphin sighting data used in boundary determinations

Source-Island area*	Study duration (first sighting – last sighting)	# unique years with sightings	Total # sightings	Median group size (range)
CRC-OH	2002-2017	6	50	55 (4-170)
CRC-MN	2000-2020	9	77	50 (7-190)
CRC-HI	2002-2021	20	477	60 (1-400)
NMFS	2002-2020	7	49	55 (3-426)
Total	2000-2021	22	649	60 (1-426)

**OH = Oʻahu; MN = Maui Nui; HI = Hawaiʻi Island*

Satellite tag data

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; Table 2, Figure 2; Baird and Webster, 2019; Kratofil et al., 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 1-hour intervals and locations on land were re-routed around a polygon representing the islands with an added 50-m distance using the *pathroutr* package (London, 2021).

Table 2. Pantropical spotted dolphin OMNHI satellite tag data summary

# deployments	Study duration (first tag – last tag)	# unique years with deployments	Median (range) deployment duration (days)	Total # Argos locations*	Total # hourly *crawl* locations
5	2015-2018	4	18.4 (9.0-21.4)	1,335	2,324

*****Value represents Douglas-filtered Argos locations used to generate *crawl* tracks. See supplementary material for details on satellite tag processing methods

Parent BIA boundary: Range size

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* (Figure 3). 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 (Figure 3). The resulting area of the parent BIA (including three recognized stocks) is 57,111 km^2.

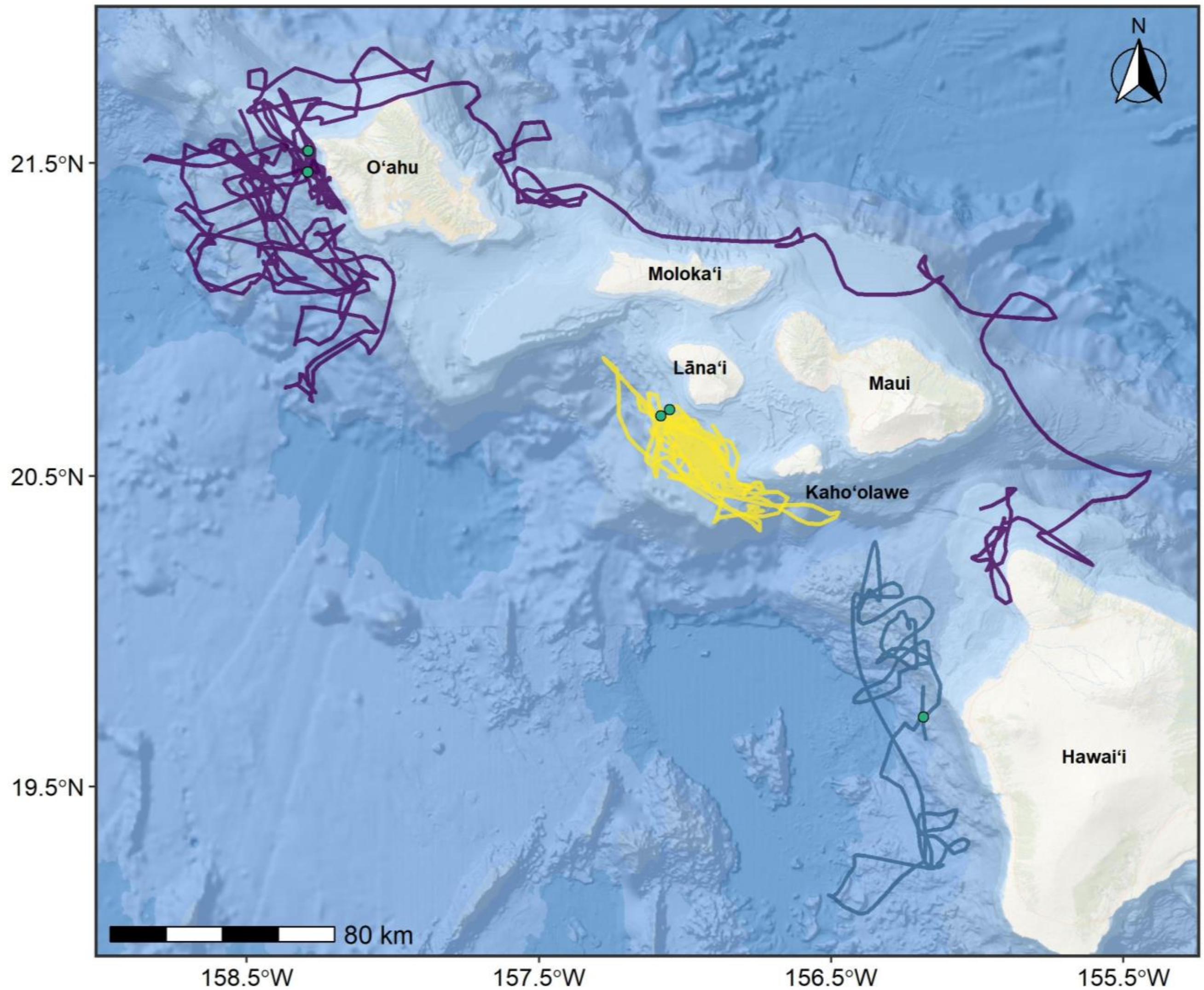

Figure 2. Tracklines of hourly *crawl* positions of satellite-tagged pantropical spotted dolphins from the O'ahu (n=2), Maui Nui (n=2) and Hawai'i Island (n=1) populations, re-routed around land (with 50-m distance) where necessary to avoid tracks crossing land. Trackline color corresponds to presumed population assignment determined by deployment location relative to stock boundary (O'ahu = purple; Maui Nui = yellow; Hawai'i Island = blue). Tag deployment locations are shown as green circles. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

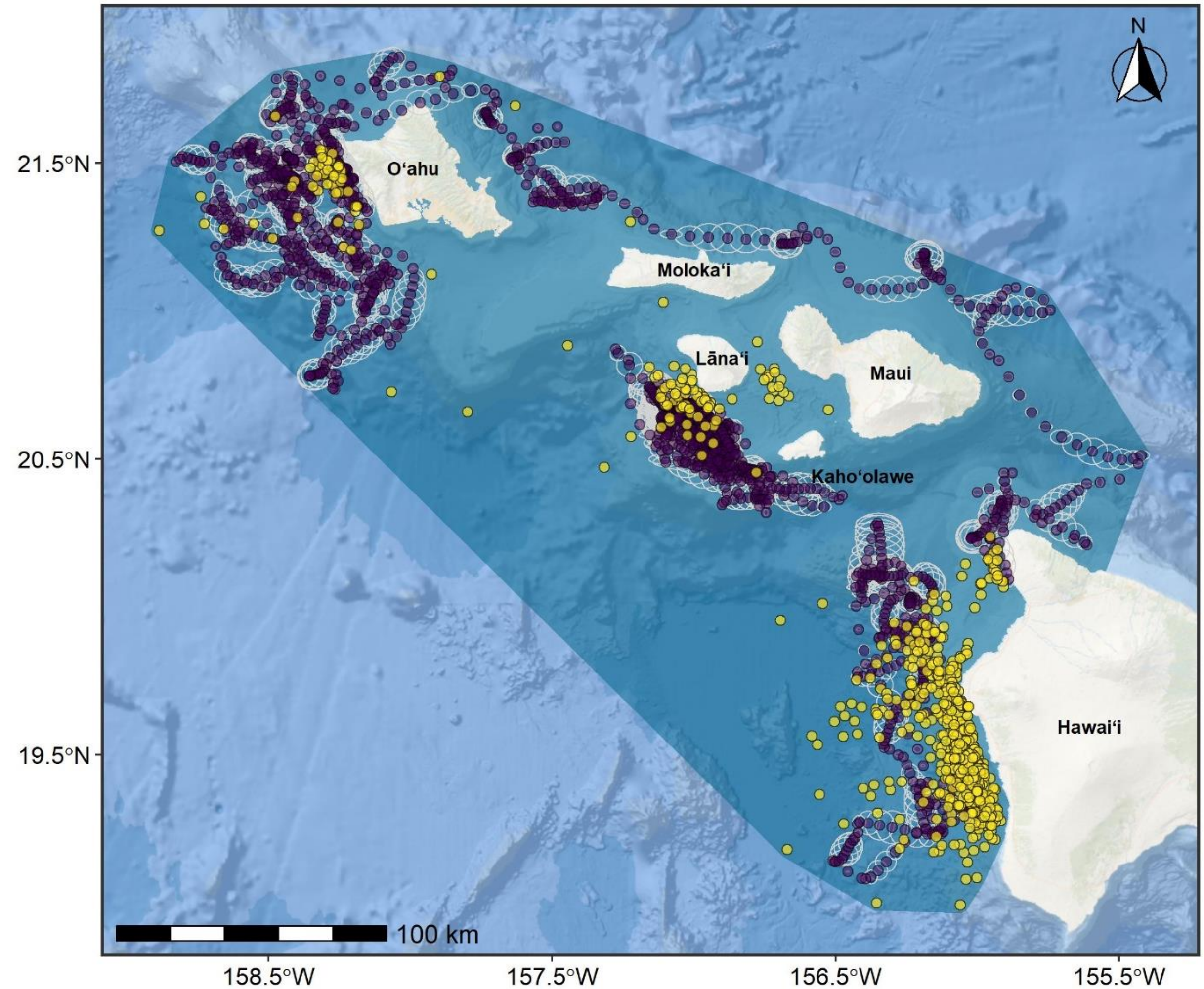

Figure 3. Parent BIA boundary (blue polygon) for insular pantropical spotted dolphins from O'ahu to Hawai'i Island (OMNHI). This parent BIA is represented as a minimum convex polygon (MCP) encompassing all *crawl*-predicted satellite tag locations (purple circles) and sighting locations (yellow circles), extended by a 3 km distance to the outer boundary to include *crawl* standard error (68% confidence interval) ellipses (light grey ellipses). Points are partially transparent to highlight high density areas (i.e., where multiple points overlap). The inner (shoreward) boundary is defined as a 50-m distance from the coast. Total area of the modified MCP = 57,111 km^2. Note: not all error ellipses are visible, as their size may be smaller than that of the mapped point. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Parent BIA: Scoring

Intensity

Abundance:

Abundance estimates specific to each island-associated stock of pantropical spotted dolphins in Hawai‘i 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 Hawai‘i 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 range 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.

Range size:

The size of the modified MCP representing the BIA is 57,111 km^2.

Scoring criteria:

Intensity scoring: First, abundance and range size are scored independently as follows for each population based on the best available information:

Abundance: **(3)** = 125 or fewer individuals; **(2)** = 126 to 500 individuals; **(1)** = 501 to 2,000 individuals.

Range size: **(3)** = less than 2,000 km^2; **(2)** = 2,001-10,000 km^2; **(1)** = greater than 10,001 km^2

Abundance and range size scores are combined to generate an overall Intensity score using the matrix below:

S-BIA Intensity				
Range	3	2	3	3
	2	1	2	3
	1	1	1	2
		1	2	3
		Abundance		

Abundance = 501-2,000; **score = 1**

Range size = 57,111 km^2; **score = 1**

<u>Overall Intensity score = 1</u>

Rationale

The abundance estimate range used here is based on long-term study of pantropical spotted dolphins around the islands (Figure 1, Table 1; 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.

Data Support:

Amount and quality of information used to delineate BIA; justified in the narrative.

> **(3)** = high confidence in both the fact that the population is small and resident and the abundance and range size estimates of population
>
> **(1)** = notably lower confidence
>
> **(2)** = represents the remainder of situations that are not notably high or low confidence

Data Support notes:

- 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 (Figure 2).
- Tag positional uncertainty and irregularity accounted for through *crawl* model, and boundary encompasses nearly all of crawl standard error (68% confidence interval) ellipses

Data Support score = 2 (intermediate confidence)

Rationale

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 (Figure 2; 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; Figure 1) and information on movements are limited to a low satellite tag sample size (Table 2; Baird and Webster, 2019; Kratofil et al., 2022).

Importance score

Importance Score Matrix

Intensity	3	2	3	3
	2	1	2	2
	1	0	1	1
		1	2	3
		Data Support		

Intensity = 1
Data support = 3
Importance score = 1

Boundary Certainty:
Describe the factors used in the boundary delineation.

- **(3)** = high confidence in boundary location
- **(1)** = notably lower confidence
- **(2)** = represents the remainder of situations that are not notably high or low confidence

We have intermediate confidence in Boundary Certainty for the parent BIA for OMHI 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 (Figure 1, Figure 3).

Boundary Certainty score = 2

Spatiotemporal Variability indicator:
Dynamic (d), ephemeral (e), or static (s). If the area is dynamic or ephemeral, describe the factor(s) that drive the change in location or timing.
Spatiotemporal variability indicator **is static**. No information to suggest the area is used dynamically or ephemerally.

OMNHI: Child BIA boundary delineation

Although there exists some evidence of movement between these island areas (Baird and Webster, 2019; Kratofil et al., 2022; Figure 2), 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; Figure 1, 2). 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 child 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 (Figure 4). The Oʻahu and Hawaiʻi Island spotted dolphin child BIAs were based on an MCP encompassing all sighting and *crawl* locations for each island (Figure 4). The Oʻahu child BIA was modified to exclude the leeward areas of Maui Nui, as neither of the satellite tagged Oʻahu dolphins used this area. The Oʻahu child BIA also excluded the satellite track segment from Molokaʻi to Hawaiʻi Island as it is currently unknown whether such movements are part of their primary range, and this movement is already accounted for in the parent BIA (Figure 4).

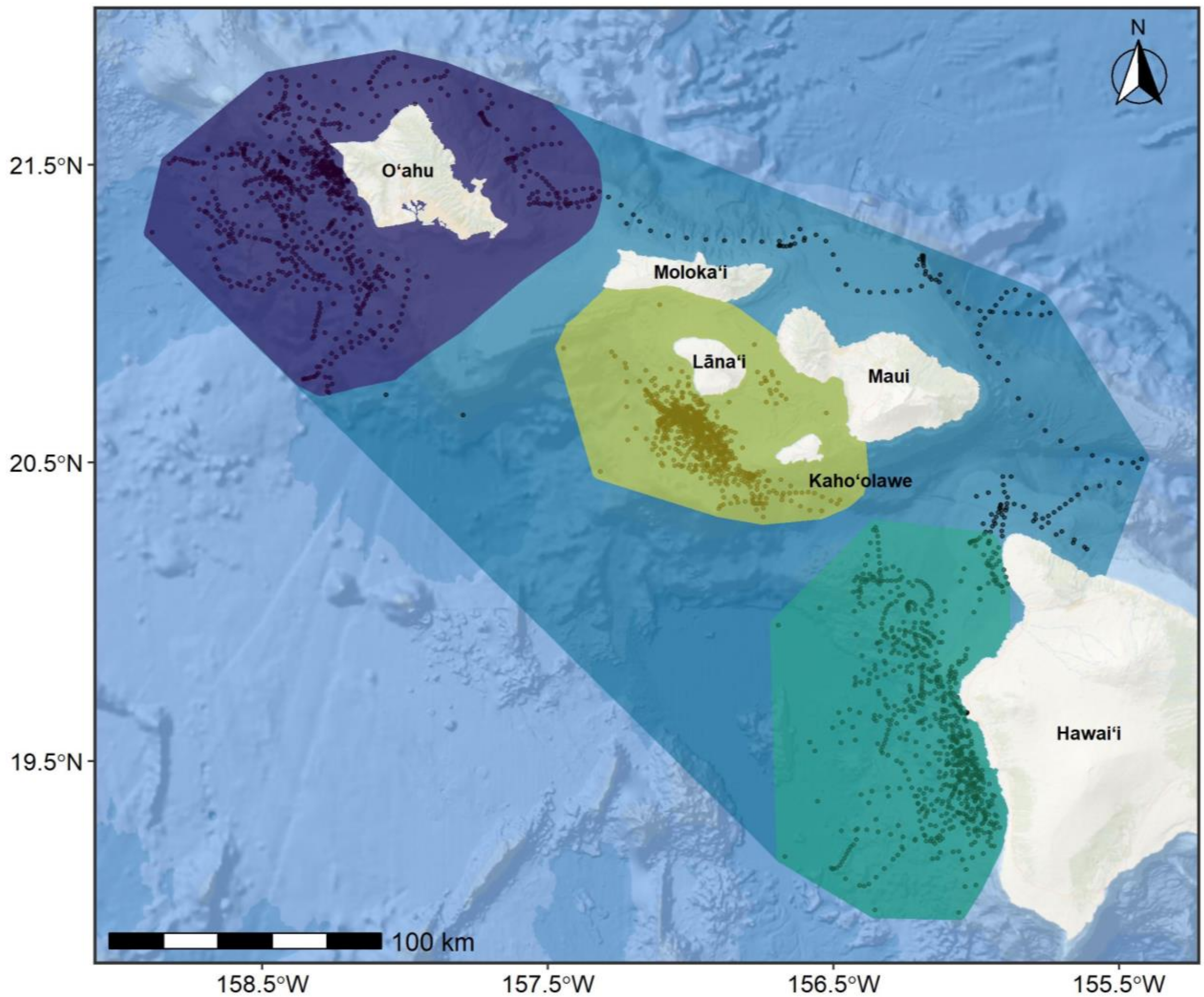

Figure 4. Parent OMNHI BIA for pantropical spotted dolphins from the three stocks (blue polygon, area = 57,111 km^2) and child BIAs for the O'ahu stock (purple polygon, area = 12,952 km^2), represented as a MCP around all O'ahu *crawl* and sighting locations, modified to exclude leeward areas of Maui Nui and track segment spanning Moloka'i to Hawai'i Island; Maui Nui stock (yellow polygon, area = 6,743 km^2), represented as the leeward portion of its recognized stock boundary modified to include sighting and *crawl* locations outside of the boundary (south end of boundary); and Hawai'i Island stock (green polygon, area = 10,768 km^2), represented as a MCP around all Hawai'i Island *crawl* and sighting locations. Hourly *crawl* locations of satellite-tagged spotted dolphins and sighting locations are shown as points under the polygons. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Child BIA: Scoring

Intensity

Abundance:

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.

Range size:

Area of O‘ahu child BIA:	12,952 km^2
Area of Maui Nui child BIA:	6,743 km^2
Area of Hawai‘i Island child BIA:	10,768 km^2

Overall Intensity scores:
O‘ahu = 1
Maui Nui = 1
Hawai‘i Island = 1

Rationale

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 (Figure 2, 4). Therefore, we assigned an Intensity score of 1 for each of the child BIAs.

Data Support

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 (Figure 2) 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).

Data Support scores:
O‘ahu = 2
Maui Nui = 2
Hawai‘i Island = 2

Importance score:

Importance Score Matrix				
Intensity	3	2	3	3
	2	1	2	2
	1	0	1	1
		1	2	3
		Data Support		

Importance scores:
O‘ahu = 1
Maui Nui = 1
Hawai‘i Island = 1

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.

Boundary Certainty scores:
O‘ahu = 2 (intermediate certainty)
Maui Nui = 2 (intermediate certainty)
Hawai‘i Island = 2 (intermediate certainty)

Spatiotemporal Variability indicator:
No information to suggest their use of these areas varies over space or time (static).

Summary of hierarchical BIA scoring for OMNHI pantropical spotted dolphins (see Figure 4)

		Scoring				
	S-BIA	**Intensity**	**Data Support**	**Importance**	**Boundary Certainty**	**Spatiotemporal Variability**
Parent BIA	MCP	1	2	1	2	s
Child BIA	O‘ahu	1	2	1	2	s

Child BIA	Maui Nui	1	2	1	2	s
Child BIA	Hawai‘i Island	1	2	1	2	s

Hierarchical BIA labels:
Parent: **S-BIA1-s-b2-HI008-0abc**
O‘ahu: **S-BIA1-s-b2-HI008-a**
Maui Nui: **S-BIA1-s-b2-HI008-b**
Hawai‘i Island: **S-BIA1-s-b2-HI008-c**

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Gray's spinner dolphin (*Stenella longirostris*)

Background

There is one pelagic stock and five insular stocks of gray's spinner dolphins (*Stenella longirostris;* spinner dolphin, hereafter) recognized by NMFS in the Hawaiian Archipelago (Caretta et al., 2021): two stocks in the northwestern Hawaiian Islands (NWHI), one around Manawai (Pearl and Hermes Reef), and the other around Hōlanikū (Kure Atoll) and Kuaihelani (Midway Atoll), and three in the main Hawaiian Islands (MHI), one each associated with Kauaʻi/Niʻihau, Oʻahu/Maui Nui, and Hawaiʻi Island, respectively. The distinction of these stocks is supported by genetic (Andrews et al., 2006, 2010) and photo-identification studies, with strong fidelity to nearshore waters and protected bays and limited inter-island movements (Norris et al., 1994; Benoit-Bird and Au, 2003; Hill et al., 2010, 2011; Karczmarski et al., 2005). Aerial surveys and photo-identification studies all indicate that these stocks are relatively small (Hill et al., 2011; Karczmarski et al., 1998; Tyne et al., 2016). Since the first BIA effort (Van Parijs et al., 2015), no additional evidence has emerged to suggest that spinner dolphins regularly range outside of their recognized stock boundaries. Therefore, in this assessment we use the same boundaries as described in Baird et al. (2015) and assign scores and associated narratives following the new protocol (Harrison et al., this issue).

BIA boundary delineation

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.

Sighting data

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 (Figure 1) 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) as shown in Figure 1.

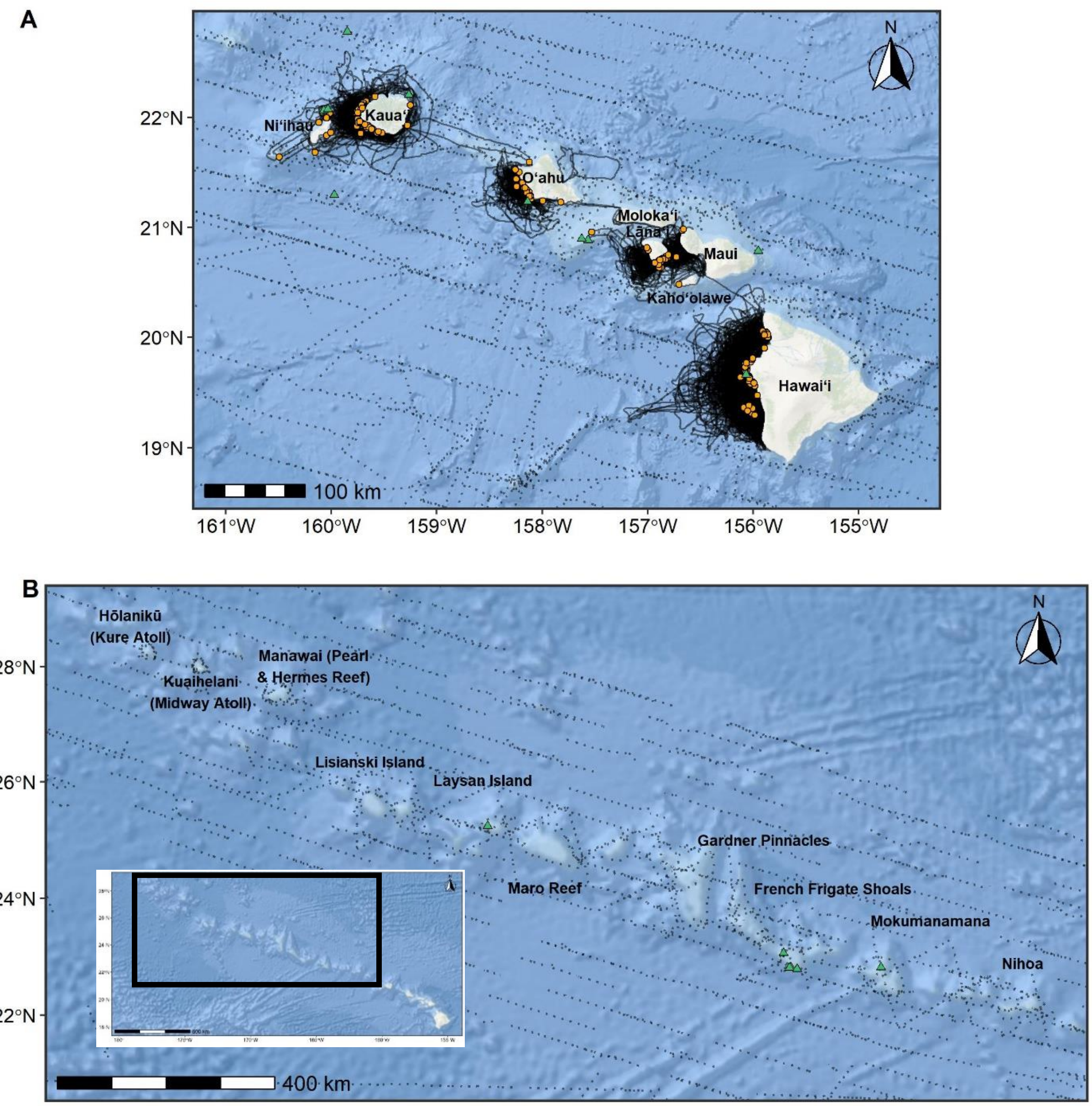

Figure 1. Spinner dolphin sighting locations (CRC = orange circles, n=303; NMFS = green triangles, n=10) overlaid on research vessel tracklines from efforts conducted by CRC (solid lines) during 2000-2021 (148,080 km effort) and NMFS ship-based line-transect survey tracklines (dotted lines) during 2002-2020 (23,830 km of effort as mapped here) in the MHI (Panel A) and NWHI (Panel B) regions. Note that the two MHI offshore NMFS sightings (one south of Kaua‘i/Ni‘ihau and the other north of Kaua‘i/Ni‘ihau) likely do not belong to the insular spinner dolphin stocks. Combined effort is 171,910 km in the MHI region and 33,448 km in the NWHI region, as mapped here. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Table 1. CRC and NMFS spinner dolphin sighting data

Region-Stock*	Study duration (first sighting – last sighting)	# unique years with sightings	Total # sightings	Median group size (range)
MHI-KN	2003-2021	12	124	35 (2-300)
MHI-OMN	2000-2020	10	52	55 (1-175)
MHI-HI	2002-2021	19	133	25 (1-185)
MHI-Total	2000-2021	21	303	35 (1-300)
NWHI-KH	NA	NA	0	NA
NWHI-M	NA	NA	0	NA

**KN = Kauaʻi/Niʻihau; OMN = Oʻahu/Maui Nui; HI = Hawaiʻi Island; KH = Kuaihelani/Hōlanikū; M = Manawai*

BIA boundary: Range size

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 (18.5 km) 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 band from shore. The range sizes of each BIA are listed in Table 2.

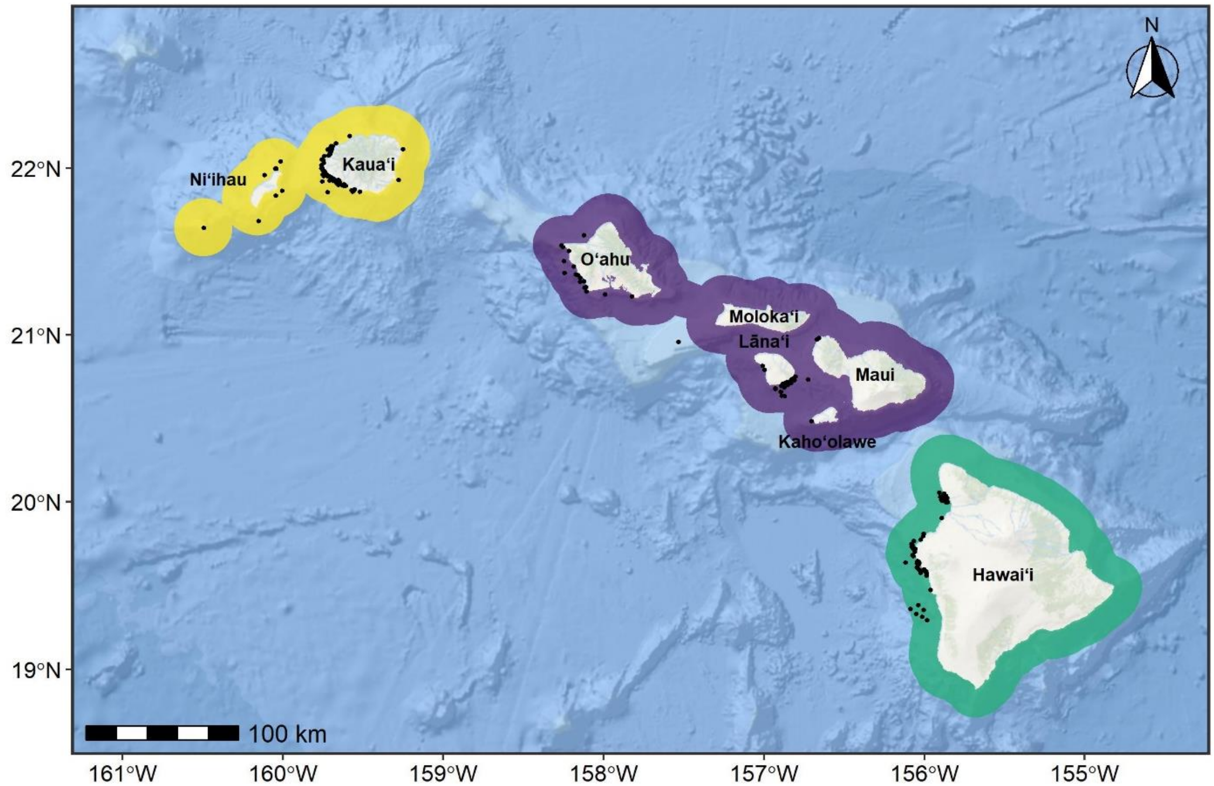

Figure 2. BIA boundaries for spinner dolphins in the main Hawaiian Islands region, including Hawai'i Island (green polygon, area = 9,477 km^2), O'ahu/Maui Nui (purple polygon, area = 14,651 km^2), and Kaua'i/Ni'ihau (yellow polygon, area = 7,233 km^2). Sightings from CRC small boat survey efforts are shown as black points; note individuals from the single sighting outside of the O'ahu/Maui Nui boundary (on Penguin Bank) have also been identified off O'ahu (L. McPherson, pers. comm.). In addition, the cluster of offshore sightings off South Kona, Hawaii Island were a few individual spinner dolphins seen with a larger group of spotted dolphins. The inner (shoreward) boundary of each BIA is defined as a 5-m distance band from the coastline. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

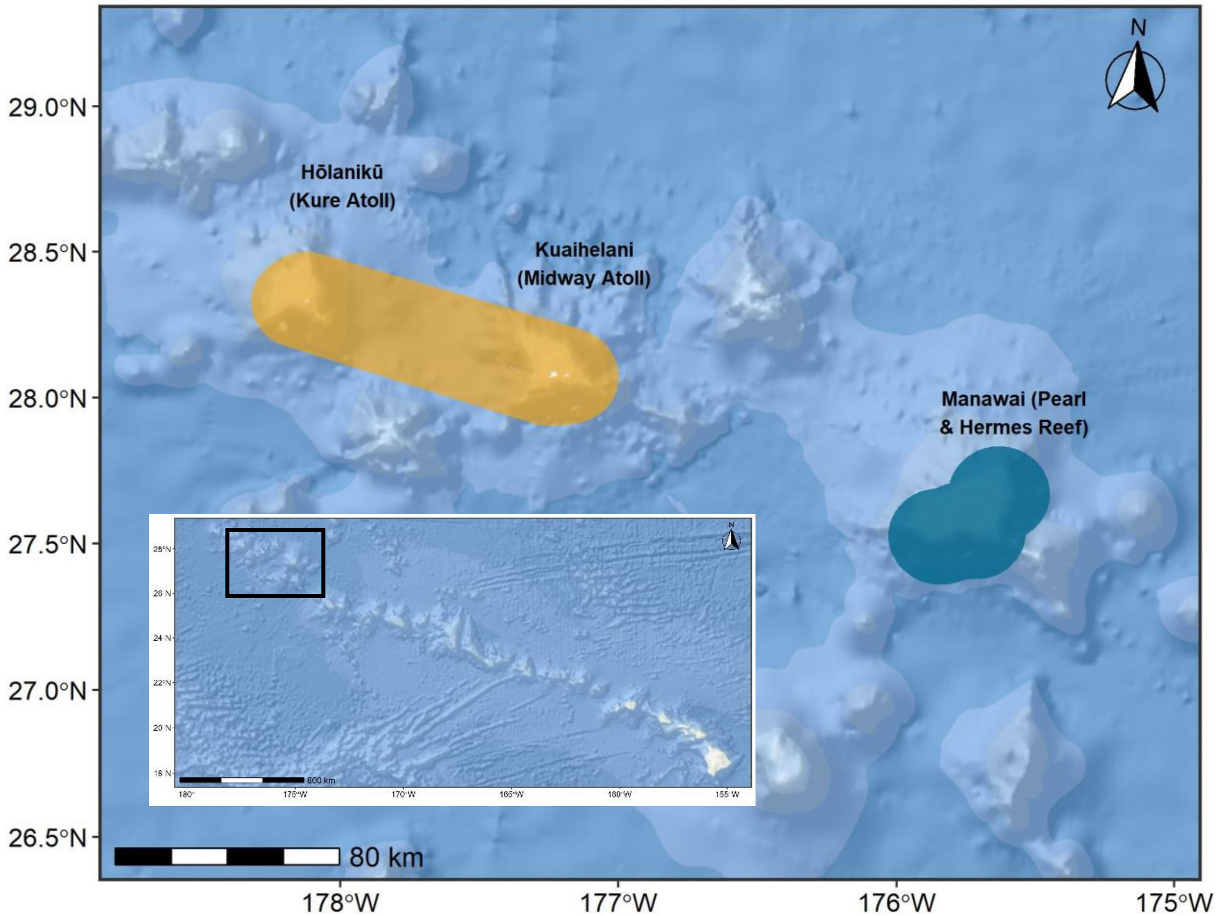

Figure 3. BIA boundaries for spinner dolphins in the northwestern Hawaiian Islands region, including Kuaihelani and Hōlanikū (Midway and Kure Atolls, respectively; orange polygon, area = 4,841 km^2) and Manawai (Pearl and Hermes Reef; blue polygon, area = 2,094 km^2). The inner (shoreward) boundary of each BIA is defined as a 5-m distance band from the coastline. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

BIA: Scoring
Intensity
Abundance:
Hawai‘i Island
Tyne et al. (2016) reported an abundance estimate for Hawai‘i Island spinner dolphins of 665 (CV=0.09) individuals based on mark-recapture methods using photo-ID (2010-2012), with 235 distinct individuals (Tyne et al., 2016).

O‘ahu/Maui Nui
The most recent estimate from photo-ID mark-recapture analysis of data collected from July to September 2007 off the leeward side of O‘ahu was n=355 (CV=0.09; Hill et al., 2011). However, this estimate is dated and did not account for animals occupying other areas of O‘ahu nor those found off Maui Nui.

Kaua‘i/Ni‘ihau
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 Kaua‘i and thus is likely an underestimate of the true population size (Hill et al., 2011).

Manawai (Pearl & Hermes Reef)
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.

Kuaihelani/Hōlanikū (Midway/Kure Atolls)
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 assumed the abundance is in the 126 to 500 individuals range category of the BIA Intensity scoring criteria.

Scoring criteria:
Intensity scoring: First, abundance and range size are scored independently as follows for each population based on the best available information:

Abundance: **(3)** = 125 or fewer individuals; **(2)** = 126 to 500 individuals; **(1)** = 501 to 2,000 individuals.

Range size: **(3)** = less than 2,000 km^2; **(2)** = 2,001-10,000 km^2; **(1)** = greater than 10,001 km^2

Table 2. Spinner dolphin BIA range sizes and abundance scores

Locality*	Island area	Range size in km^2 (score)	Abundance estimate (score)
NWHI	Kuaihelani/Hōlanikū (Midway/Kure Atolls)	4,841 (2)	260 (2)
NWHI	Manawai (Pearl and Hermes Reef)	2,094 (2)	300 (2)
MHI	Kaua‘i/Ni‘ihau	7,233 (2)	601 (1)
MHI	O‘ahu/Maui Nui	14,651 (1)	355 (2)
MHI	Hawai‘i Island	9,477 (2)	665 (1)

NWHI = northwestern Hawaiian Islands; MHI = main Hawaiian Islands

Abundance and range size scores are combined to generate an overall intensity score using the matrix below:

S-BIA Intensity

Range	3	2	3	3
	2	1	2	3
	1	1	1	2
		1	2	3
		Abundance		

Intensity scores

Kuaihelani/Hōlanikū (Midway/Kure Atolls): 2
Manawai (Pearl and Hermes Reef): 2
Kaua‘i/Ni‘ihau: 1
O‘ahu/Maui Nui: 1
Hawai‘i Island: 1

Rationale
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.

Data Support:
Amount and quality of information used to delineate BIA; justified in the narrative.
- **(3)** = high confidence in both the fact that the population is small and resident and the abundance and range size estimates of population
- **(1)** = notably lower confidence
- **(2)** = represents the remainder of situations that are not notably high or low confidence

Data Support notes:

Data Support scores
Kuaihelani/Hōlanikū (Midway/Kure Atolls): 1
Manawai (Pearl and Hermes Reef): 1
Kaua'i/Ni'ihau: 2
O'ahu/Maui Nui: 2
Hawai'i Island: 3

Rationale: MHI stocks
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 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 Hawai'i Island stock having the most recent and robust abundance estimate. Therefore, we assigned Data Support scores of (2) for Kaua'i/Ni'ihau and O'ahu/Maui Nui and (3) for Hawai'i Island.

Rationale: NWHI stocks
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.

Importance score

Importance Score Matrix				
Intensity	3	2	3	3
	2	1	2	2
	1	0	1	1
		1	2	3
		Data Support		

Importance scores:
Kuaihelani/Hōlanikū (Midway/Kure Atolls): 1
Manawai (Pearl and Hermes Reef): 1
Kaua'i/Ni'ihau: 1
O'ahu/Maui Nui: 1
Hawai'i Island: 1

Boundary Certainty:
Describe the factors used in the boundary delineation.
- **(3)** = high confidence in boundary location
- **(1)** = notably lower confidence
- **(2)** = represents the remainder of situations that are not notably high or low confidence

NWHI stocks:
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.

MHI stocks:
We have high confidence in the Boundary Certainty for each of the MHI spinner dolphin stocks. 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).

Boundary Certainty scores:
Kuaihelani/Hōlanikū (Midway/Kure Atolls): 2
Manawai (Pearl and Hermes Reef): 2
Kauaʻi/Niʻihau: 3
Oʻahu/Maui Nui: 3
Hawaiʻi Island: 3

Spatiotemporal Variability indicator:
Dynamic (d), ephemeral (e), or static (s). If the area is dynamic or ephemeral, describe the factor(s) that drive the change in location or timing.
Spatiotemporal variability indicator **is static for all spinner dolphin BIAs**. No information to suggest the area is used dynamically or ephemerally.

Summary of BIA scoring for spinner dolphin S-BIAs in the MHI and NWHI

		Scoring				
	S-BIA	**Intensity**	**Data Support**	**Importance**	**Boundary Certainty**	**Spatiotemporal Variability**
Kuaihelani/Hōlanikū	Stock boundary	2	1	1	2	s
Manawai	Stock boundary	2	1	1	2	s
Kauaʻi/Niʻihau	Stock boundary	1	2	1	3	s
Oʻahu/Maui Nui	Stock boundary	1	2	1	3	s
Hawaiʻi Island	Stock boundary	1	3	1	3	s

BIA labels for spinner dolphin S-BIAs:

Kuaihelani/Hōlanikū (Midway/Kure Atolls): S-BIA1-s-b2-HI015-0
Manawai (Pearl and Hermes Reef): S-BIA1-s-b2-HI014-0
Kauaʻi/Niʻihau: S-BIA1-s-b3-HI013-0

O'ahu/Maui Nui: S-BIA1-s-b3-HI012-0
Hawai'i Island: S-BIA1-s-b3-HI011-0

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Pygmy killer whale (*Feresa attenuata*)

Background

A single stock of pygmy killer whales (*Feresa attenuata*) is recognized by NMFS within the U.S. EEZ around the Hawaiian Islands, although multiple lines of evidence suggest further population structure within the archipelago, with multiple island-associated stocks (Baird et al., 2011a, 2011b; Baird, 2016; Mahaffy et al., 2013; McSweeney et al., 2009; Oleson et al., 2013). Individuals identified off Hawaiʻi Island have been resighted over periods 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). Resighting rates of pygmy killer whales off Oʻahu and Maui Nui since 2000 also suggest a small, resident population associated with these islands (Baird, 2016; CRC unpublished; Mahaffy et al., 2013; McSweeney et al., 2009). Some inter-island movements between Oʻahu/Maui Nui and Hawaiʻi Island have been documented through photo-identification data, although such instances are rare and social network analyses have shown limited associations between the two populations (Baird, 2016; Mahaffy et al., 2013). Information on movements from satellite tag data further support the existence of Hawaiʻi Island and Oʻahu/Maui Nui island-associated populations (Baird et al., 2011a, 2011b; Baird, 2016; Mahaffy et al., 2013). 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, for the purposes of this BIA assessment, pygmy killer whales off Hawaiʻi Island and Oʻahu/Maui Nui were assessed as separate populations based on the several independent lines of evidence.

Oʻahu-Maui Nui: BIA boundary delineation

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.

Oʻahu-Maui Nui: Sighting and photographic data

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 (Table 1, Figure 1; 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 (Table 1). 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; Figure 1, 3); effort from these surveys in the area shown in Figure 1 total to 4,231 km)

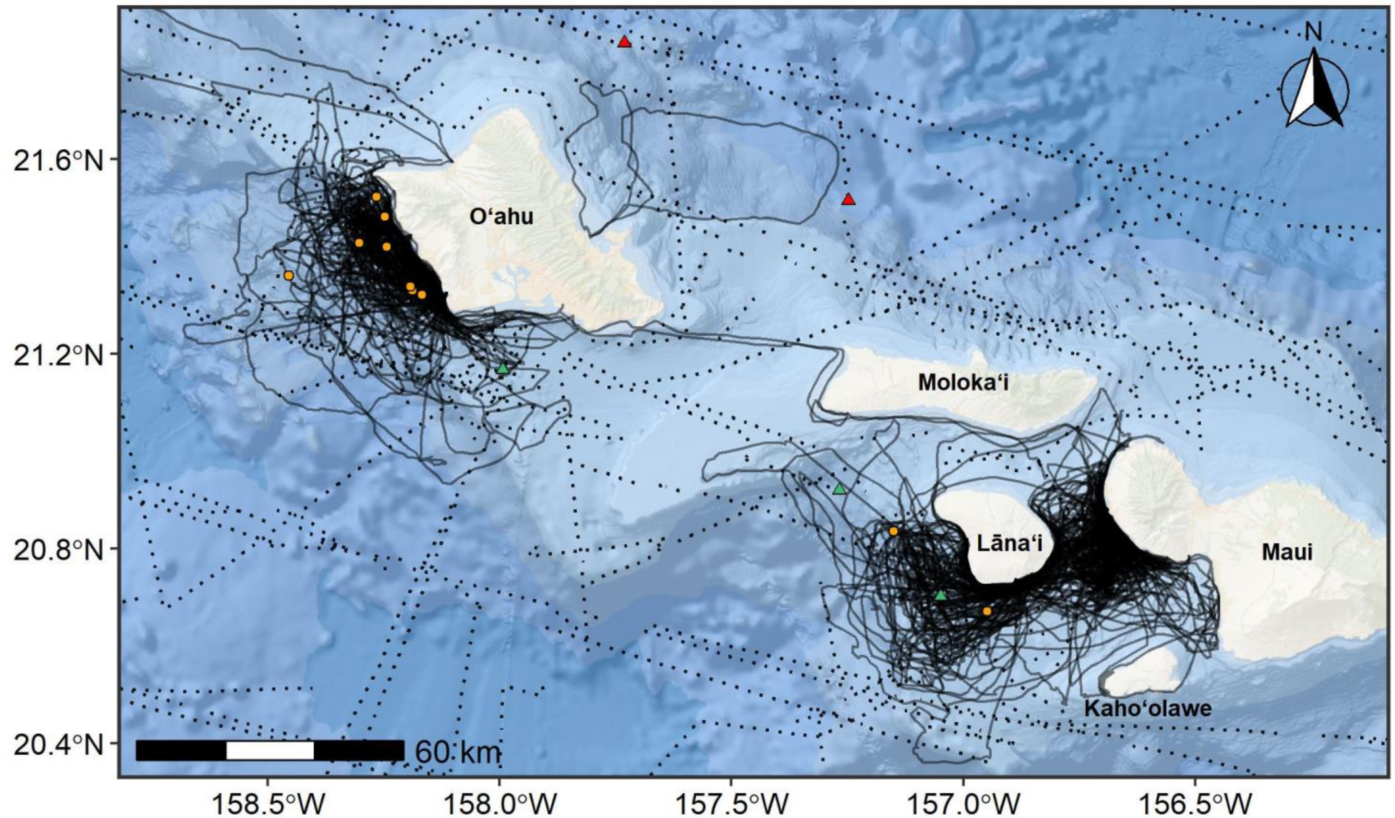

Figure 1. Pygmy killer whale sighting locations (circles = CRC, triangles = NMFS) off O‘ahu (n=9) and Lāna‘i (n=4) overlaid on CRC small-boat survey research vessel tracklines (solid lines) from efforts conducted during 2002-2017 off O‘ahu and during 2000-2020 off Lāna‘i (26,418 km of effort combined) and NMFS ship-based line-transect surveys (dotted lines) conducted during 2002-2020 (4,231 km of effort in the area mapped here). Red NMFS sighting locations (n=2) indicate sightings of individuals outside of the insular O‘ahu-Maui Nui population and/or are outside the known range of the insular population. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Table 1. Oʻahu-Maui Nui pygmy killer whale sighting data used in boundary determinations

Island area-Source	Study duration (first sighting – last sighting)	# unique years with sightings	Total # sightings	Median group size (range)
Oʻahu-CRC	2010-2017	3	8	18 (3-30)
Maui Nui-CRC	2000-2017	2	2	16 (8-23)
Oʻahu-NMFS	2009	1	1	13 (NA)
Maui Nui-NMFS	2002-2020	2	2	14 (13-16)
Total	2000-2020	5	13	15 (3-30)

Oʻahu-Maui Nui: Satellite tag data

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 (Table 2, Figure 2; Baird et al., 2011b). Detailed methods on satellite tag data processing are provided in Supplementary File B. 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 1-hour intervals and locations on land were re-routed around a polygon representing the 400-m isobath using the *pathroutr* package (London, 2021) (shallowest sighting off Oʻahu=450 m, CRC unpublished).

Table 2. Pygmy killer whale Oʻahu satellite tag data summary

# deployments	Study duration (first tag – last tag)	# unique years with deployments	Median (range) deployment duration (days)	Total # Argos locations	Total # hourly crawl locations
4	2010-2016	2	9.5 (4.8-25.5)	637	1,184

Oʻahu-Maui Nui BIA boundary: Range size

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* (Figure 3); 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; Figure 3). The resulting area of the parent BIA (i.e., population range size) is 7,416 km^2.

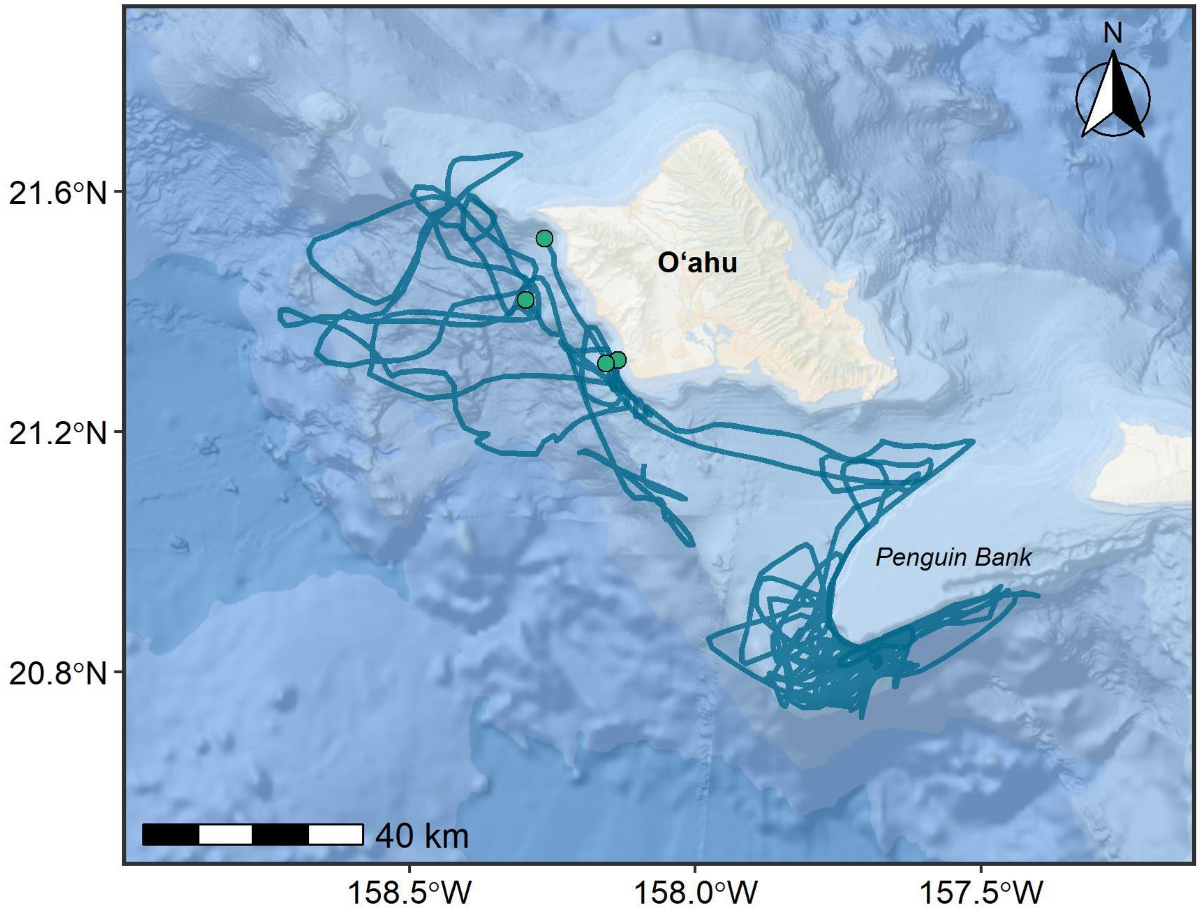

Figure 2. Tracklines of hourly *crawl* positions of satellite tagged pygmy killer whales (n=4), re-routed around the 400-m isobath where necessary to avoid tracks crossing land. Tag deployment locations are shown as green circles. The original Argos tracks (i.e., not fit to *crawl*) of the two individuals that used waters near Penguin Bank showed that they used waters along the edges of the bank, rather than the shallow waters of the main region of the bank. Thus, using the 400-m isobath as the barrier polygon for re-routing is likely appropriate for all tags despite variation in spatial use. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

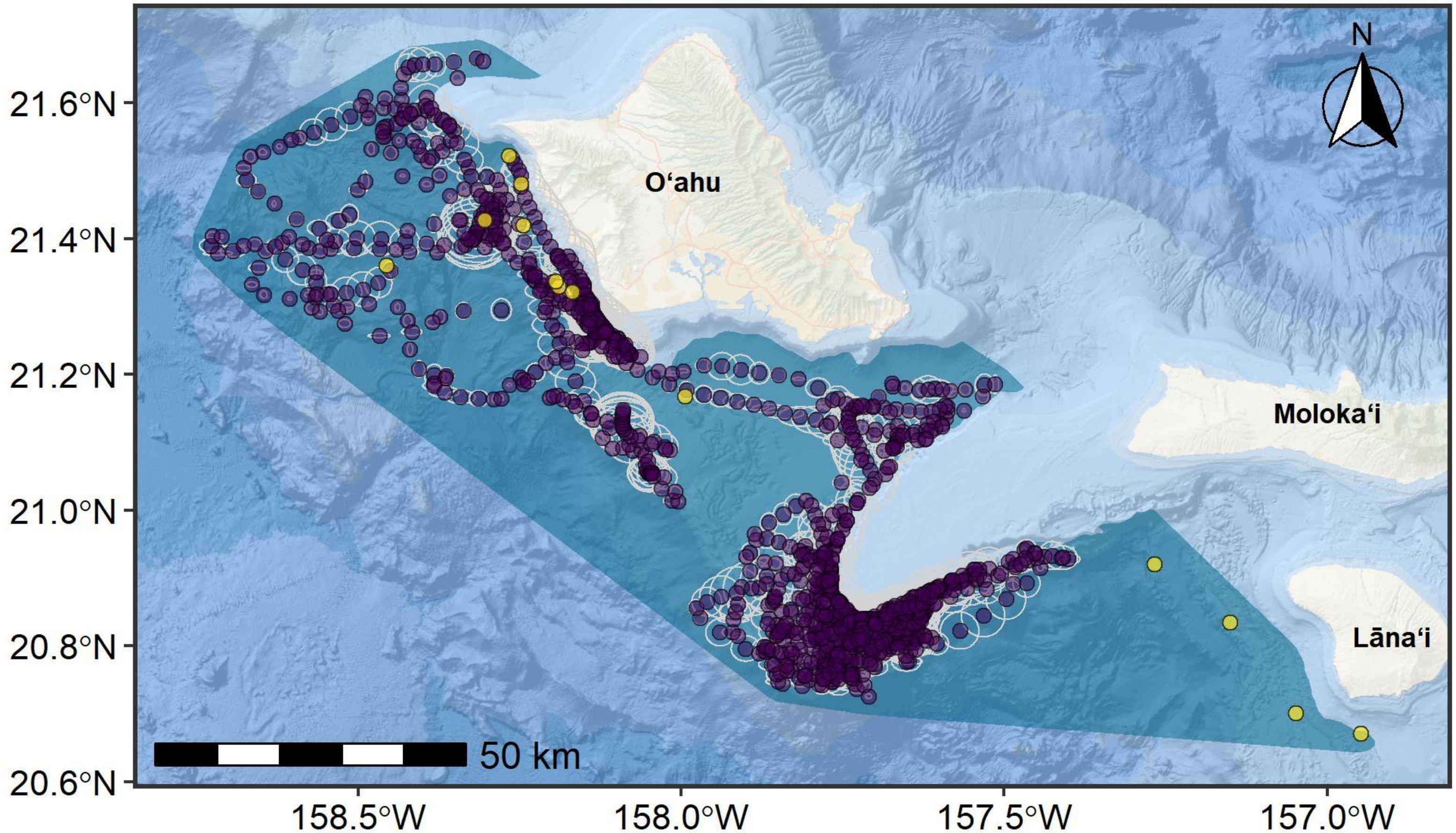

Figure 3. BIA boundary (blue polygon) for the O‘ahu-Maui Nui pygmy killer whale population. The BIA is represented as a minimum convex polygon (MCP) encompassing all *crawl*-predicted satellite tag locations (purple circles) and sighting locations (yellow circles), extended by 3-km to the outer boundary to capture positional uncertainty associated with the *crawl* locations (i.e., standard error (68% confidence interval) error ellipses, shown in light grey). The inner (shoreward) boundary was defined as the 400-m isobath. Points are partially transparent to highlight high-density areas (i.e., where multiple points overlap). Total area of the MCP = 7,416 km^2. Note: not all error ellipses are visible, as their size may be smaller than that of the mapped point. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

O‘ahu-Maui Nui BIA: Scoring
Intensity
Abundance:
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 Hawai‘i 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 O‘ahu-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 O‘ahu 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.

Range size:
The size of the modified MCP representing the parent BIA is 7,416 km^2.

Scoring criteria:
Intensity scoring: First, abundance and range size are scored independently as follows for each population based on the best available information:

Abundance: **(3)** = 125 or fewer individuals; **(2)** = 126 to 500 individuals; **(1)** = 501 to 2,000 individuals.

Range size: **(3)** = less than 2,000 km^2; **(2)** = 2,001-10,000 km^2; **(1)** = greater than 10,001 km^2

Abundance and range size scores are combined to generate an overall Intensity score using the matrix below:

S-BIA Intensity				
Range	3	**2**	**3**	**3**
	2	**1**	**2**	**3**
	1	**1**	**1**	**2**
		1	2	3
		Abundance		

Abundance = 125 or fewer; **score = 3**
Range size = 7,416 km^2; **score = 2**
<u>**Overall Intensity score = 3**</u>

Rationale
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 (Table 2; Figure 2).

Data Support:
Amount and quality of information used to delineate BIA; justified in the narrative.
  (3) = high confidence in both the fact that the population is small and resident and the abundance and range size estimates of population
  (1) = notably lower confidence
  (2) = represents the remainder of situations that are not notably high or low confidence
Data Support notes:

- 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

<u>Data Support score = 2 (in between low and high confidence)</u>
Rationale
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.

Importance score

Importance Score Matrix				
Intensity	3	2	3	3
	2	1	2	2
	1	0	1	1
		1	2	3
		Data Support		

Intensity = 3
Data Support = 2
Importance score = 3

Boundary Certainty:
Describe the factors used in the boundary delineation.

- **(3)** = high confidence in boundary location
- **(1)** = notably lower confidence
- **(2)** = represents the remainder of situations that are not notably high or low confidence

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 (Figure 1).

Boundary Certainty score = 2

Spatiotemporal Variability indicator:
Dynamic (d), ephemeral (e), or static (s). If the area is dynamic or ephemeral, describe the factor(s) that drive the change in location or timing.
Spatiotemporal variability indicator **is static**. No information to suggest the area is used dynamically or ephemerally.

Summary of BIA scoring for Oʻahu-Maui Nui pygmy killer whale population (see Figure 3)

		Scoring				
	S-BIA	**Intensity**	**Data Support**	**Importance**	**Boundary Certainty**	**Spatiotemporal Variability**
BIA	MCP	3	2	3	2	s

BIA label for O‘ahu-Maui Nui pygmy killer whale S-BIA:
S-BIA3-s-b2-HI002-0

Hawai‘i Island: BIA boundary delineation

Both sighting and satellite tag data were used to inform the S-BIA boundary for the Hawai‘i 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.

Hawai‘i Island: Sighting and photographic data

Sighting data were collected from non-systematic, dedicated small-boat surveys conducted off Hawai‘i Island from 2002-2021 (Table 3, Figure 4; see Baird et al., 2013 for details on surveys). Surveys off Hawai‘i Island total 97,438 km of effort with a total of 52 pygmy killer whale sightings (Figure 4). 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 Hawai‘i 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 Hawai‘i Island insular population were used in boundary determinations (n=1 out of 3 total; Figure 4, 6); effort from these surveys in the area shown in Figure 4 total 4,336 km)

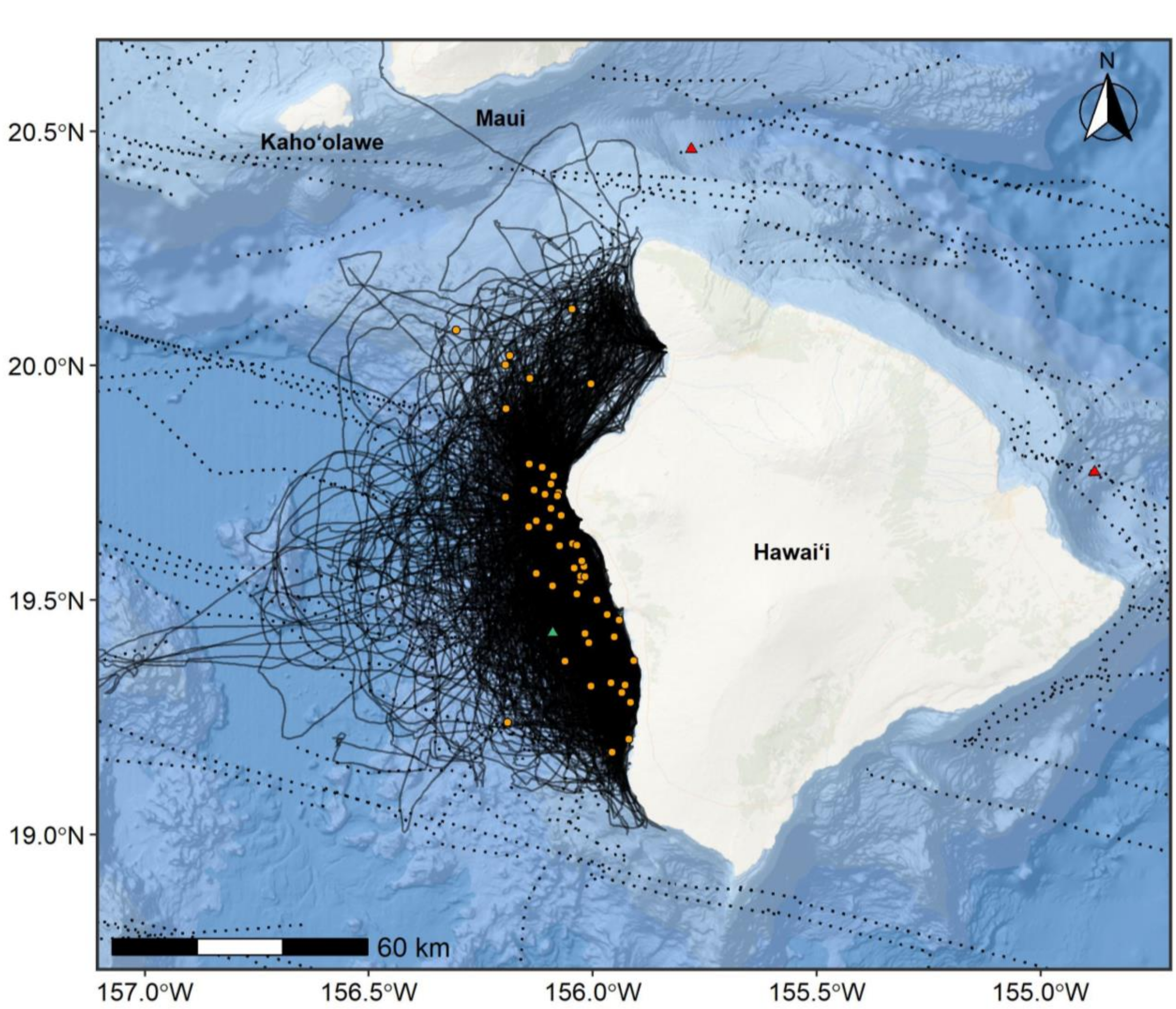

Figure 4. Pygmy killer whale sighting locations (circles = CRC, triangles = NMFS) off Hawai'i Island (n=53) overlaid on CRC small-boat survey research vessel tracklines (solid lines) from efforts conducted during 2002-2021 (97,438 km of effort) and NMFS ship-based line-transect surveys (dotted lines) conducted during 2002-2020 (4,336 km of effort in the area mapped here). Red NMFS sighting locations (n=2) indicate sightings where population assignment is currently unknown and/or sightings are outside the known range of the insular population. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Table 3. Hawaiʻi Island pygmy killer whale sighting data used in boundary determinations

Source	Study duration (first sighting – last sighting)	# unique years with sightings	Total # sightings	Median group size (range)
CRC	2002-2021	17	52	11 (2-33)
NMFS	2009	1	1	6 (NA)
Total	2002-2021	17	53	11 (2-33)

Hawaiʻi Island: Satellite tag data

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 (Table 4, Figure 5; see Baird et al., 2011a). Detailed methods on satellite tag data processing methods are provided in Supplementary File B. 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 1-hour intervals and locations on land were re-routed around a polygon representing the 100-m isobath around the island using the *pathroutr* package (London, 2021). *Crawl* locations interpolated over large periods without any underlying Argos locations were removed prior to analyses (gap threshold = 1 day).

Table 4. Pygmy killer whale Hawaiʻi Island satellite tag data summary

# deployments	Study duration (first tag – last tag)	# unique years with deployments	Median deployment duration (min-max) days	Total # Argos locations	Total # hourly crawl locations
2	2008-2009	2	16.3 (10.3-22.3)	392	721

Hawaiʻi Island BIA boundary: Range size

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* (Figure 6); 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; Figure 6). 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 km^2.

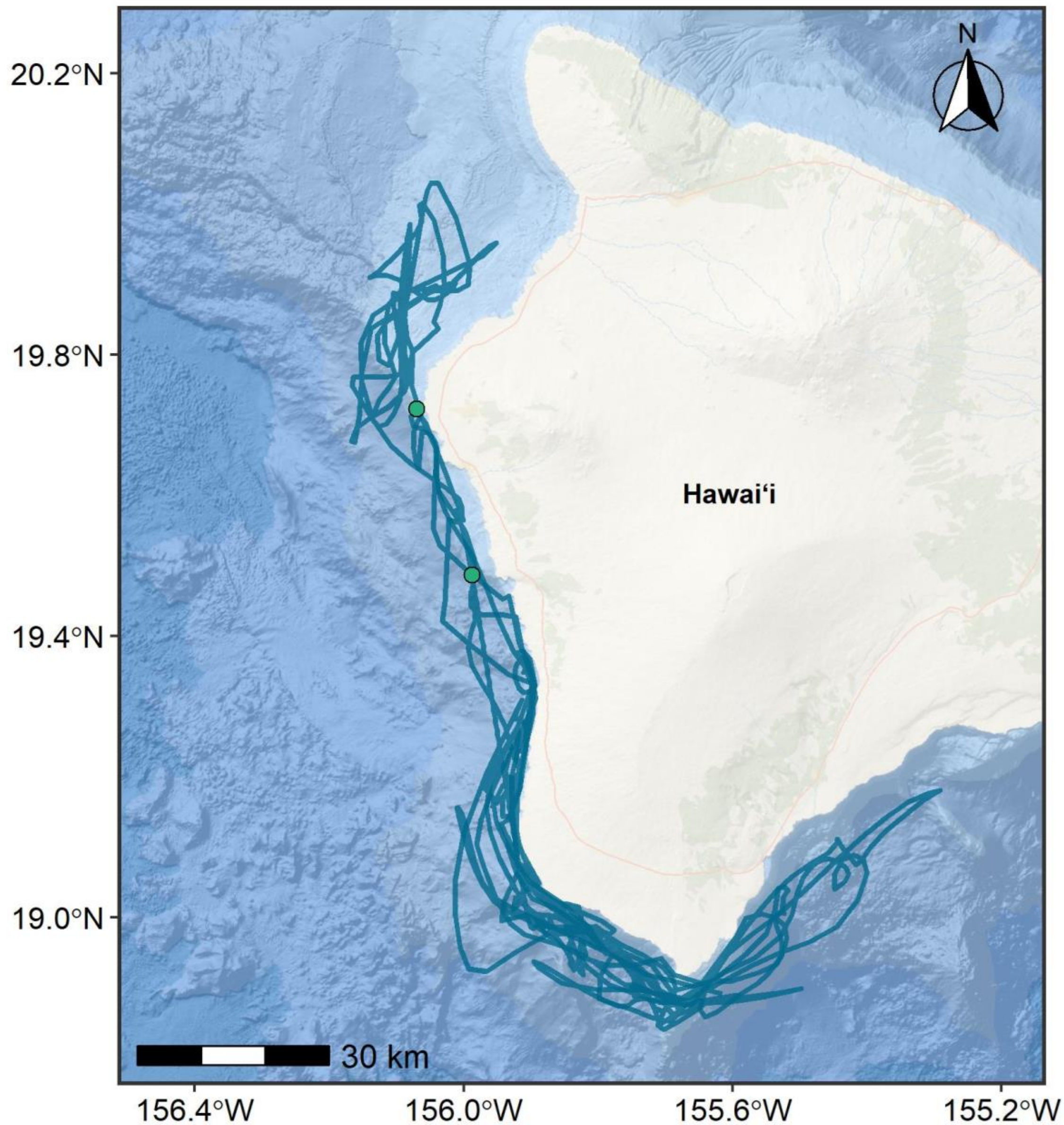

Figure 5. Tracklines of hourly *crawl* positions of satellite tagged pygmy killer whales (n=2), re-routed around the 100-m isobath where necessary to avoid tracks crossing land. Tag deployment locations are shown as green circles. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

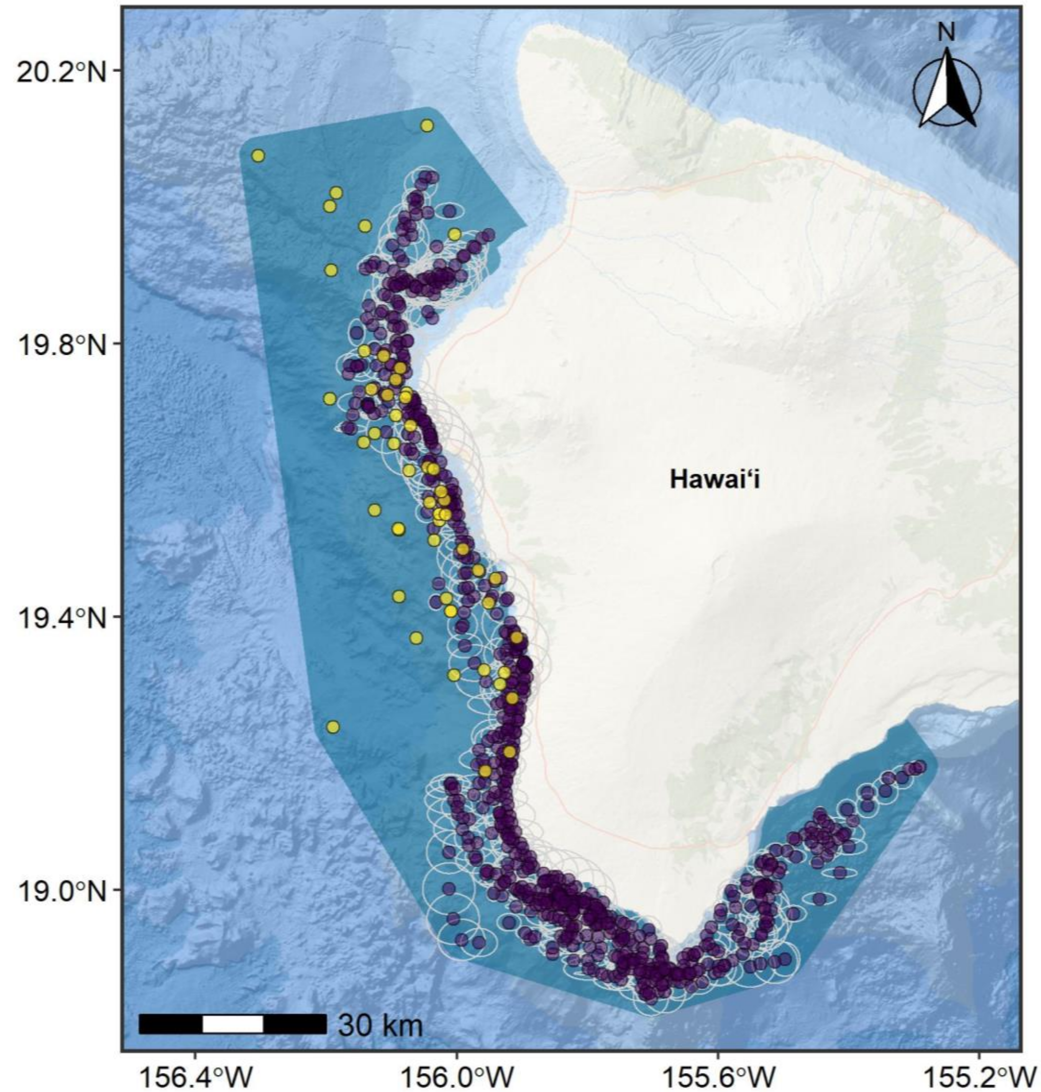

Figure 6. BIA boundary (blue polygon) for the Hawai'i Island pygmy killer whale population represented as a minimum convex polygon (MCP) encompassing all *crawl*-predicted satellite tag locations (purple circles) and sighting locations (yellow circles), extended by 3-km to the outer boundary to capture positional uncertainty estimated by *crawl* (standard error (68% confidence interval) ellipses (light grey ellipses)). The inner (shoreward) boundary of the BIA was defined as the 100-m isobath. Points are partially transparent to highlight high-density areas (i.e., where multiple points overlap). Total area of the MCP = 5,201 km^2. Note: not all error ellipses are visible, as their size may be smaller than that of the mapped point. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Hawai‘i Island BIA: Scoring
Intensity
Abundance:
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 Hawai‘i 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 Hawai‘i 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 of the BIA Intensity scoring criteria.

Range size:
The size of the modified MCP representing the BIA is 5,201 km^2.

Scoring criteria:
Intensity scoring: First, abundance and range size are scored independently as follows for each population based on the best available information:

Abundance: **(3)** = 125 or fewer individuals; **(2)** = 126 to 500 individuals; **(1)** = 501 to 2000 individuals.

Range size: **(3)** = less than 2,000 km^2; **(2)** = 2,001-10,000 km^2; **(1)** = greater than 10,001 km^2

Abundance and range size scores are combined to generate an overall Intensity score using the matrix below:

S-BIA Intensity

Range	3	2	3	3
	2	1	2	3
	1	1	1	2
		1	2	3
		Abundance		

Abundance = 126-500; **score = 2**
Range size = 5,201 km^2; **score = 2**
<u>Overall Intensity score = 2</u>

Rationale
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 (Table 4; Figure 5).

Data Support:
Amount and quality of information used to delineate BIA; justified in the narrative.

(3) = high confidence in both the fact that the population is small and resident and the abundance and range size estimates of population

(1) = notably lower confidence

(2) = represents the remainder of situations that are not notably high or low confidence

Data Support notes:

- 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

Data Support score = 2 (in between low and high confidence)

Rationale

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.

Importance score

Importance Score Matrix

Intensity	3	2	3	3
	2	1	2	2
	1	0	1	1
		1	2	3
		Data Support		

Intensity = 2
Data Support = 2
Importance score = 2

Boundary Certainty:
Describe the factors used in the boundary delineation.
- **(3)** = high confidence in boundary location
- **(1)** = notably lower confidence
- **(2)** = represents the remainder of situations that are not notably high or low confidence

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 (Figure 4).
Boundary Certainty score = 2

Spatiotemporal Variability indicator:
Dynamic (d), ephemeral (e), or static (s). If the area is dynamic or ephemeral, describe the factor(s) that drive the change in location or timing.
Spatiotemporal Variability indicator **is static**. No information to suggest the area is used dynamically or ephemerally.

Summary of BIA scoring for Hawaiʻi Island pygmy killer whale population (see Figure 6)

		Scoring				
	S-BIA	**Intensity**	**Data Support**	**Importance**	**Boundary Certainty**	**Spatiotemporal Variability**
BIA	MCP	2	2	2	2	s

BIA label for Hawaiʻi Island pygmy killer whale S-BIA:
S-BIA2-s-b2-HI003-0

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Melon-headed whale (*Peponocephala electra*)

Background

Two stocks of melon-headed whales (*Peponocephala electra*) are recognized by NMFS in Hawaiian waters: a Hawaiian Islands stock and a small, resident stock associated with insular waters off Kohala, Hawaiʻi Island (hereafter, Kohala resident stock; Caretta et al., 2021). Demographic independence between these two stocks is supported by genetic differentiation (Martien et al., 2017), movements from telemetry studies (Baird, 2016; Woodworth et al., 2012), and a lack of association based on photo-identification studies (Aschettino et al., 2011). Photo-identified individuals from the Kohala resident stock have been re-sighted off Hawaiʻi Island over time spans up to 23 years (1986-2008; 4 different sightings) and on up to 17 separate occasions (Aschettino et al. 2011). Individuals from the Hawaiian Islands stock have been resighted throughout the archipelago and tagged individuals have ranged widely among the islands and offshore, suggesting no particular fidelity towards any island, unlike the Kohala residents. Baird et al. (2015) delineated a BIA for Kohala resident melon-headed whales; here we revised this BIA using updated satellite tag data and sighting information.

BIA boundary delineation

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.

Sighting and photographic data

Sighting data were collected from non-systematic, dedicated small-boat surveys conducted off Hawaiʻi Island from 2002-2021 (Table 1, Figure 1; 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 (Figure 1). 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 (Figure 2); 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 (Figure 1). 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; Figure 1, 3); effort from these surveys in the area shown in Figure 1 total to 4,906 km.

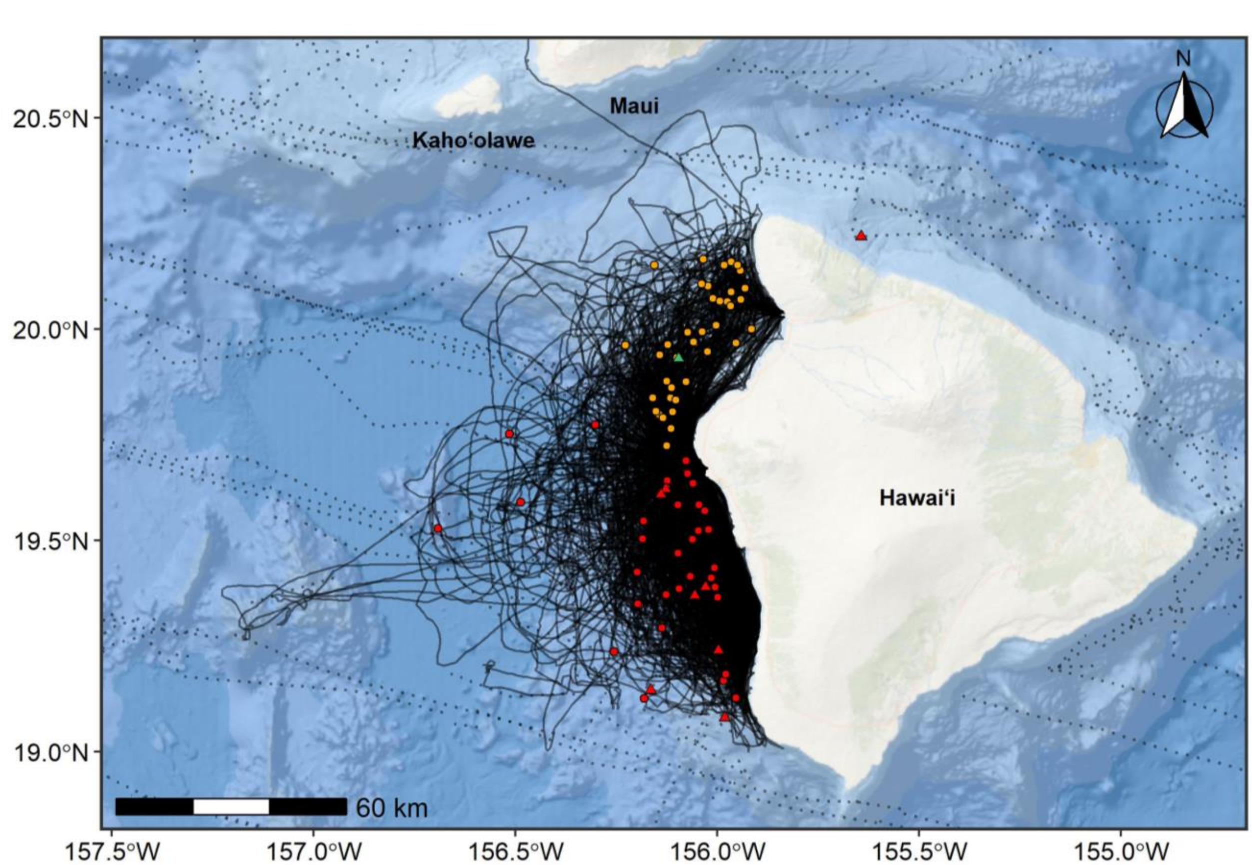

Figure 1. Melon-headed whale sighting locations off Hawaiʻi Island (n=86; circles = CRC, triangles = NMFS) overlaid on CRC small-boat research vessel tracklines (solid lines) from efforts conducted from 2002 through 2021 and NMFS ship-based line-transect surveys conducted during 2002-2020 (dotted lines; 102,344 km of effort combined). Thirty-five sightings (red circles and red triangles) were known or suspected to be part of the Hawaiian Islands stock (not Kohala resident stock) and thus excluded from the BIA boundary (final analytical sample size = 40 sightings). Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Table 1. Kohala resident melon-headed whale sighting data used in boundary determinations

Locality-Source	Study duration (first sighting – last sighting)	# unique years with sightings	Total # sightings	Median group size (range)
Kohala, HI-CRC	2005-2021	14	39	179 (4-550)
Kohala, HI-NMFS	2020	1	1	107 (NA)
Total	2005-2021	14	40	179 (4-550)

Satellite tag data
Satellite tags were deployed on nine melon-headed whales known or thought to be from the Kohala resident stock during dedicated survey efforts off leeward Hawai'i Island from 2008 to 2017 (Table 2, Figure 2; 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 1-hour intervals and locations on land were re-routed around a polygon representing the 200-m isobath using the *pathroutr* package (London, 2021).

Table 2. Kohala resident melon-headed whale satellite tag data summary

# deployments	Study duration (first tag – last tag)	# unique years with deployments	Median (range) deployment duration (days)	Total # Argos locations*	Total # hourly *crawl* locations
9	2008-2017	6	11.2 (4-25.4)	1,794	2,622

*Value represents Douglas-filtered Argos locations used to generate *crawl* tracks. See supplementary material for details on satellite tag processing methods

BIA boundary: Range size
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* (Figure 3); 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 BIA (i.e., population range size) is 3,816 km^2.

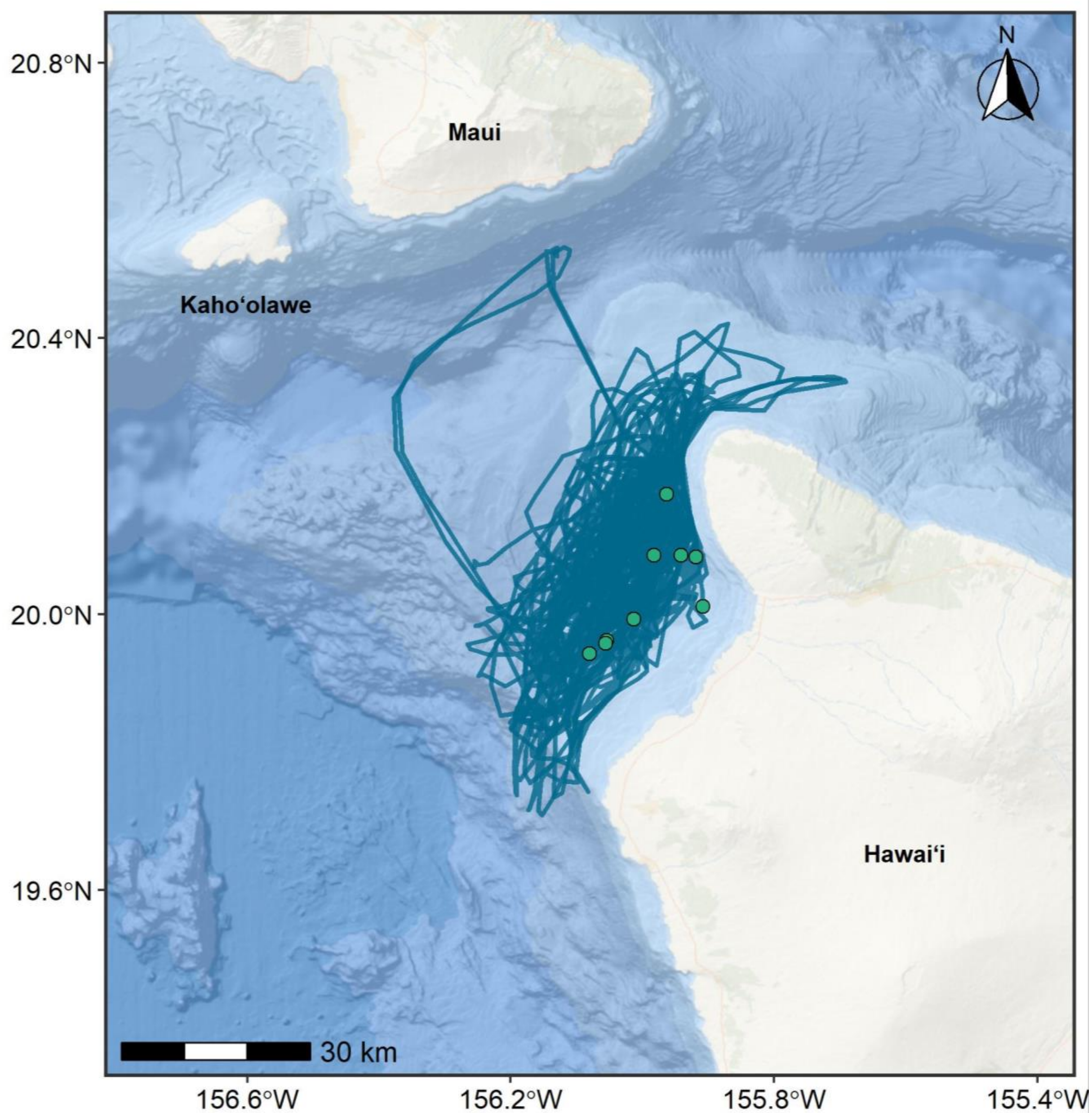

Figure 2. Tracklines of 1-hour *crawl* positions of satellite-tagged Kohala resident melon-headed whales (n=9) re-routed around land (with 200-m isobath) where necessary to avoid tracks crossing land. Tag deployment locations are shown as green circles. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

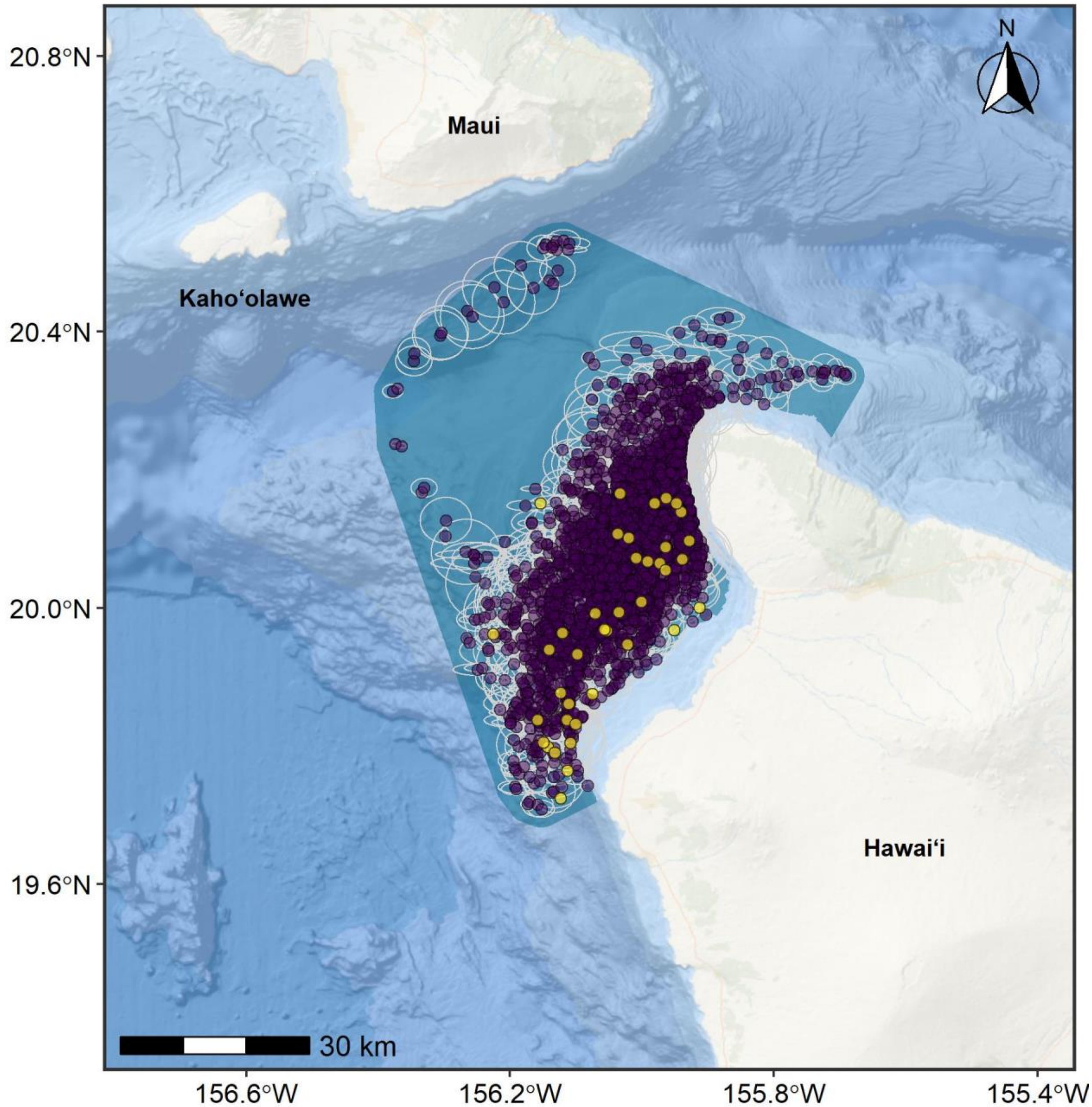

Figure 3. BIA boundary (blue polygon) for the Kohala resident melon-headed whale stock. This BIA is represented as a minimum convex polygon (MCP) encompassing all *crawl*-predicted satellite tag locations (purple circles) and sighting locations (yellow circles), extended by 3 km to the outer boundary to include *crawl* standard error (68% confidence interval) ellipses (light grey ellipses). Points are partially transparent to highlight high density areas (i.e., where multiple points overlap). The inner (shoreward) boundary is defined as the 200-m isobath. Total area of the boundary = 3,816 km^2. Note: not all error ellipses are visible, as their size may be smaller than that of the mapped point. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

BIA: Scoring
Intensity
Abundance:
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 of the BIA Intensity scoring criteria.

Range size:
The size of the modified MCP representing the BIA is 3,816 km^2.

Scoring criteria:
Intensity scoring: First, abundance and range size are scored independently as follows for each population based on the best available information:
Abundance: **(3)** = 125 or fewer individuals; **(2)** = 126 to 500 individuals; **(1)** = 501 to 2,000 individuals.
Range size: **(3)** = less than 2,000 km^2; **(2)** = 2,001-10,000 km^2; **(1)** = greater than 10,00 km^2

Abundance and range size scores are combined to generate an overall Intensity score using the matrix below:

S-BIA Intensity

Range	3	2	3	3
	2	1	2	3
	1	1	1	2
		1	2	3
		Abundance		

Abundance = 126-500; **score = 2**
Range size = 3,816 km^2; **score = 2**
<u>Overall Intensity score = 2</u>

Rationale
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.

Data Support:
Amount and quality of information used to delineate BIA; justified in the narrative.

(3) = high confidence in both the fact that the population is small and resident and the abundance and range size estimates of population
(1) = notably lower confidence
(2) = represents the remainder of situations that are not notably high or low confidence

Data Support notes:

- 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

Data Support score = 3 (high confidence)

Rationale

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 (Table 2; Figure 2) maintain support for the existence of this small and resident stock with a relatively small range off Kohala, Hawaiʻi Island.

Importance score

Importance Score Matrix				
Intensity	3	2	3	3
	2	1	2	2
	1	0	1	1
		1	2	3
		Data Support		

Intensity = 2
Data support = 3
Importance score = 2

Boundary Certainty:
Describe the factors used in the boundary delineation.
- **(3)** = high confidence in boundary location
- **(1)** = notably lower confidence
- **(2)** = represents the remainder of situations that are not notably high or low confidence

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 (Figure 2, 3).

Boundary Certainty score = 3

Spatiotemporal Variability indicator:
Dynamic (d), ephemeral (e), or static (s). If the area is dynamic or ephemeral, describe the factor(s) that drive the change in location or timing.
Spatiotemporal variability indicator **is static**. No information to suggest the area is used dynamically or ephemerally.

Summary of BIA scoring for Kohala resident melon-headed whale population (see Figure 3)

		Scoring				
	S-BIA	**Intensity**	**Data Support**	**Importance**	**Boundary Certainty**	**Spatiotemporal Variability**
BIA	MCP	2	3	2	3	s

BIA label for Kohala melon-headed whale S-BIA:
S-BIA2-s-b3-HI006-0

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False killer whale (*Pseudorca crassidens*)

Background

Three stocks of false killer whales (*Pseudorca crassidens*) have been recognized from Hawaiian waters: a broadly ranging pelagic stock, an insular Northwestern Hawaiian Islands stock (NWHI), and an insular main Hawaiian Islands (MHI) stock that was listed as endangered under the ESA in 2012 (Carretta et al. 2021). The ranges of all three stocks partially overlap (Bradford et al. 2015), but individuals can be assigned to a stock based on genetics (Chivers et al., 2010; Martien et al. 2014) and/or photo-identification (Baird et al. 2008; Baird, 2016). The MHI stock comprises at least four social clusters (i.e., stable groups of regularly associating and related individuals (Baird et al., 2012; Mahaffy et al., In prep; Martien et al., 2019). Information on movements from satellite tag data indicate that these social clusters may have geographically distinct core ranges but share a common MHI-wide range from Kaua‘i/Ni‘ihau to Hawai‘i Island, with individuals moving frequently and quickly among most or all of these island areas (Baird et al., 2010, 2012, 2019). NWHI false killer whales satellite tagged off Kaua‘i and Nihoa have been tracked no further east than Kaua‘i/Ni‘ihau and as far west as the Gardner Pinnacles, moving primarily along shelf/slope regions of this portion of the archipelago (Baird et al., 2013b; Baird, 2016). Sightings of NWHI false killer whales in other regions of the main Hawaiian Islands have been documented (e.g., O‘ahu, Hawai‘i Island), but are extremely rare (CRC unpublished). Although the two insular false killer whale stocks’ ranges overlap at Kaua‘i/Ni‘ihau, these two insular stocks appear to be socially isolated based on associations, with no encounters including individuals from both stocks, and there is also evidence for genetic differentiation between the two stocks (Martien et al., 2014). Baird et al., (2015) delineated a single BIA for MHI false killer whales based on high-density areas identified by satellite tag data. In this assessment, two BIAs were delineated for false killer whales in Hawai‘i – one for each of the MHI and NWHI stocks – in accordance with demographic and geographic differences between these two stocks. Herein we detail the BIA description for NWHI false killer whales.

MHI: BIA boundary delineation

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 stock based on primary habitat identified through satellite tag data.

MHI: Sighting and photographic data

Sighting and photographic data were collected from CRC non-systematic, dedicated small-boat surveys conducted throughout the main Hawaiian Islands from 2000-2021 (Table 1, Figure 1; 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 (Figure 1). In addition, photos taken by other researchers during localized research efforts (e.g., Pacific Whale Foundation off Maui Nui, Dan McSweeney off Hawai‘i 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 (Figure 1; 23,830 km of effort for the area mapped in Figure 1).

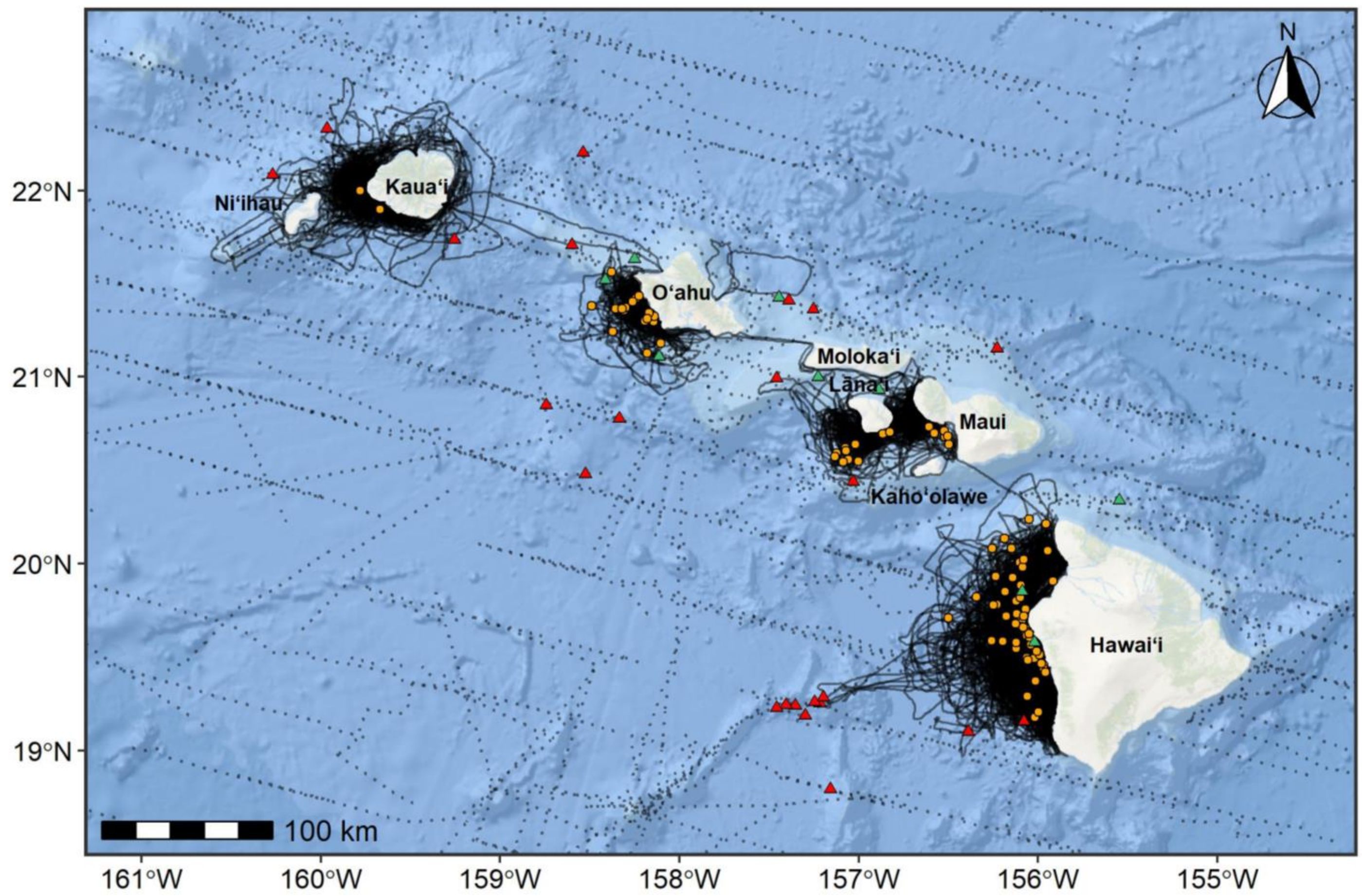


Figure 1. MHI insular false killer whale sighting locations (n=101; orange circles = CRC, green triangles = NMFS) overlaid on CRC small-boat research vessel tracklines from efforts conducted from 2000 through 2021 (148,080 km of effort) and NMFS ship-based line-transect surveys conducted during 2002-2020 (23,830 km of effort). Red triangles indicate NMFS sightings of false killer whales with unknown stock assignment or have been confirmed to not belong to the MHI insular false killer whale stock (n=25). Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Table 1. MHI insular false killer whale sighting data from CRC small boat surveys and NMFS ship-based line-transect surveys

Island-Source	Study duration (first sighting – last sighting)	# unique years with sightings	Total # sightings	Median group size (range)
Kaua'i/Ni'ihau-CRC	2014-2021	2	2	25 (20-30)
O'ahu-CRC	2002-2017	5	17	13 (3-35)
Maui Nui-CRC	2000-2020	6	16	14 (6-35)
Hawai'i Island-CRC	2002-2021	16	57	17 (1-41)
O'ahu-NMFS	2009-2017	3	4	37 (2-60)
Maui Nui-NMFS	2010-2017	2	2	12 (1-24)
Hawai'i Island-NMFS	2005-2017	3	3	17 (10-31)
Total	2000-2021	20	101	15 (1-60)

MHI: Satellite tag data

Location data from satellite tags were available for 65 deployments on MHI insular false killer whales from 2007-2021 (Table 2, Figure 2; Baird et al. 2012, 2021; 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 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, 2021). *Crawl* locations interpolated over periods spanning one or more days without any underlying Argos locations were removed.

Table 2. MHI insular false killer whale satellite tag data summary

# deployments	Study duration (first tag – last tag)	# unique years with deployments	Median (range) deployment duration (days)	Total # Argos locations*	Total # 4-hourly *crawl* locations
65	2007-2021	13	40 (2.1-199)	38,286	18,851

*Value represents Douglas-filtered Argos locations (or Argos and GPS locations, for applicable tags) used to generate *crawl* tracks. See supplementary material for details on satellite tag processing methods

MHI Parent BIA boundary: Range size

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 band to the outer boundary of the MCP to account for positional uncertainty in the locations estimated by *crawl* (Figure 3). The inner (shoreward) boundary was defined as a 50-m distance band 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 (Figure 3). The resulting area of the parent BIA (i.e., population range size) is 94,217 km^2.

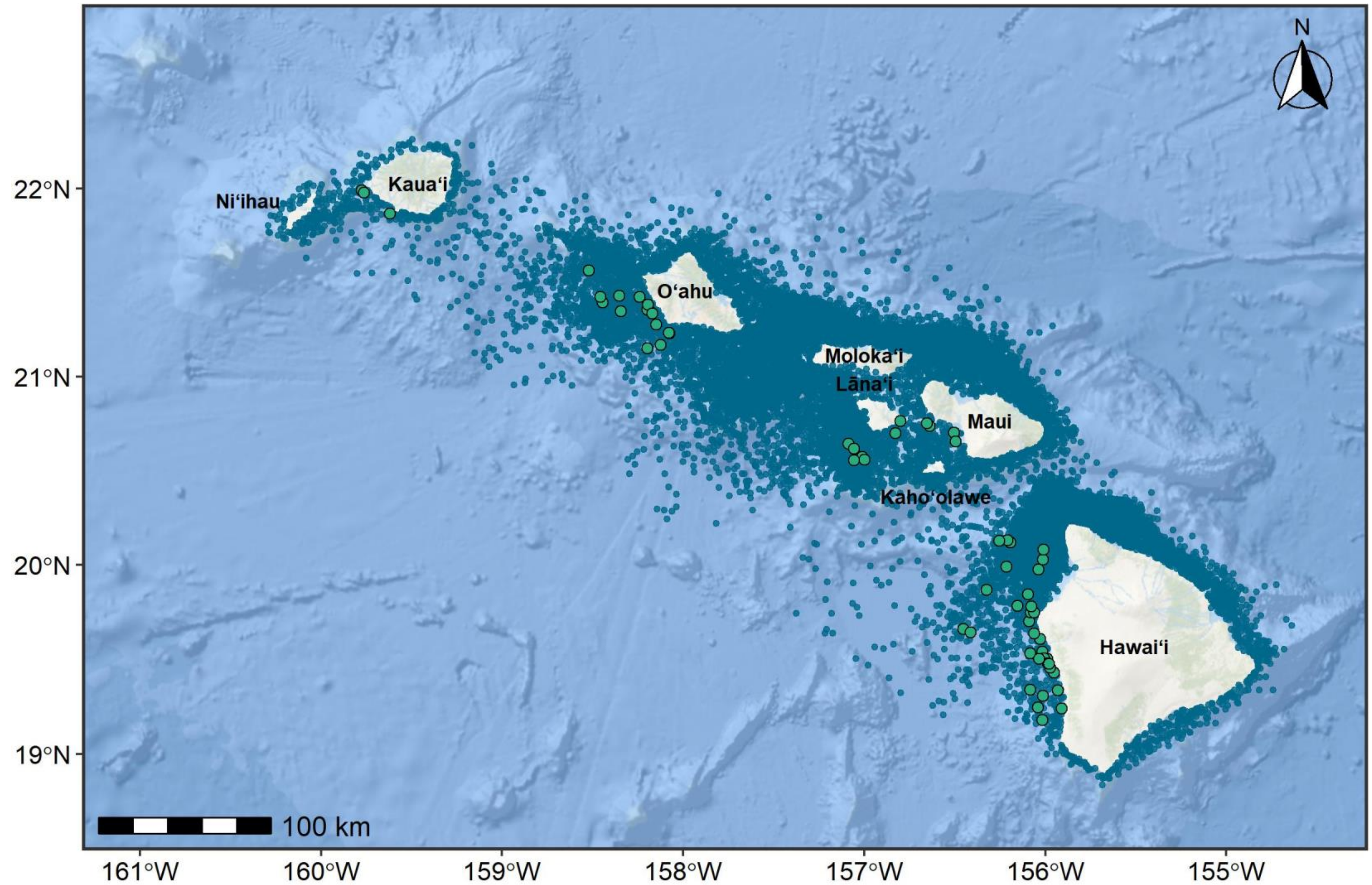


Figure 2. 4-hour *crawl* positions of satellite tagged false killer whales from the MHI insular stock (n=65), re-routed around land (with 50-m added distance band) where necessary to avoid positions on land. Tag deployment locations are shown as green circles. Basemap image is the intellectual property of Esri and is used herein with permission.

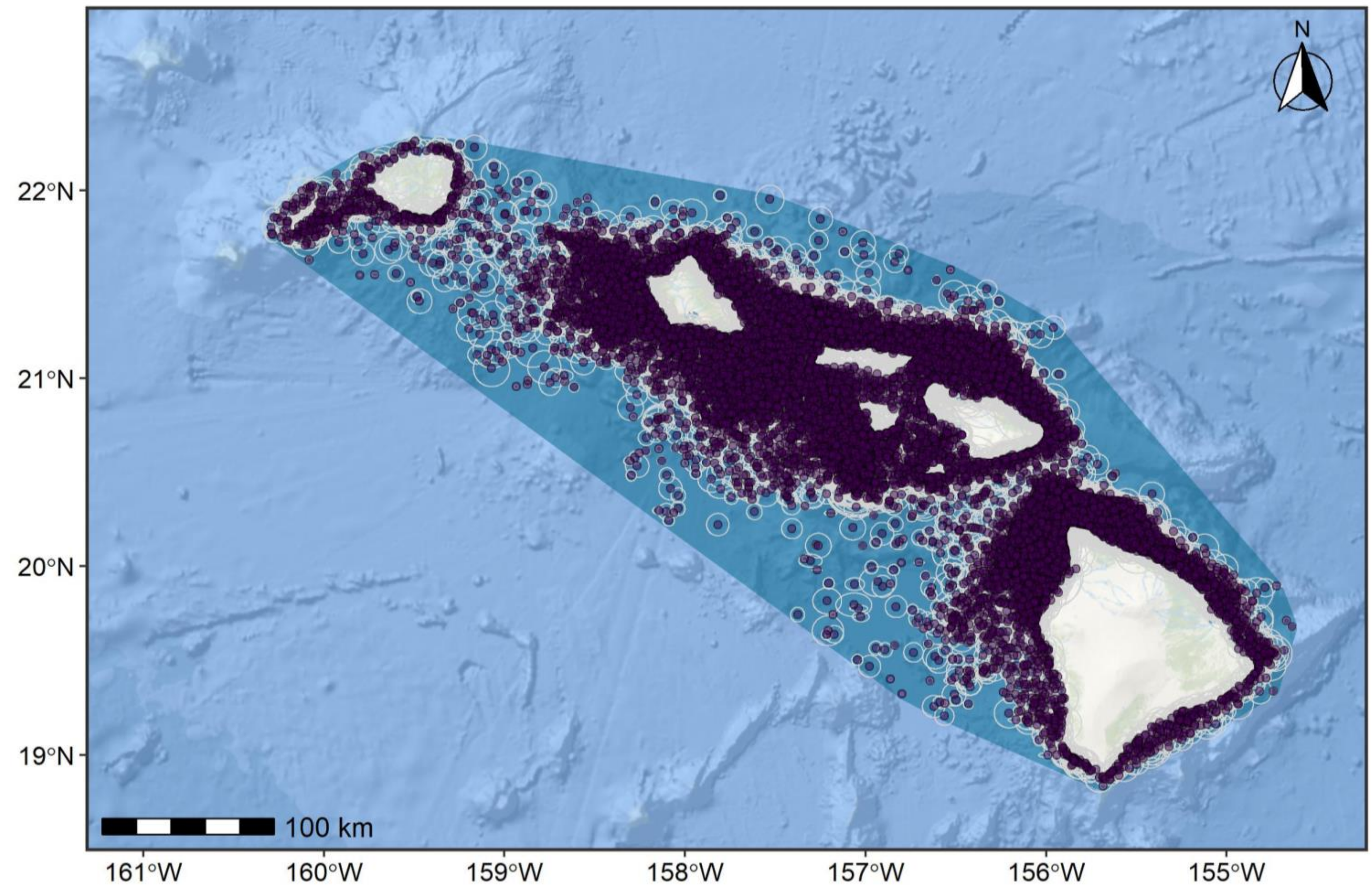


Figure 3. Parent BIA (blue polygon) for the MHI insular false killer whale stock. This parent BIA is represented as a minimum convex polygon (MCP) encompassing all *crawl*-predicted satellite tag locations (purple circles), extended by 3 km on the outer boundary to include the *crawl* standard error (68% confidence interval) ellipses (light grey ellipses). Points are partially transparent to highlight high density areas (i.e., where multiple points overlap). The inner (shoreward) boundary is defined as a 50-m distance band from shore. Total area of the parent BIA = 94,217 km^2. Note: not all error ellipses are visible, as their size may be smaller than that of the mapped point. Basemap image is the intellectual property of Esri and is used herein with permission.

MHI BIA: Scoring
Intensity
Abundance:
The most recent abundance estimate for this stock is 167 individuals (95% CI 128-218) from 2015; the estimate was based on long-term photo-identification data collected by CRC, other researchers, and community scientists (Bradford et al., 2018).

Range size:
The size of the modified MCP representing the parent BIA is 94,217 km^2.

Scoring criteria:
Intensity scoring: First, abundance and range size are scored independently as follows for each population based on the best available information:

Abundance: **(3)** = 125 or fewer individuals; **(2)** = 126 to 500 individuals; **(1)** = 501 to 2,000 individuals.

Range size: **(3)** = less than 2,000 km^2; **(2)** = 2,001-10,000 km^2; **(1)** = greater than 10,001 km^2

Abundance and range size scores are combined to generate an overall intensity score using the matrix below:

S-BIA Intensity				
Range	3	**2**	**3**	**3**
	2	**1**	**2**	**3**
	1	**1**	**1**	**2**
		1	2	3
		Abundance		

Abundance = 126 to 500; **score = 2**
Range size = 91,581 km^2; **score = 1**
<u>Overall Intensity score = 1</u>

Rationale
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 Kaua‘i/Ni‘ihau to Hawai‘i Island.

Data Support:
Amount and quality of information used to delineate BIA; justified in the narrative.

(3) = high confidence in both the fact that the population is small and resident and the abundance and range size estimates of population

(1) = notably lower confidence

(2) = represents the remainder of situations that are not notably high or low confidence

Data Support notes:

- 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

<u>Data Support score = 3 (high confidence)</u>

Rationale

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; Figure 3); 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.

Importance score

Importance Score Matrix				
Intensity	3	**2**	**3**	**3**
	2	**1**	**2**	**2**
	1	0	**1**	**1**
		1	2	3
		Data Support		

Intensity = 1
Data support = 3
<u>**Importance score = 1**</u>

Boundary Certainty:
Describe the factors used in the boundary delineation.

- **(3)** = high confidence in boundary location
- **(1)** = notably lower confidence
- **(2)** = represents the remainder of situations that are not notably high or low confidence

<u>**Boundary Certainty score = 3**</u>

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*).

Spatiotemporal Variability indicator:
Dynamic (d), ephemeral (e), or static (s). If the area is dynamic or ephemeral, describe the factor(s) that drive the change in location or timing.
Spatiotemporal variability indicator **is static**. No information to suggest the area is used dynamically or ephemerally.

MHI false killer whale: Child BIA boundary delineation

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 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).

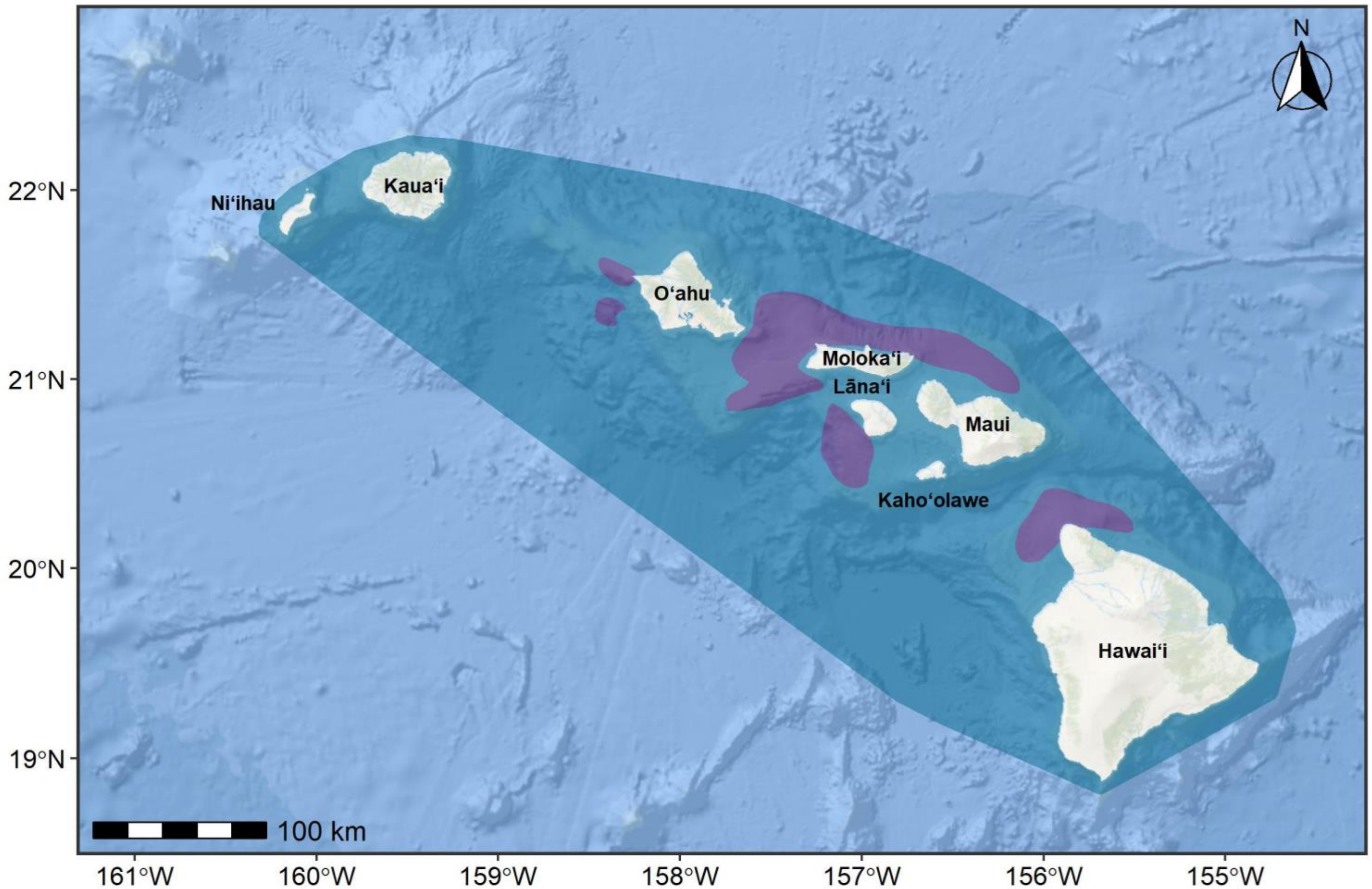


Figure 4. Parent BIA (blue polygon, area = 94,217 km^2) and child BIA (purple polygons, total area = 7,775 km^2) for the MHI insular false killer whale stock. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

MHI Child BIA: Scoring
Intensity
Abundance:
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.

Area of child BIA (all polygons combined): 7,775 km^2

<u>Overall Intensity score = 3</u>

Rationale
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. The most recent estimated abundance for the entire stock is only 167 individuals, and the core ranges characterized here reflect intensified use of this small stock.

Data Support
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 O‘ahu and between O‘ahu and Maui Nui.

<u>Data Support score = 3 (high confidence)</u>

Importance score:

Importance Score Matrix

Intensity	3	2	3	3
	2	1	2	2
	1	0	1	1
		1	2	3
		Data Support		

<u>Importance score = 3</u>

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).

Boundary Certainty score = 3

Summary of BIA scoring for MHI false killer whale population (see Figure 3, 4)

		Scoring				
	S-BIA	**Intensity**	**Data support**	**Importance**	**Boundary Certainty**	**Spatiotemporal Variability**
Parent BIA	MCP	1	3	1	3	s
Core BIA	50% UD	3	3	3	3	s

Hierarchical BIA labels:
Parent: **S-BIA1-s-b3-HI035-0a**
Child-core: **S-BIA3-s-b3-HI035-a**

NWHI: BIA boundary delineation

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.

NWHI: Sighting and photographic data

Sighting and photographic data for individuals from the NWHI stock come from three different sources: CRC small-boat surveys, NMFS ship-based line-transect surveys, and community science contributions. CRC has conducted non-systematic, dedicated small-boat surveys throughout the main Hawaiian Islands from 2000-2021 (Table 3, Figure 5; 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 group sightings in four different years (2012, 2013, 2015, 2020), all of which were off Kauaʻi/Niʻihau (Figure 5). 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 Figure 5; see Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020 for details on surveys). False killer whales from this stock 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 stock 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).

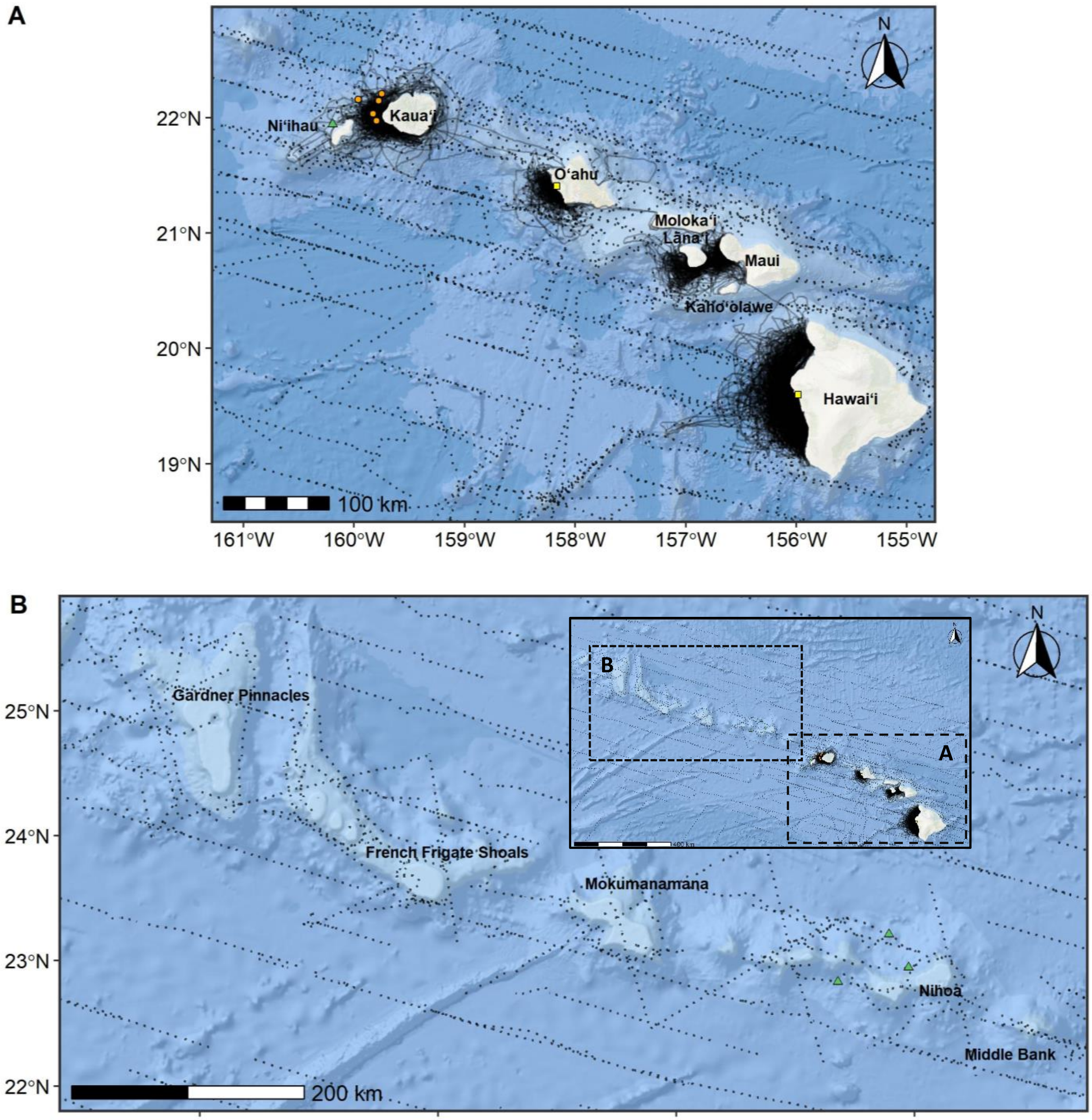


Figure 5. NWHI false killer whale sighting locations (n=5, CRC, orange circles; n=4, NMFS, green triangles) overlaid on research vessel tracklines from efforts conducted by CRC from 2000-2021 and NMFS from 2002-2020 (194,535 km of effort combined) in the MHI (Panel A) and NWHI (Panel B) regions. Latitude and longitude were not available for community science contributions, although general area (e.g., Wai‘anae, O‘ahu and Kona, Hawai‘i Island, marked by yellow squares) was noted. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Table 3. NWHI false killer whale sighting data from CRC and NMFS surveys

Island	Study duration (first sighting – last sighting)	# unique years with sightings	Total # sightings	Median group size (range)
CRC-Kaua'i/Ni'ihau	2012-2020	4	5	18 (8-20)
NMFS-Ni'ihau	2006	1	1	8 (NA)
NMFS-Nihoa	2010	1	3	20 (9-52)
Total	2006-2020	6	9	18 (8-20)

NWHI: Satellite tag data

Location data from satellite tags were available for seven deployments on NWHI false killer whales from 2010-2015, tagged either off Nihoa (n=2) or Kaua'i (n=5) (Table 4, Figure 6; 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 4-hour intervals and locations on land were re-routed around a polygon representing the islands with a 50-m distance band added using the *pathroutr* package (London, 2021). *Crawl* locations interpolated over periods spanning one or more days without any underlying Argos locations were removed.

Table 4. NWHI false killer whale satellite tag data summary

# deployments	Study duration (first tag – last tag)	# unique years with deployments	Median (range) deployment duration (days)	Total # Argos locations*	Total # 4-hourly *crawl* locations
7	2010-2015	4	21 (4.7-52.2)	2,059	1,037

*Value represents Douglas-filtered Argos locations used to generate *crawl* tracks. See supplementary material for details on satellite tag processing methods

NWHI BIA boundary: Range size

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 band to the outer boundary of the MCP to account for positional uncertainty in the locations estimated by *crawl* (Figure 7). Although there are two sightings of individuals from this stock off Wai'anae, O'ahu, and one of off Kona, Hawai'i, these areas are not considered to be part of the regular range of this population, given they represent less than 2% of all false killer whale encounters off O'ahu, and less than 0.4% of false killer whale encounters to the islands to the east of O'ahu (CRC unpublished). The inner (shoreward) boundary was defined as a 50-m distance band 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 km^2.

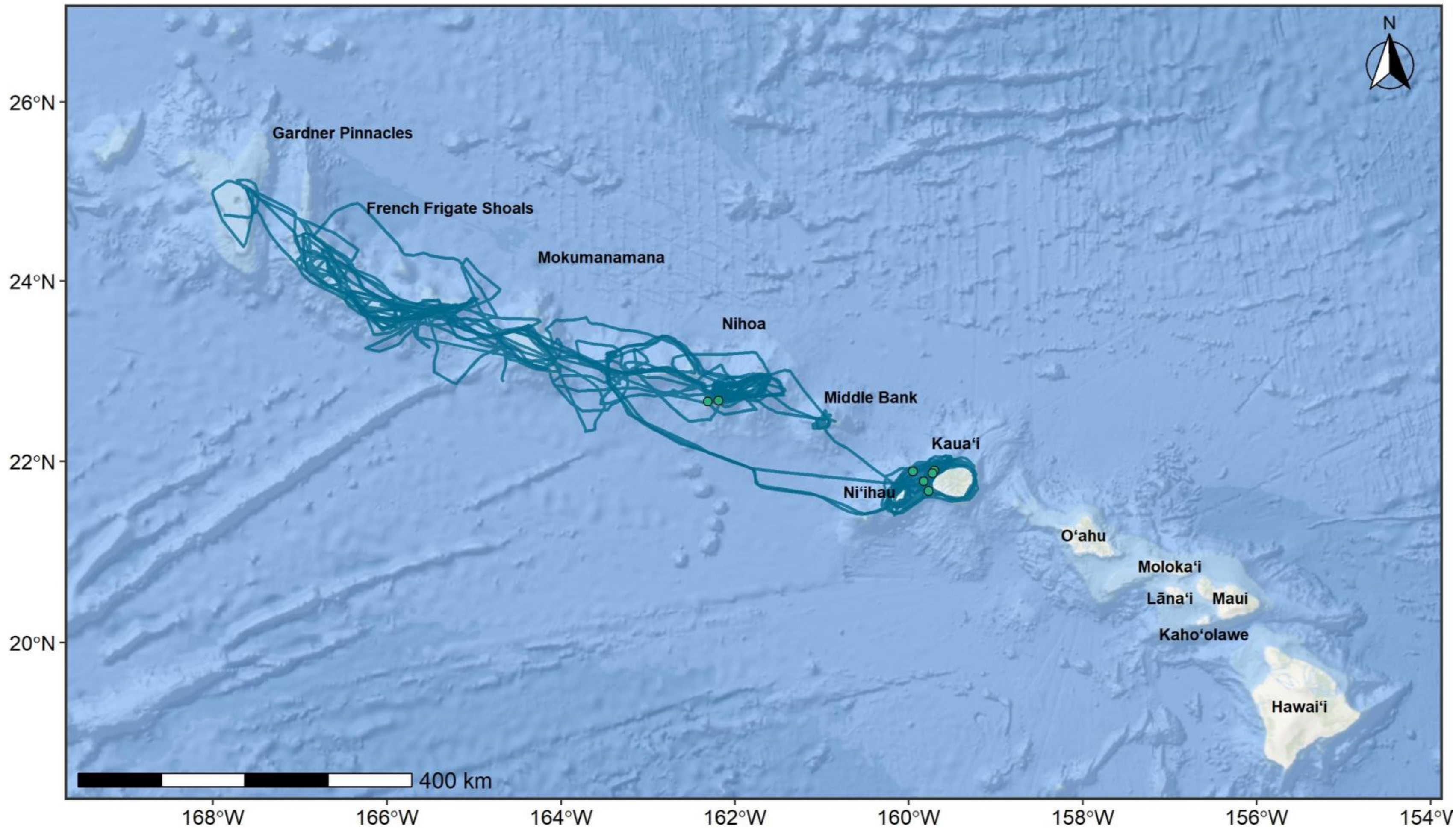


Figure 6. Hourly *crawl* tracks of satellite-tagged false killer whales from the Northwestern Hawaiian Islands insular stock (n=7), re-routed around land (with 50-m added distance band) where necessary to avoid positions on land. Tag deployment locations are shown as green circles. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

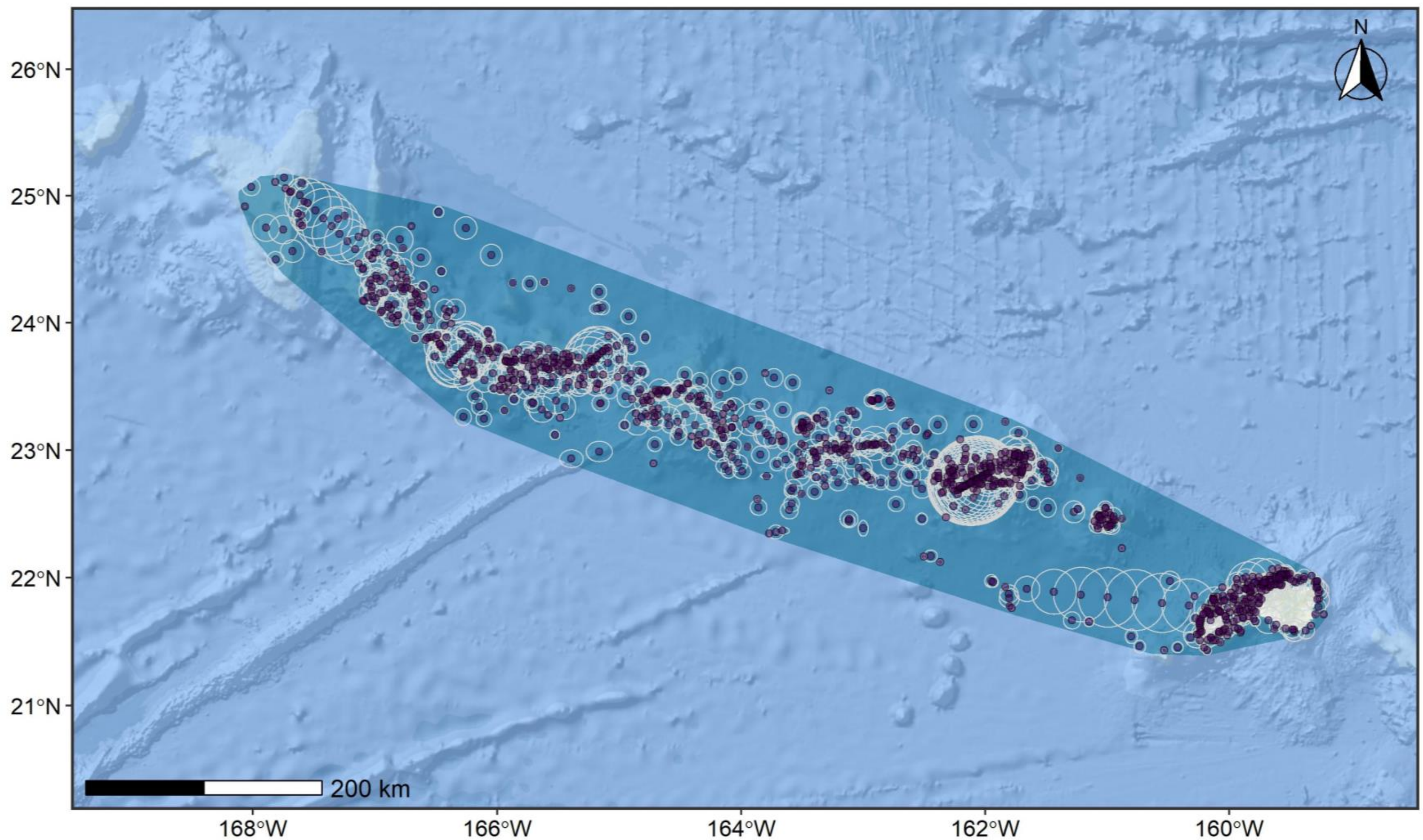


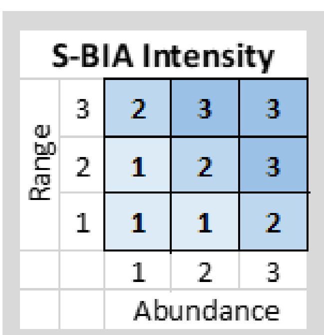
Figure 7. BIA (blue polygon) for the NWHI false killer whale stock. This BIA is represented as a minimum convex polygon (MCP) encompassing all *crawl*-predicted satellite tag locations (purple circles), extended by 3 km on the outer boundary to include the *crawl* standard error (68% confidence interval) ellipses (light grey ellipses). Points are partially transparent to highlight high density areas (i.e., where multiple points overlap). The inner (shoreward) boundary is defined as a 50-m distance band from shore. Total area of the BIA = 138,001 km^2. Note: not all error ellipses are visible, as their size may be smaller than that of the mapped point. Basemap image is the intellectual property of Esri and is used herein with permission.

NWHI BIA: Scoring
Intensity
Abundance:
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 but recognize there is uncertainty in this estimate due to limited survey coverage on this stock.

Range size:
The size of the modified MCP representing the BIA is 138,001 km^2.

Scoring criteria:
Intensity scoring: First, abundance and range size are scored independently as follows for each population based on the best available information:
Abundance: **(3)** = 125 or fewer individuals; **(2)** = 126 to 500 individuals; **(1)** = 501 to 2,000 individuals.
Range size: **(3)** = less than 2,000 km^2; **(2)** = 2,001-10,000 km^2; **(1)** = greater than 10,001 km^2

Abundance and range size scores are combined to generate an overall intensity score using the matrix below:



S-BIA Intensity				
Range	3	2	3	3
	2	1	2	3
	1	1	1	2
		1	2	3
		Abundance		

Abundance = 126 to 500; **score = 2**
Range size = 138,001 km^2; **score = 1**
<u>Overall Intensity score = 1</u>

Rationale
The abundance estimate used to inform the intensity score is contemporary and specific to this stock; 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 stock is small but, similar to the abundance estimate, limited survey and sighting data on this stock 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.

Data Support:
Amount and quality of information used to delineate BIA; justified in the narrative.

> **(3)** = high confidence in both the fact that the population is small and resident and the abundance and range size estimates of population
> **(1)** = notably lower confidence
> **(2)** = represents the remainder of situations that are not notably high or low confidence

Data Support notes:

- 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 Kaua‘i/Ni‘ihau and others primarily between the Gardner Pinnacles and Middle Bank (Figure 2)
- Tag positional uncertainty and irregularity accounted for through *crawl* model, and boundary encompasses nearly all of crawl standard error (68% confidence interval) ellipses

Data Support score = 2 (intermediate confidence)

Rationale

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., Kaua‘i/Ni‘ihau).

Importance score

Importance Score Matrix				
Intensity	3	2	3	3
	2	1	2	2
	1	0	1	1
		1	2	3
		Data Support		

Intensity = 1
Data support = 2
Importance score = 1

Boundary Certainty:
Describe the factors used in the boundary delineation.

- **(3)** = high confidence in boundary location
- **(1)** = notably lower confidence
- **(2)** = represents the remainder of situations that are not notably high or low confidence

Boundary Certainty score = 2

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.

Spatiotemporal Variability indicator:
Dynamic (d), ephemeral (e), or static (s). If the area is dynamic or ephemeral, describe the factor(s) that drive the change in location or timing.
Spatiotemporal variability indicator **is static**. No information to suggest the area is used dynamically or ephemerally.

Summary of scoring for NWHI insular false killer whale S-BIA (see Figure 7)

	Scoring				
S-BIA	**Intensity**	**Data support**	**Importance**	**Boundary Certainty**	**Spatiotemporal Variability**

Parent BIA	MCP	1	2	1	2	s

BIA label for NWHI false killer whale S-BIA:
S-BIA1-s-b2-HI034-0

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Short-finned pilot whale (*Globicephala macrorhynchus*)

Background

NMFS recognizes only a single EEZ-wide stock of short-finned pilot whale (*Globicephala macrorhynchus*) in Hawaiian waters (Caretta et al., 2021). However, long-term re-sightings of individuals, movements from satellite tag deployments, and genetic analyses all support the existence of a more complex population structure, that includes at least one insular population comprised of several regional communities as well as a broader-ranging pelagic population (Baird, 2016; Mahaffy et al., 2015; Oleson et al., 2013; Van Cise et al., 2017). 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, all three lines of evidence 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). Satellite tagged whales from the eastern community have largely associated with slope waters around Hawaiʻi Island; movements to other island areas and offshore have been documented, although are extremely rare (Baird, 2016; CRC unpublished). In contrast, the western community tends to use deeper waters and makes offshore and inter-island movements more frequently, as shallower slope waters are limited within their known primary range (Baird, 2016). Less is known about movements and structure of the central community of insular short-finned pilot whales, although available data shows range overlap with both western and eastern communities with higher use off south Maui Nui and Oʻahu (Baird, 2016). Collectively, there is evidence documenting inter-island movements throughout the main Hawaiian Islands of known insular short-finned pilot whales. Given overlap in ranges from movement data, individuals from different communities may interact to some degree. However, these lines of evidence and current understanding of MHI short-finned pilot whale social structure suggest that community structure is more distinct (i.e., individuals heavily associate with those within their own community, and are less likely to disperse to other communities). Despite this, current data preclude a robust understanding of the spatial extent specific to each community from which we could delineate community-specific S-BIAs. Therefore, we delineated a single parent BIA to represent the range of the entire insular short-finned pilot whale small and resident population (MHI population, hereafter) and highlighted community-specific ranges through hierarchical BIAs.

BIA boundary delineation

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 were 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.

Sighting and photographic data

Sighting and photographic data were collected from CRC non-systematic, dedicated small-boat surveys conducted throughout the main Hawaiian Islands (MHI) from 2000-2021 (Table 1, Figure 1; 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; Figure 1). In addition, photos taken by other researchers during localized research efforts (e.g., Pacific Whale Foundation off Maui Nui, Dan McSweeney off Hawai‘i 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.

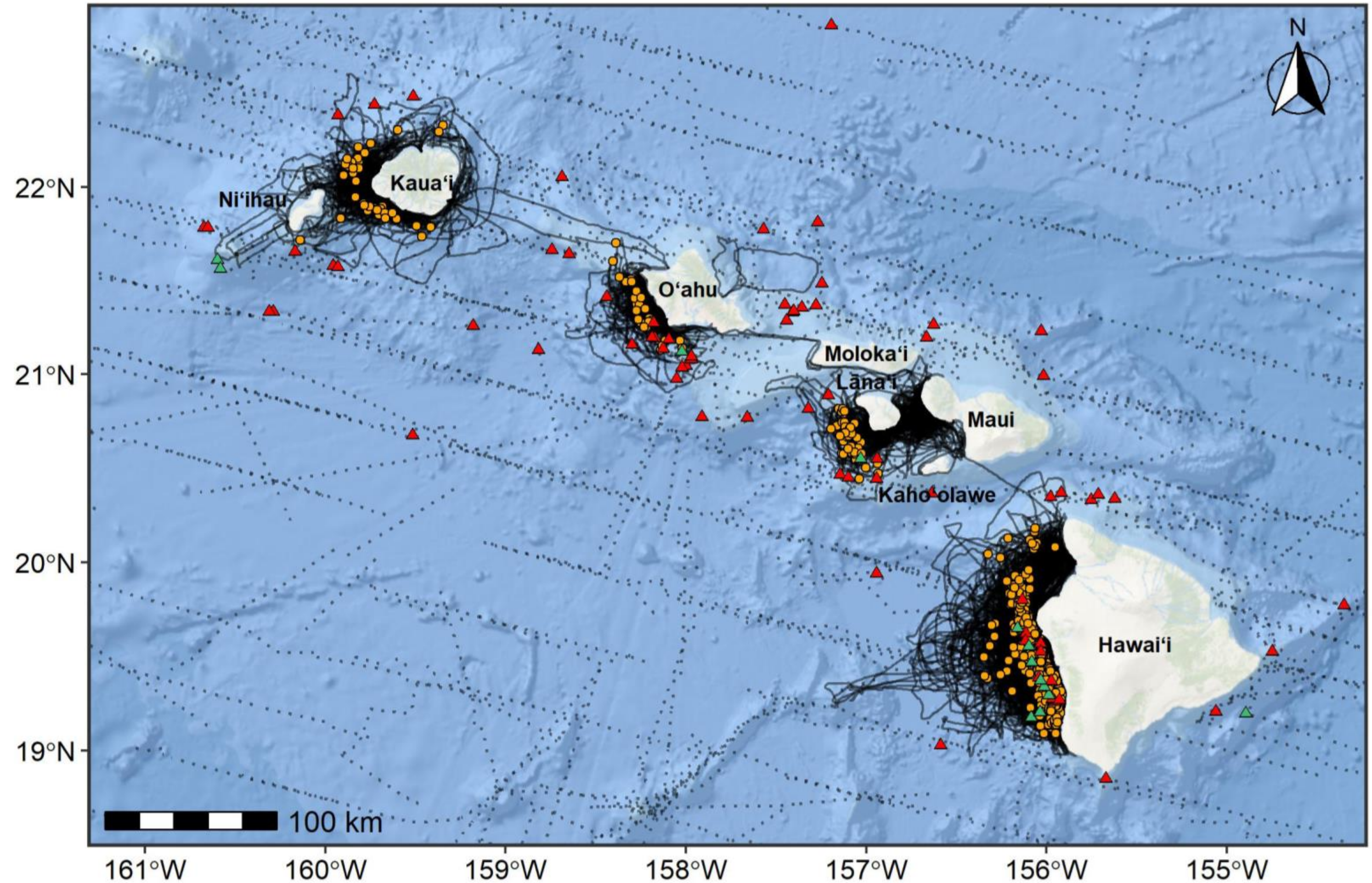

Figure 1. MHI short-finned pilot whale sighting locations (n=836; CRC = orange circles; NMFS = green triangles) overlaid on CRC small-boat research vessel tracklines from efforts conducted during 2000-2021 (148,080 km of effort) and NMFS ship-based line-transect surveys undertaken between 2002-2020 (23,830 km of effort as mapped here). CRC sightings of known or suspected pelagic short-finned pilot whale groups, or of individuals with unknown population assignment, are shown as red circles and triangles (n=90). Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Table 1. MHI short-finned pilot whale sighting data from CRC small-boat surveys and NMFS ship-based line-transect surveys

Island-Source	Study duration (first sighting – last sighting)	# unique years with sightings	Total # sightings	Median group size (range)
Kaua'i/Ni'ihau-CRC	2003-2021	12	40	20 (5-85)
O'ahu-CRC	2003-2017	5	30	22 (1-70)
Maui Nui-CRC	2000-2020	6	51	16 (1-40)
Hawai'i Island-CRC	2002-2021	20	702	17 (1-195)
Kaua'i/Ni'ihau-NMFS	2010	1	2	13 (12-14)
O'ahu-NMFS	2016	1	1	9 (NA)
Maui Nui-NMFS	2016	1	1	25 (NA)
Hawai'i Island-NMFS	2009-2016	2	9	22 (10-53)
Total	2000-2021	21	836	17 (1-195)

Satellite tag data

Location data from satellite tags were available for 128 deployments on short-finned pilot whales known or thought to be from one of the insular communities, from 2006-2021 (Table 2, Figure 2; 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 4-hour intervals and locations on land were re-routed around a polygon representing the 300-m isobath using the *pathroutr* package (London, 2021). *Crawl* locations interpolated over periods spanning 1 or more days without any underlying Argos locations were removed.

Table 2. MHI short-finned pilot whale satellite tag data summary by community

Community	# deployments	Study duration (first tag – last tag)	# unique years with deployments	Median (range) deployment duration (days)	Total # Argos locations*	Total # 4-hourly *crawl* locations
Western	24	2008-2021	10	24 (7.6-89.1)	9,585	4,123
Central	18	2010-2017	5	29 (3.7-229)	7,739	5,013
Eastern	86	2006-2019	11	29 (4.6-110)	29,383	17,004
Total	128	2006-2021	16	29 (3.7-299)	46,707	26,120

*Value represents Douglas-filtered Argos (or Argos and filtered GPS combined for applicable tags) locations used to generate *crawl* tracks. See supplementary material for details on satellite tag processing methods

Parent BIA boundary: Range size

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 (Figure 2). 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 (Figure 3). The resulting area of the parent BIA (i.e., population range size) is 58,999 km^2.

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).

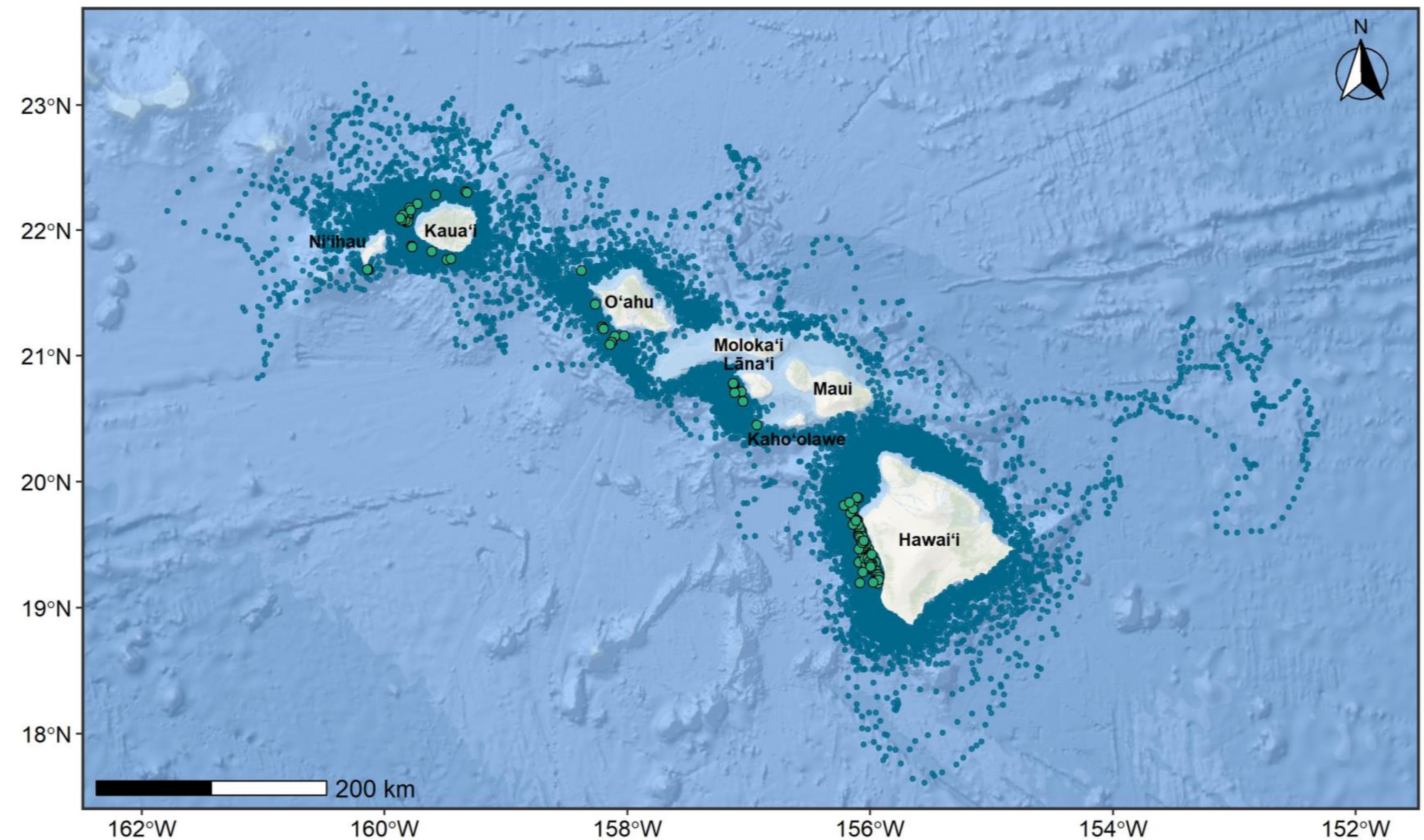

Figure 2. Four-hour *crawl* positions of satellite tagged short-finned pilot whales from the insular population (n=128), re-routed around land (based on 300-m isobath) where necessary to avoid positions on land. Tag deployment locations are shown as green circles. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

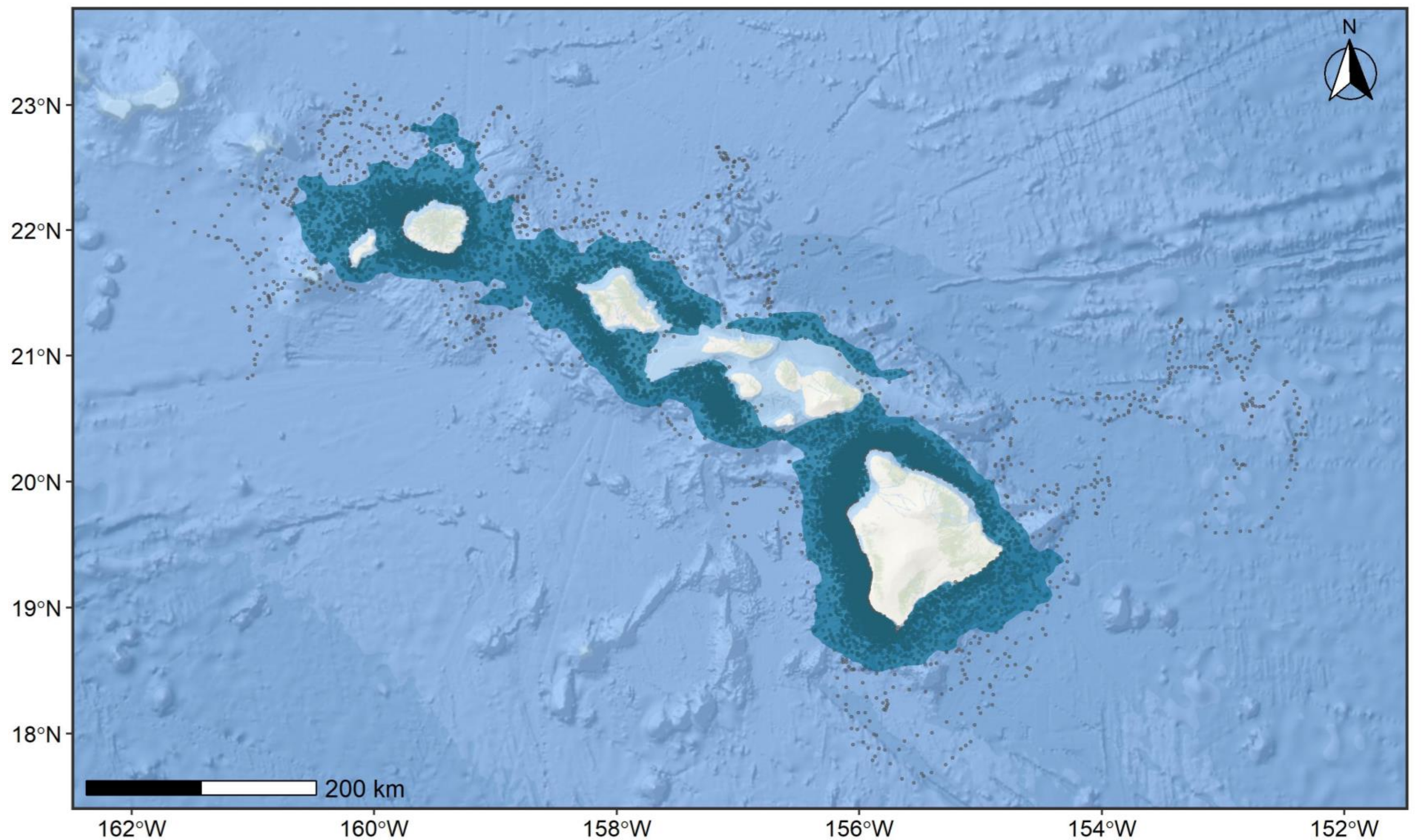

Figure 3. Parent BIA (blue polygon) for the MHI short-finned pilot whales represented as a 95% isopleth of the estimated UD from kernel density analysis. All 4-hour *crawl* locations and sighting points are shown as gray circles under the BIA polygon. The inner (shoreward) boundary is defined as the 300-m isobath. Total area of the parent BIA = 58,999 km^2. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

BIA: Scoring
Intensity
Abundance:
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).

Range size:
The size of the polygon representing the parent BIA is 58,999 km^2.

Scoring criteria:
Intensity scoring: First, abundance and range size are scored independently as follows for each population based on the best available information:

Abundance: **(3)** = 125 or fewer individuals; **(2)** = 126 to 500 individuals; **(1)** = 501 to 2,000 individuals.

Range size: **(3)** = less than 2,000 km^2; **(2)** = 2,001-10,000 km^2; **(1)** = greater than 10,001 km^2

Abundance and range size scores are combined to generate an overall intensity score using the matrix below:

S-BIA Intensity

Range				
	3	2	3	3
	2	1	2	3
	1	1	1	2
		1	2	3
		Abundance		

Abundance = 501 to 2,000; **score = 1**
Range size = 58,999 km^2; **score = 1**
<u>**Overall Intensity score = 1**</u>

Rationale
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.

Data support:
Amount and quality of information used to delineate BIA; justified in the narrative.

- **(3)** = high confidence in both the fact that the population is small and resident and the abundance and range size estimates of population
- **(1)** = notably lower confidence
- **(2)** = represents the remainder of situations that are not notably high or low confidence

Data support notes:

- 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

Data Support score = 3 (high confidence)

Rationale

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 (Table 2).

Importance score

Importance Score Matrix				
Intensity	3	2	3	3
	2	1	2	2
	1	0	1	1
		1	2	3
		Data Support		

Intensity = 1
Data support = 3
Importance score = 1

Boundary certainty:
Describe the factors used in the boundary delineation.

- **(3)** = high confidence in boundary location
- **(1)** = notably lower confidence
- **(2)** = represents the remainder of situations that are not notably high or low confidence

Boundary certainty score = 3

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).

Spatiotemporal Variability indicator:
Dynamic (d), ephemeral (e), or static (s). If the area is dynamic or ephemeral, describe the factor(s) that drive the change in location or timing.
Spatiotemporal variability indicator **is static**.

No information to suggest the area is used dynamically or ephemerally. 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.

MHI short-finned pilot whale: Hierarchical BIA boundary delineation

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 (Figure 4).

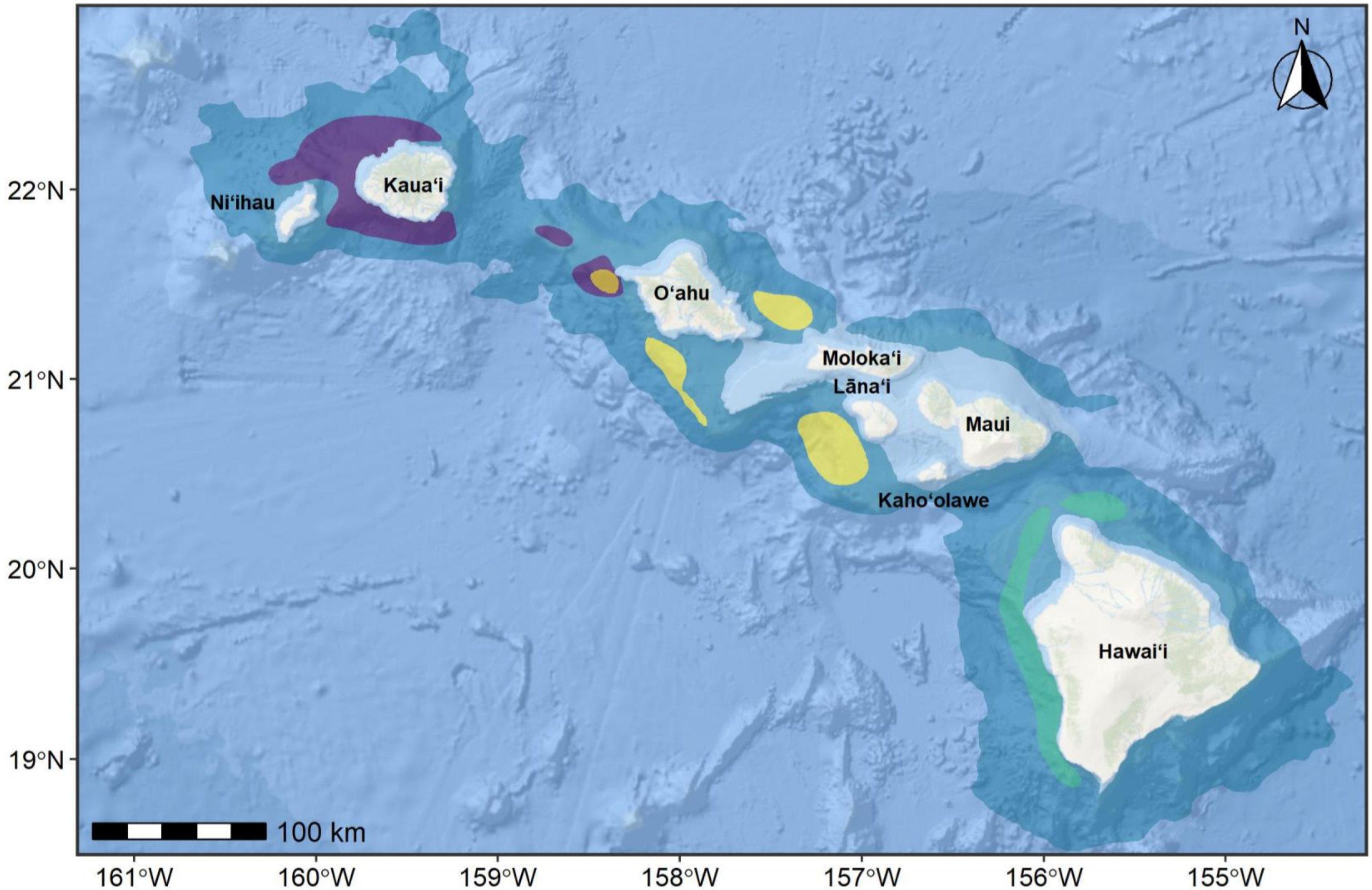

Figure 4. Child BIAs for the MHI short-finned pilot whale population, represented as core areas (50% isopleth of the estimated UD from KDE) of each community (western = purple polygon, area = 4,040 km^2; central = yellow polygon, area = 2,427 km^2; eastern = green polygon, area = 2,658 km^2). The parent BIA (blue polygon, area = 58,999 km^2) is shown for reference. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Child BIAs: Scoring
Intensity
Abundance:
The child BIAs (core areas of use) 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 (proportion of population contained within child BIAs 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 (Figure 1), 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.

Area of child BIAs:
Western: 4,040 km^2
Central: 2,427 km^2
Eastern: 2,658 km^2

Estimated proportion of the population contained within each child BIA:
Western: 25%
Central: 25%
Eastern: 50%

Overall Intensity scores (each) = 3

Rationale
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 (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). 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.

Data Support
The child BIAs described here were drawn using satellite tag data from 93 groups of tagged short-finned pilot whales (western, n=18; central, n=13; eastern, n=62), 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. 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).

<u>Data Support score = 3 (high confidence)</u>

Importance score:

Importance Score Matrix

Intensity	3	2	3	3
	2	1	2	2
	1	0	1	1
		1	2	3
		Data Support		

<u>Importance scores (each) = 3</u>

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).

Spatiotemporal Variability indicator:
Dynamic (d), ephemeral (e), or static (s). If the area is dynamic or ephemeral, describe the factor(s) that drive the change in location or timing.
Spatiotemporal variability indicator **is static**.

No information to suggest the area is used dynamically or ephemerally. 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 each child BIA as static.

<u>Boundary certainty scores (each) = 3</u>

Summary of BIA scoring for MHI short-finned pilot whale (see Figure 3, 4)

		Scoring				
	S-BIA	**Intensity**	**Data support**	**Importance**	**Boundary certainty**	**Spatiotemporal variability**
Parent BIA	95% UD	1	3	1	3	s
Child	50% UD	3	3	3	3	s

BIA-W						
Child BIA-C	50% UD	3	3	3	3	s
Child BIA-E	50% UD	3	3	3	3	s

Hierarchical BIA labels:
Parent: **S-BIA1-s-b3-HI030-0abc**
Child (Western community, core): **S-BIA3-s-b3-HI030-a**
Child (Central community, core): **S-BIA3-s-b3-HI030-b**
Child (Eastern community, core): **S-BIA3-s-b3-HI030-c**

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Dwarf sperm whale (*Kogia sima*)

Background

A single stock of dwarf sperm whales (*Kogia sima*) is recognized by NMFS in Hawaiian waters (Caretta et al., 2021); however, the existence of a separate small, resident population associated with Hawaiʻi Island has long been acknowledged (Baird, 2005, 2016; Baird et al., 2021; Mahaffy et al., 2009; Oleson et al., 2013). A recent study analyzing photo-identification data from 20 years of survey effort off the west coast of Hawaiʻi Island reported high site fidelity to slope waters and small geographical ranges within the study area (Baird et al., 2021). Further, based on depth of sightings of individuals that were re-sighted versus those that were seen once, Baird et al. (2021) suggested that the range of insular, resident dwarf sperm whales overlaps with that of dwarf sperm whales belonging to a broader pelagic population. While limited genetic samples (primarily from stranded animals) has precluded a genetic assessment of population structure, the lines of evidence derived from the best available data on this species support the existence of a small and resident population of dwarf sperm whales associated with Hawaiʻi Island.

BIA boundary delineation

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).

Sighting and photographic data

Sighting data were collected from non-systematic, dedicated small boat surveys conducted off Hawaiʻi Island from April 2002 to November 2021 (Table 1, Figure 1; 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 Hawaʻi Island (Bradford et al., 2021).

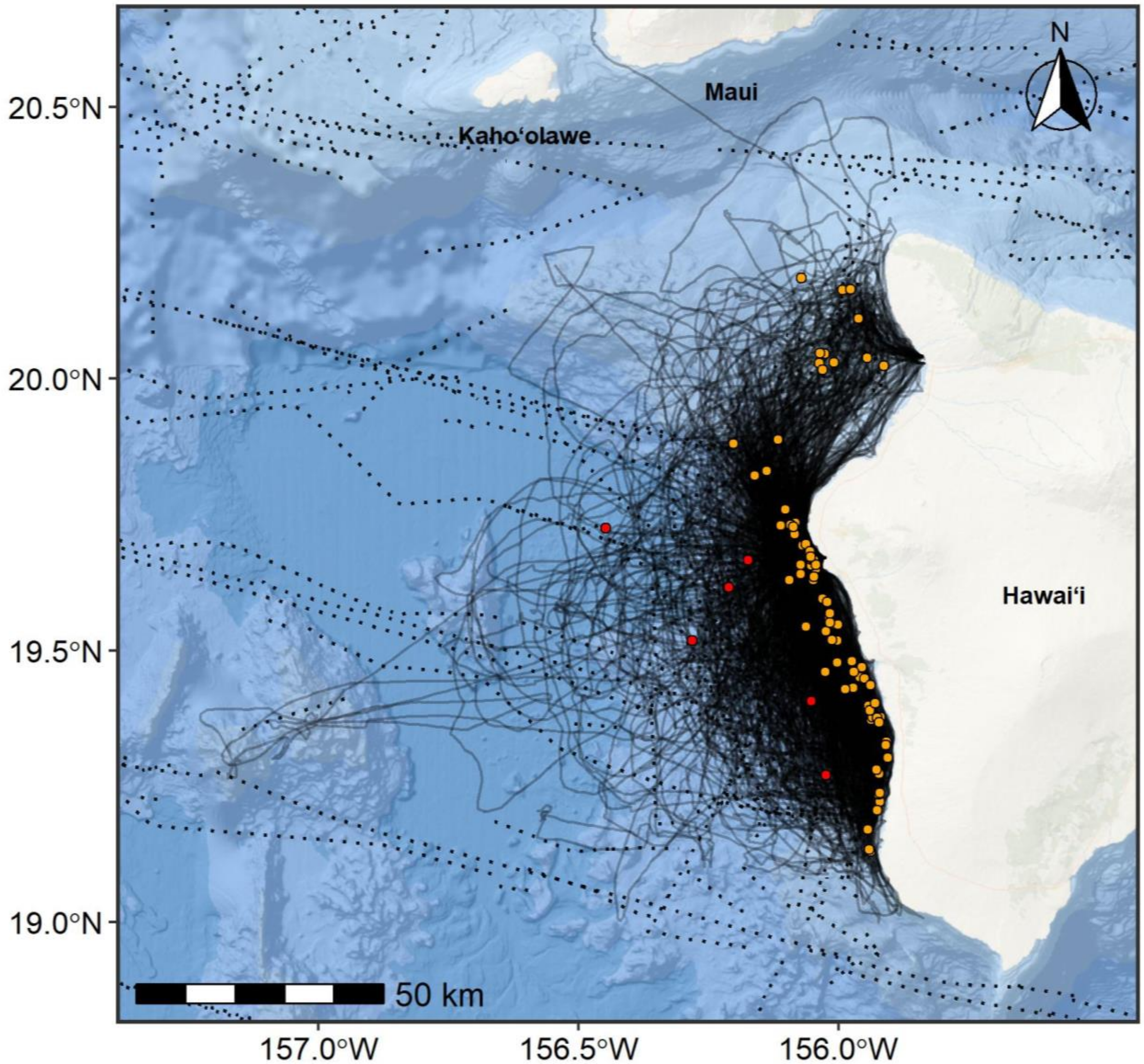

Figure 1. Dwarf sperm whale sighting locations off Hawai'i Island (n=89) overlaid on research vessel tracklines (CRC = solid lines, NMFS = dotted lines) from efforts conducted during 2002-2021 (97,438 km of effort CRC and 3,717 km of effort NMFS). Six sightings deeper than 2,000 m depth (shown here as red circles) were excluded from the BIA boundary determination as they were thought to be from a broader pelagic population (final sample size = 83, orange circles; Baird et al., 2021). Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Table 1. Dwarf sperm whale sighting data used in boundary determinations

Island area	Study duration (first sighting – last sighting)	# unique years with sightings	Total # sightings	Median group size (range)
Hawai‘i Island	2003-2021	17	83	3 (1-8)

BIA boundary: Range size

The basis of the parent BIA was a minimum convex polygon (MCP) encompassing all sighting locations in less than 2,000-m depth (Figure 2). The inner (shoreward) boundary was defined as the 300-m isobath based on the shallowest sighting of dwarf sperm whales off this island (352 m). Based on sighting rates in relation to bathymetric depths (Baird et al., 2021; Baird et al., 2013), we designated the area between the 500-m and 1,000-m isobaths within the MCP as the child BIA (core range) of the population (Figure 2). The resulting area of the parent BIA (i.e., population range size) is 1,341 km^2 and child BIA (i.e., population core range size) is 457 km^2.

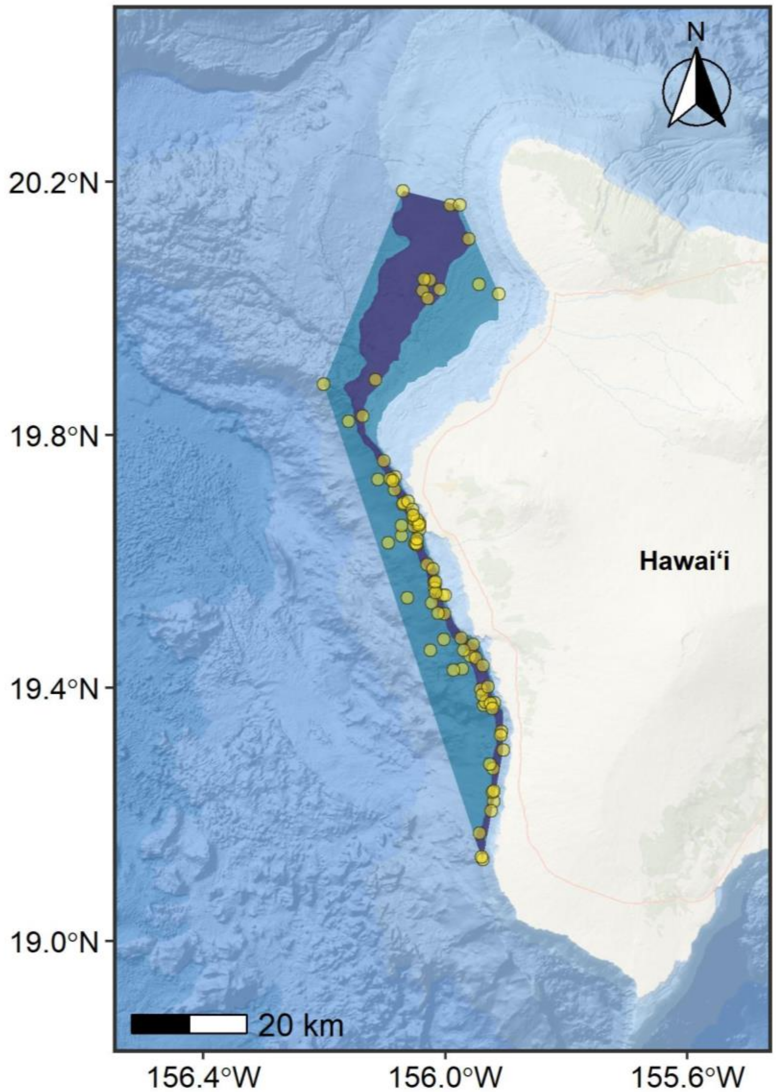

Figure 2. Parent BIA boundary (blue polygon) for the Hawai'i Island dwarf sperm whale population represented as a minimum convex polygon (MCP) encompassing all sighting locations in less than 2,000 m (yellow circles). The child BIA boundary (core range; purple polygon) is represented as the area between the 500-m and 1,000-m isobaths within the parent BIA. Points are partially transparent to highlight high-density areas (i.e., where multiple points overlap). The inner (shoreward) boundary for both BIAs is defined as the 300-m isobath. Total area of the parent BIA = 1,341 km^2 and the child BIA is 457 km^2. Basemap image is the intellectual property of Esri and is used herein with permission.

BIA: Scoring

Intensity

Abundance:

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.

We assume 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. A total of 55 sightings (66% of all sightings at < 2,000 m depth) were within the estimated core range.

Range size:

The size of the MCP representing the parent BIA is 1,341 km^2.
The size of the area between the 500-m and 1,000-m isobaths within the MCP representing the child BIA is 457 km^2.

Scoring criteria:

Intensity scoring: First, abundance and range size are scored independently as follows for each population based on the best available information:

Abundance: **(3)** = 125 or fewer individuals; **(2)** = 126 to 500 individuals; **(1)** = 501 to 2,000 individuals.

Range size: **(3)** = less than 2,000 km^2; **(2)** = 2,001-10,000 km^2; **(1)** = greater than 10,001 km^2

Abundance and range size scores are combined to generate an overall Intensity score using the

S-BIA Intensity				
Range	3	2	3	3
	2	1	2	3
	1	1	1	2
		1	2	3
		Abundance		

matrix above:
Abundance:
Parent BIA = 125 or fewer; **score = 3**
Child BIA = **score = 3**

Range size:
Parent BIA = 1,341 km^2; **score = 3**
Child BIA = 457 km^2; **score = 3**

<u>Overall Intensity scores:</u>
<u>Parent BIA = 3</u>
<u>Child BIA = 3</u>

Rationale
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 Hawai‘i Island (Baird et al., 2021). We assigned an Intensity score of 3 to the child BIA as it represents intensified use relative to the broader parent BIA.

Data Support:
Amount and quality of information used to delineate BIA; justified in the narrative.
(3) = high confidence in both the fact that the population is small and resident and the abundance and range size estimates of population
(1) = notably lower confidence
(2) = represents the remainder of situations that are not notably high or low confidence

Data Support notes:

- 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

<u>Data Support scores:</u>
<u>Parent BIA = 2 (intermediate confidence)</u>
<u>Child BIA = 2 (intermediate confidence)</u>

Rationale
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 Hawai‘i 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.

Importance score

Importance Score Matrix				
Intensity	3	2	3	3
	2	1	2	2
	1	0	1	1
		1	2	3
		Data Support		

Intensity:
Parent BIA = 3
Child BIA = 3

Data Support:
Parent BIA = 2
Child BIA = 2

<u>Importance scores:</u>
<u>Parent BIA = 3</u>
<u>Child BIA = 3</u>

Boundary Certainty:
Describe the factors used in the boundary delineation.
- **(3)** = high confidence in boundary location
- **(1)** = notably lower confidence
- **(2)** = represents the remainder of situations that are not notably high or low confidence

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 (Figure 2). 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.

<u>Boundary Certainty scores:</u>
<u>Parent BIA = 2</u>
<u>Child BIA = 2</u>

Spatiotemporal Variability indicator:
Dynamic (d), ephemeral (e), or static (s). If the area is dynamic or ephemeral, describe the factor(s) that drive the change in location or timing.
Spatiotemporal variability indicator **is static**. No information to suggest the area is used dynamically or ephemerally.

Summary of BIA scoring for resident Hawaiʻi Island dwarf sperm whale population (see Figure 2)

		Scoring				
	S-BIA	**Intensity**	**Data Support**	**Importance**	**Boundary Certainty**	**Spatiotemporal Variability**
Parent BIA	MCP	3	2	3	2	s
Child BIA	1,000-m isobath	3	2	3	2	s

BIA labels for Hawaiʻi Island dwarf sperm whale S-BIAs:
Parent BIA: S-BIA3-s-b2-HI06-0a
Child BIA: S-BIA3-s-b2-HI06-a

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Cuvier's beaked whale (*Ziphius cavirostris*)

Background

Only a single stock of Cuvier's beaked whales (*Ziphius cavirostris*) is recognized by NMFS in Hawaiian waters (Caretta et al., 2021); however, several lines of evidence support the existence of a small, resident population associated with Hawaiʻi Island (Baird et al., 2009; Baird, 2016, 2019; McSweeney et al., 2007; Oleson et al., 2013). Photo-identified individuals have been re-sighted off this island up to a span of 25 years (on 8 separate occasions) and individuals have been encountered up to 15 separate times (over 16 years; CRC unpublished), indicating a high degree of site fidelity. Resighting rates also suggest that adult females exhibit a greater degree of fidelity to Hawaiʻi compared to adult males (Baird, 2016; Mahaffy et al., 2015). Discovery curves of Cuvier's beaked whales photo-identified off Hawaiʻi also suggest that this population is relatively small (Baird, 2019). Movements of satellite-tagged Cuvier's beaked whales off Hawaiʻi Island further support fidelity to the island (Baird et al., 2010; Baird, 2016, 2019). Tagged whales spent the majority of their time in nearshore deep waters (~2,000-2,500 m deep) around Hawaiʻi Island and the nearby islands of Maui and Kahoʻolawe, with some individuals using waters off windward sides of Hawaiʻi Island where survey effort has been precluded (Baird et al., 2010; Baird, 2016, 2019). In addition, one tagged individual, an adult female, moved from Hawaiʻi Island to north of Molokaʻi (Baird, 2019). There have been no sightings of Cuvier's beaked whale in this region off north Maui Nui in part due to their inconspicuous nature and limited effort in windward waters, so the frequency of such movements from Hawaiʻi Island and the overall presence of beaked whales in the Maui Nui remains uncertain. Based on these lines of evidence, we delineated a S-BIA for Hawaiʻi Island Cuvier's beaked whales that encompasses known movements to Molokaʻi and off south Maui and Kahoʻolawe.

BIA boundary delineation

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.

Sighting and photographic data

Sighting data were collected from non-systematic, dedicated small-boat surveys conducted off Hawaiʻi Island from 2002 through 2021 (Table 1, Figure 1; 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 (Figure 1). 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; Figure 1, 3); effort from these surveys in the area shown in Figure 1 total 4,906 km.

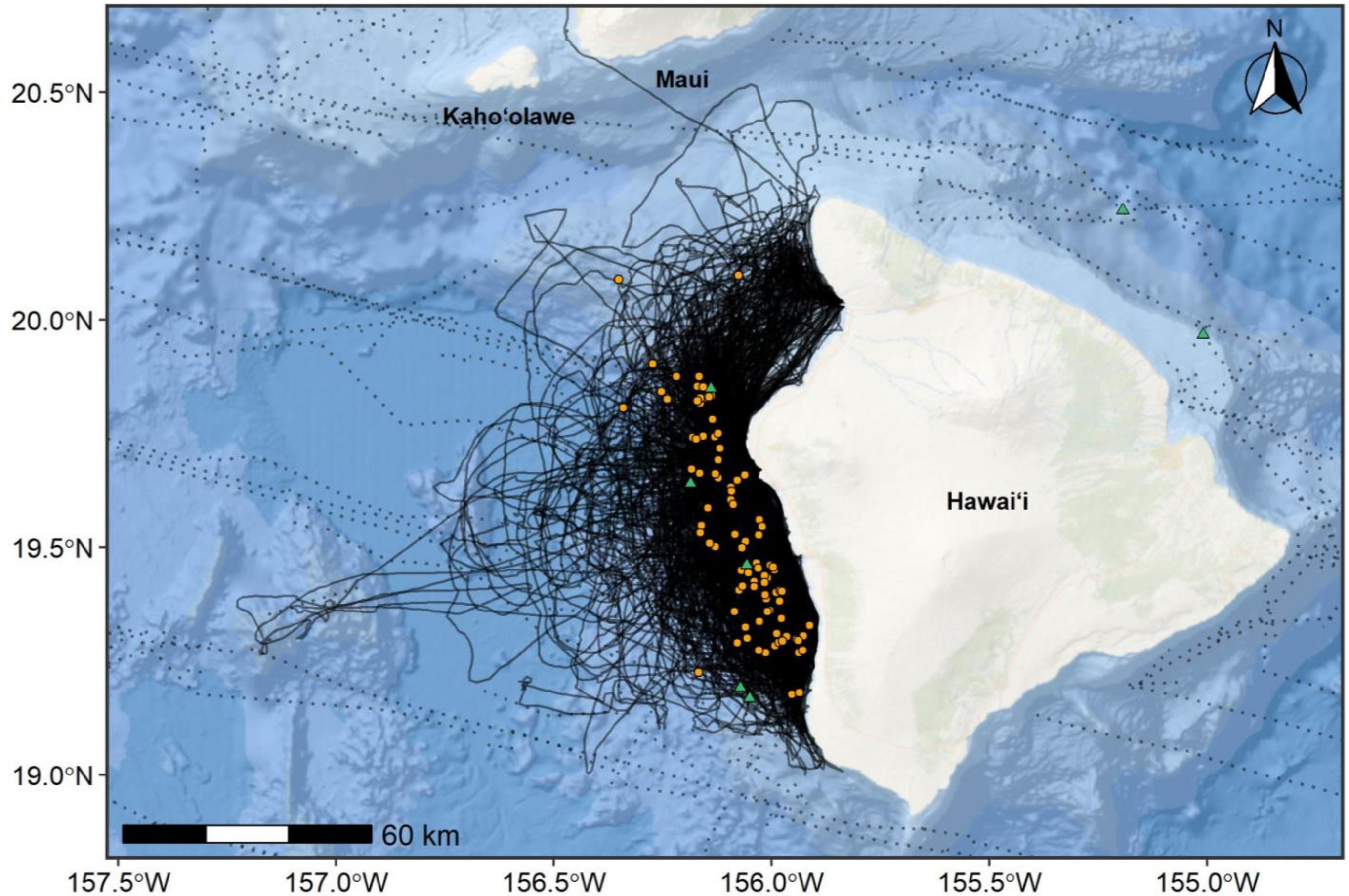

Figure 1. Cuvier's beaked whale sighting locations (n=99; circles = CRC, triangles = NMFS) overlaid on CRC small-boat research vessel tracklines (solid lines) from efforts conducted by CRC 2002-2021 and NMFS ship-based line-transect tracklines (dotted lines) from surveys conducted from 2002-2020 (102,344 km of effort combined). Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Table 1. Cuvier's beaked whale sighting data used in boundary determinations

Island-Source	Study duration (first sighting – last sighting)	# unique years with sightings	Total # sightings	Median group size (range)
Hawai'i Island-CRC	2002-2021	17	92	2 (1-5)
Hawai'i Island-NMFS	2009-2017	4	7	2 (1-6)
Total	2002-2021	17	99	2 (1-6)

Satellite tag data

Satellite tags were deployed on 10 Cuvier's beaked whales during dedicated survey efforts off leeward Hawai'i Island from 2008 through 2015 (Table 2, Figure 2; Baird et al., 2010; Baird, 2016, 2019). Detailed 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 4-hour intervals and locations on land were re-routed around a polygon representing the 800-m isobath (based on shallowest sighting of this species) using the *pathroutr* package (London, 2021). *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.

Table 2. Cuvier's beaked whale satellite tag data summary

# deployments	Study duration (first tag – last tag)	# unique years with deployments	# females/males/UK tagged	Median (range) deployment duration (days)	Total # Argos locations*	Total # 4-hourly *crawl* locations
10	2008-2015	6	7/2/1	24 (7.4-49.0)	1,667	1,362

*Value represents Douglas-filtered Argos locations used to generate *crawl* tracks. See supplementary material for details on satellite tag processing methods
UK=unknown

Parent BIA boundary: Range size

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* (Figure 3). 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 km^2.

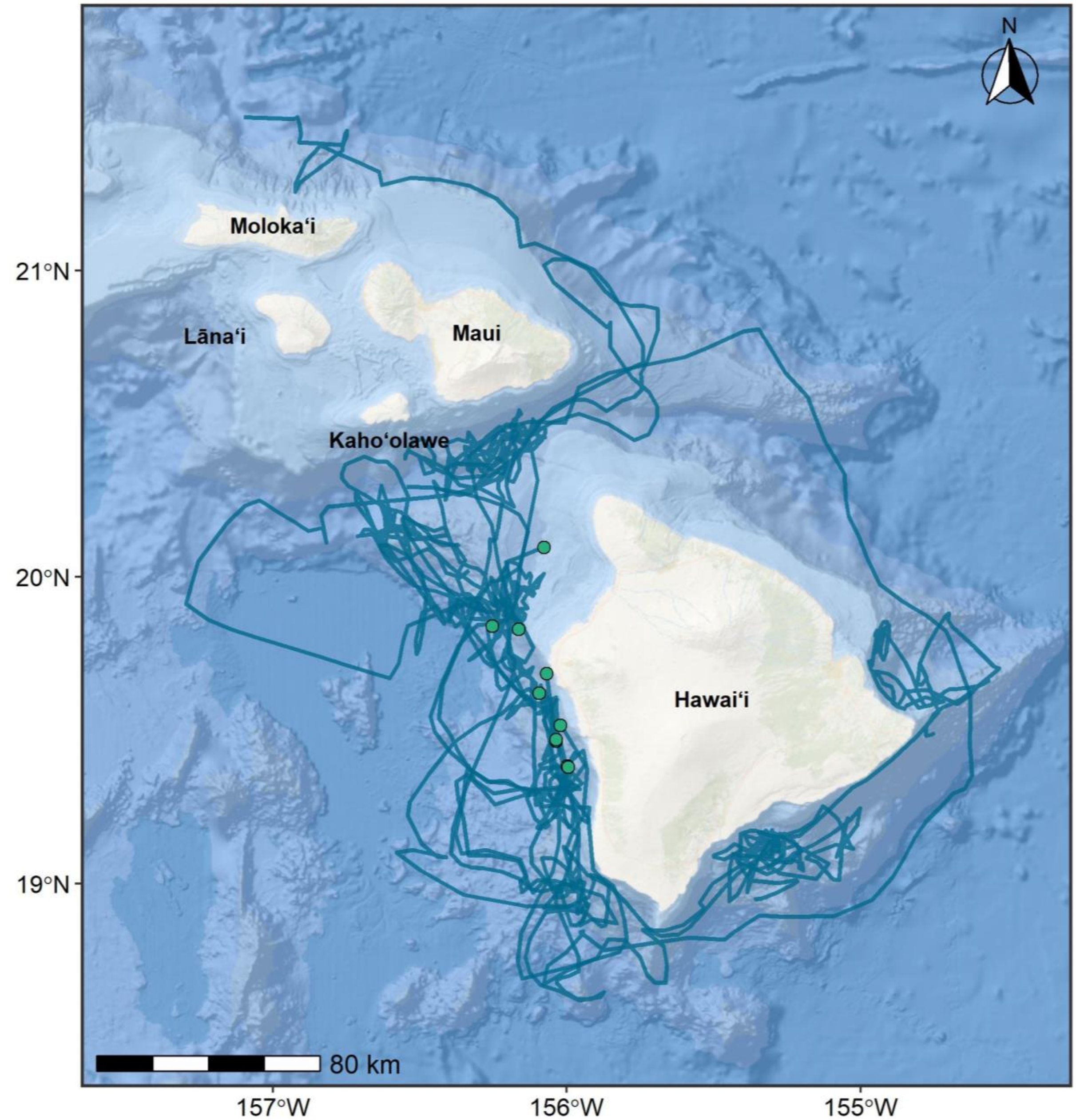

Figure 2. Tracklines of 4-hour *crawl* positions of satellite-tagged Cuvier's beaked whales from Hawai'i Island (n=10), re-routed around land (with 800-m isobath) where necessary to avoid tracks crossing land. Tag deployment locations are shown as green circles (note: some tags were deployed at approximately the same location and thus only eight deployment locations appear to be shown). Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

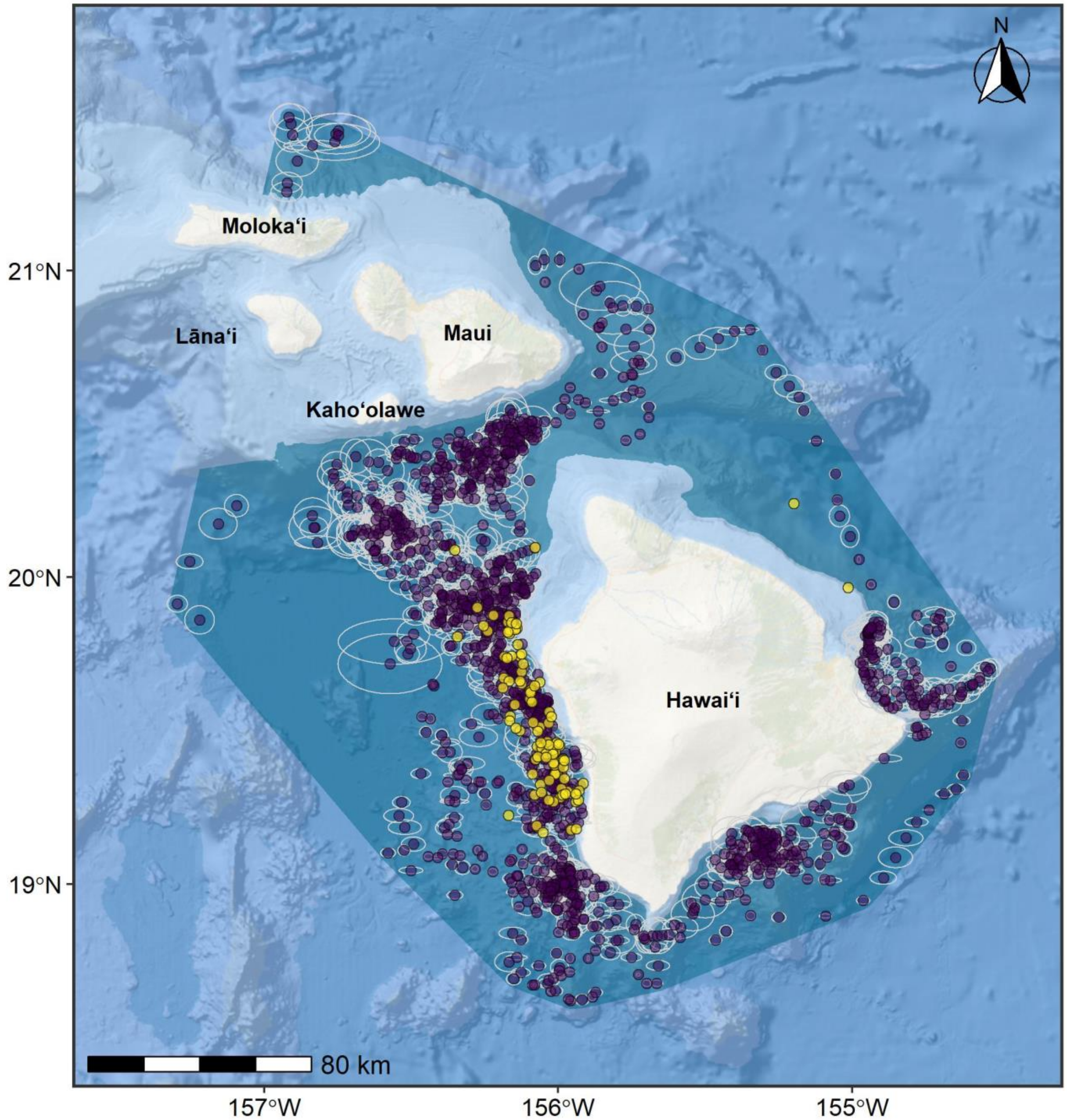

Figure 3. Parent BIA (blue polygon) for Hawai'i Island Cuvier's beaked whale population. This parent BIA is represented by a minimum convex polygon (MCP) encompassing all *crawl*-predicted satellite tag locations (purple circles) and sighting locations (yellow circles), extended by a 3-km distance to the outer boundary to capture *crawl* standard error (68% confidence interval) ellipses (light grey ellipses). Points are partially transparent to highlight high density areas (i.e., where multiple points overlap). The inner (shoreward) boundary is defined as the 800-m isobath. Total area of the parent BIA = 37,157 km^2. Note: not all error ellipses are visible, as their size may be smaller than that of the mapped point. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

BIA: Scoring
Intensity
Abundance:
Baird et al. (2009) estimated abundance of Cuvier's beaked whales off Hawai'i 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 Hawai'i 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.

Range size:
The size of the modified MCP representing the parent BIA is 37,157 km^2.

Scoring criteria:
Intensity scoring: First, abundance and range size are scored independently as follows for each population based on the best available information:

Abundance: **(3)** = 125 or fewer individuals; **(2)** = 126 to 500 individuals; **(1)** = 501 to 2,000 individuals.

Range size: **(3)** = less than 2,000 km^2; **(2)** = 2,001-10,000 km^2; **(1)** = greater than 10,001 km^2

Abundance and range size scores are combined to generate an overall Intensity score using the matrix below:

S-BIA Intensity

Range				
	3	**2**	**3**	**3**
	2	**1**	**2**	**3**
	1	**1**	**1**	**2**
		1	2	3
		Abundance		

Abundance = 125 or fewer; **score = 3**
Range size = 37,157 km^2; **score = 1**
<u>Overall Intensity score = 2</u>

Rationale
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 (Figure 2). 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 Hawai'i Island (Figure 2).

Data Support:
Amount and quality of information used to delineate BIA; justified in the narrative.

(3) = high confidence in both the fact that the population is small and resident and the abundance and range size estimates of population

(1) = notably lower confidence

(2) = represents the remainder of situations that are not notably high or low confidence

Data Support notes:

- 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 Hawai'i 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 Hawai'i 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

Data Support score = 3 (high confidence)

Rationale
The existence of a small, resident, island-associated population of Cuvier's beaked whales off Hawai'i 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 Moloka'i (Figure 2), 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 Hawai‘i Island (Figure 3), 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.

Importance score

Importance Score Matrix				
Intensity	3	2	3	3
	2	1	2	2
	1	0	1	1
		1	2	3
		Data Support		

Intensity = 2
Data support = 3
Importance score = 2

Boundary Certainty:
Describe the factors used in the boundary delineation.

- **(3)** = high confidence in boundary location
- **(1)** = notably lower confidence
- **(2)** = represents the remainder of situations that are not notably high or low confidence

Boundary Certainty score = 2
We have intermediate confidence in Boundary Certainty for the parent BIA for Hawai‘i 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 (Figure 3). 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 Hawai‘i Island (Figure 2), 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, Hawai‘i 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 (Figures 1, 3).

Spatiotemporal Variability indicator:
Dynamic (d), ephemeral (e), or static (s). If the area is dynamic or ephemeral, describe the factor(s) that drive the change in location or timing.
Spatiotemporal variability indicator **is static**. No information to suggest the area is used dynamically or ephemerally.

HI Cuvier's beaked whale: Child BIA boundary delineation

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 (Figure 2), 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 (Figure 2, 3). 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; Figure 4).

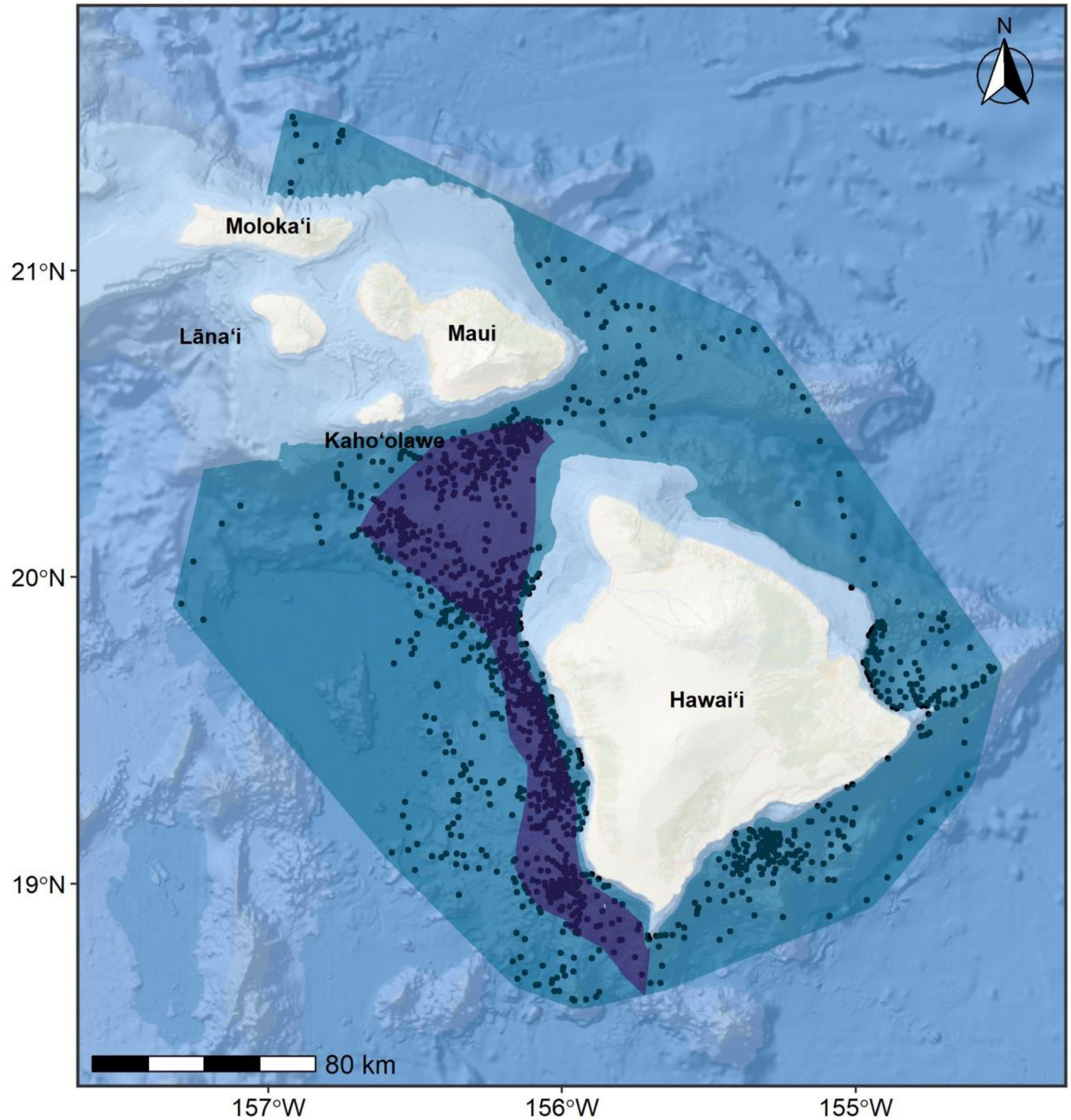

Figure 4. Parent BIA (blue polygon, area = 37,157 km^2) and child BIA (purple polygon, area = 5,400 km^2) for the Hawai‘i Island Cuvier’s beaked whale population. *Crawl* locations of satellite-tagged Cuvier’s beaked whales and sighting locations are shown as points under the polygons. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Child BIA: Scoring

Intensity

Abundance:

The child BIA for Hawai'i 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 core 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.

Area of child BIA: 5,400 km^2

<u>Overall Intensity score = 3</u>

Rationale

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 Hawai'i Island with both satellite tag locations and sighting locations concentrated in depths between 2,000 and 3,500 m (Figures 2- 4). Whales off Hawai'i Island were tagged in six different years and transmission durations ranged from 7 to 49 days (Table 2; Baird et al., 2010).

Data Support

The child BIA for Hawai'i 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 Hawai'i 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.

<u>Data Support score = 3 (high confidence)</u>

Importance score:

Importance Score Matrix				
Intensity	3	2	3	3
	2	1	2	2
	1	0	1	1
		1	2	3
		Data Support		

Importance score = 3

Boundary Certainty:
We have high certainty in the boundary for the Hawai'i 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 (Figure 2); however the majority of satellite-tagged beaked whales spent their time off the leeward side of the island (Figure 1, 2).

Boundary certainty score = 3

Summary of BIA scoring for HI Cuvier's beaked whale population (see Figure 3, 4)

		Scoring				
	S-BIA	**Intensity**	**Data support**	**Importance**	**Boundary Certainty**	**Spatiotemporal Variability**
Parent BIA	MCP	2	3	2	2	s
Core BIA	2,000-3,500 m isobath	3	3	3	3	s

Hierarchical BIA labels:
Parent: **S-BIA2-s-b2-HI021-0a**
Child-HI: **S-BIA3-s-b3-HI021-a**

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Blainville's beaked whale (*Mesoplodon densirostris*)

Background

Although NMFS recognizes only a single stock of Blainville's beaked whales (*Mesoplodon densirostris*) in Hawaiian waters (Caretta et al., 2021), several lines of evidence support the existence of a small, resident population associated with Hawaiʻi Island and a separate pelagic population (Baird et al., 2011; Baird, 2016, 2019; McSweeney et al., 2007; Oleson et al., 2013; Schorr et al., 2009). Individuals encountered off Hawaiʻi Island have high resighting rates, with almost half seen in multiple years and one documented over a time span of 29 years (CRC unpublished; McSweeney et al., 2007; Baird 2019). Movements of Blainville's beaked whales satellite-tagged off Hawaiʻi Island provide further evidence of site fidelity (Abecassis et al., 2015; Baird et al., 2010; Baird, 2016, 2019; Schorr et al., 2009). All tagged whales linked to the resident population social network generally remained along the leeward slope of Hawaiʻi Island throughout their deployments. Two tagged individuals (one adult female and one adult male) made offshore "excursions" before returning to leeward waters of Hawaiʻi Island (Abecassis et al., 2015; Baird et al., 2010; Baird, 2016, 2019; Schorr et al., 2009). Two tagged adult males made more directed movements to other islands, with one moving as far as eastern Oʻahu, aligning with findings from photo-identification suggesting that adult males exhibit less site fidelity to the island (Baird, 2016, 2019; Mahaffy et al., 2015). There has been one documented inter-island movement between Oʻahu and Hawaiʻi Island based on photo-identification data; a known Hawaiʻi Island resident female was seen with a known Oʻahu resident female off Oʻahu, providing some limited evidence of association among these island-associated communities (community = localized group within the broader population; Baird, 2019). One Blainville's beaked whale was satellite tagged off Oʻahu and this individual remained along the west slope of the island, although only three days of movement data were obtained, so the extent of intermediate-to-long-term movements remain unknown (CRC unpublished). Based on these lines of evidence, we delineate a S-BIA for Blainville's beaked whales extending from Oʻahu to Hawaiʻi Island (including Maui Nui; OMNHI, hereafter) to capture the known range of the population, recognizing movements have occurred between these regions and separate core areas likely exist for each island-associated community.

BIA boundary delineation

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.

Sighting and photographic data

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 a ship-based line-transect surveys conducted by NMFS throughout the Hawaiian Archipelago in 11 years between 2002-2020 (Table 1, Figure 1, see Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020 for details on surveys). CRC surveys off these three island areas total 123,856 km of effort with 64 sightings of Blainville's beaked whales as of November 2021, and NMFS surveys around these islands (near and offshore, as mapped in Figure 1) 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.

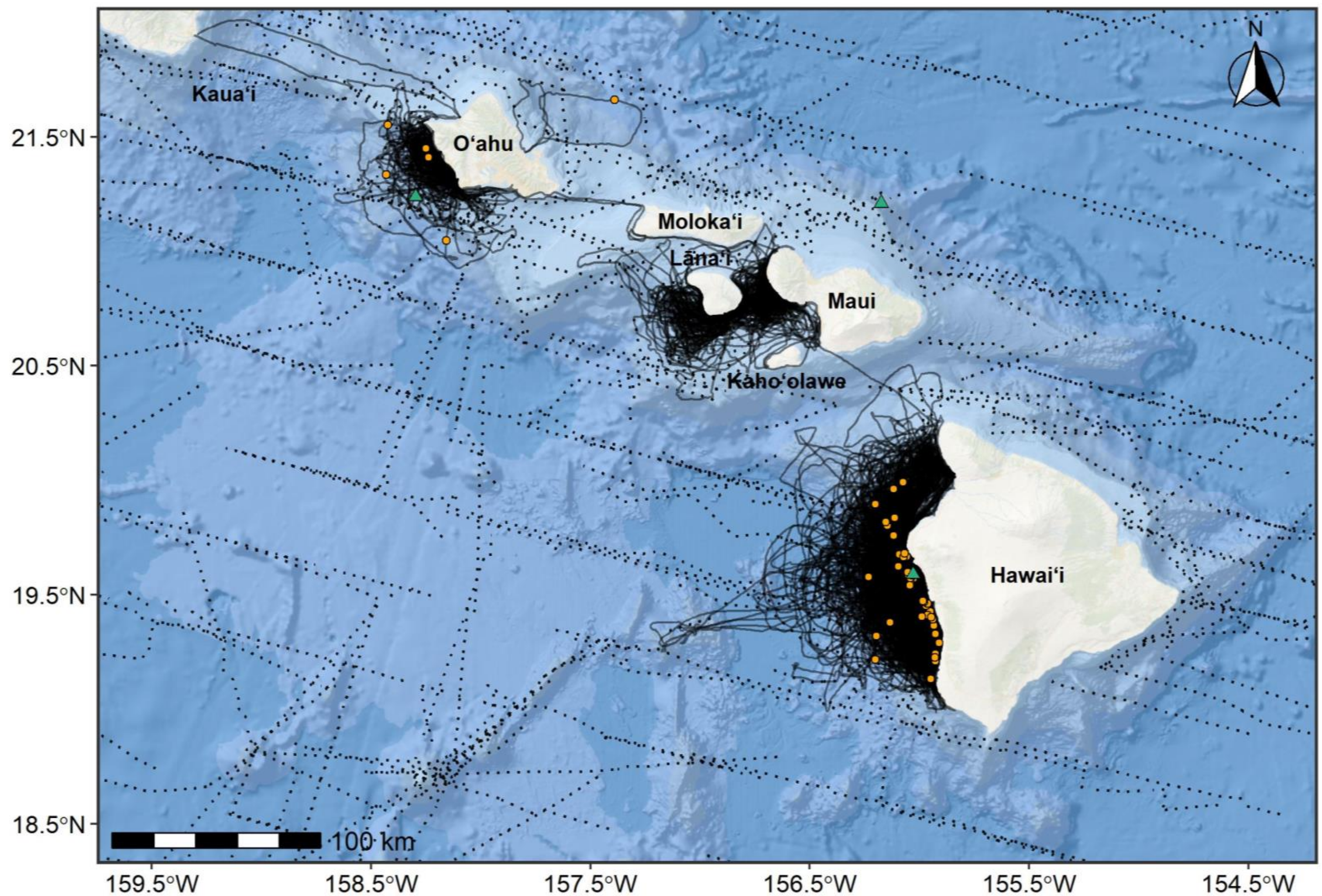

Figure 1. Blainville's beaked whale sighting locations collected by CRC (orange circles) and NMFS (green triangles) off O'ahu (n=6), Maui Nui (n=1), and Hawai'i Island (n=54) overlaid on research vessel tracklines from efforts conducted by CRC (solid lines) and NMFS (dotted lines) during 2002-2021 (140,463 km of effort combined). Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Table 1. Blainville's beaked whale sighting data used in boundary determinations

Source-Island*	Study duration (first sighting – last sighting)	# unique years with sightings	Total # sightings	Median group size (range)
CRC-O	2010-2017	3	6	4 (1-8)
CRC-HI	2002-2021	19	58	4 (1-11)
NMFS-O-MN-HI	2017	1	3	7 (4-8)
Total	2002-2021	20	67	4 (1-11)

**O = O'ahu; HI = Hawai'i Island; MN = Maui Nui*

Satellite tag data
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 (Table 2, Figure 2; 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 4-hour intervals and locations on land were re-routed around a polygon representing the 300-m isobath using the *pathroutr* package (London, 2021). *Crawl* locations interpolated over periods spanning more than 1 day without any underlying Argos locations were removed.

Table 2. Blainville's beaked whale satellite tag data summary

Island	# deployments	Study duration (first tag – last tag)	# unique years with deployments	# females/males/UK tagged	Median (range) deployment duration (days)	Total # Argos locations*	Total # 4-hourly *crawl* locations
Oʻahu	1	2017	1	NA/1/NA	3.0	30	18
Hawaiʻi Island	13	2006-2013	6	6/5/2	45 (15-159)	4,939	3,030

*Value represents Douglas-filtered Argos locations used to generate *crawl* tracks. See supplementary material for details on satellite tag processing methods.

Parent BIA boundary: Range size
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* (Figure 3). 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 (Figure 2) 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 km^2.

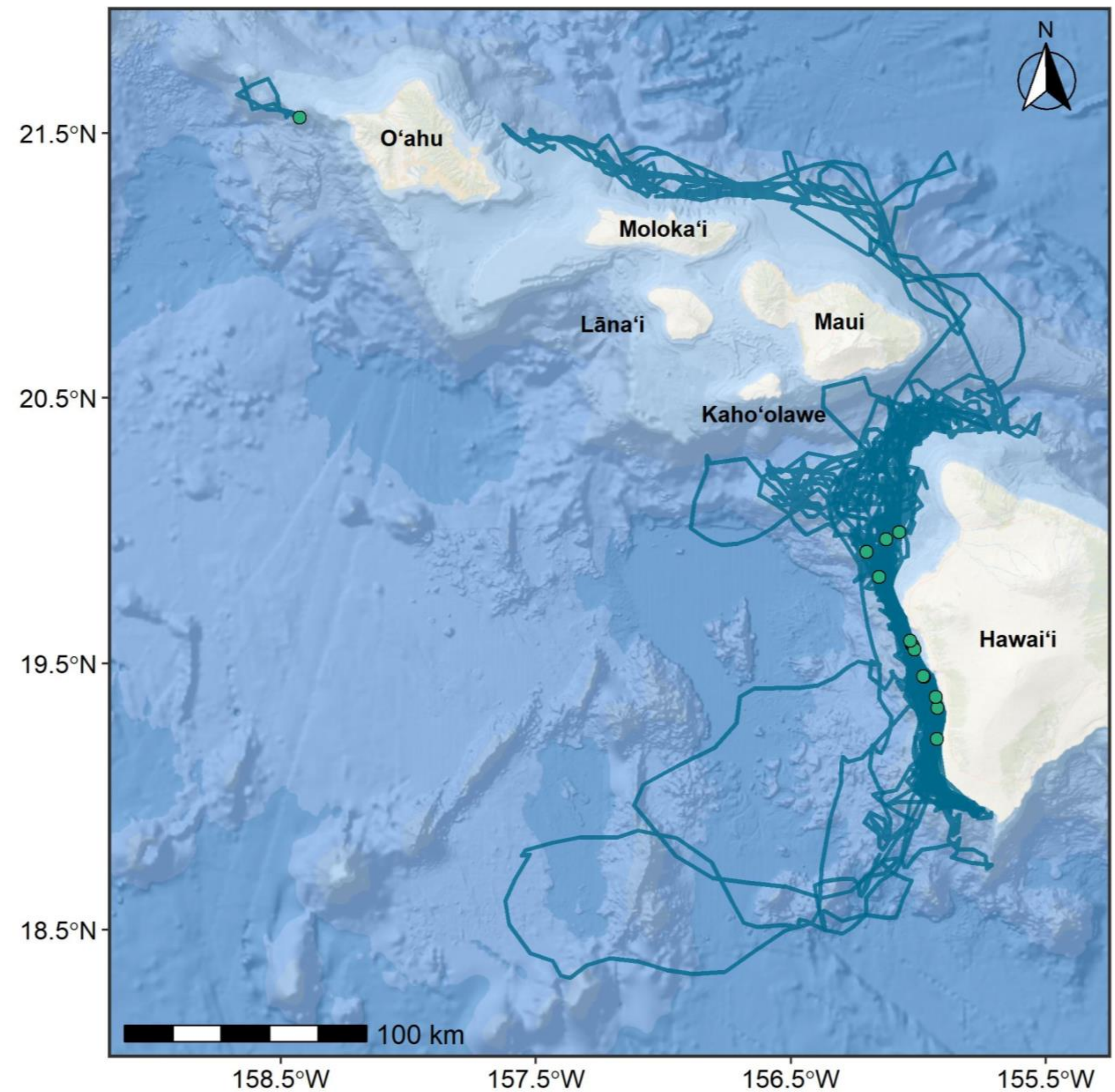

Figure 2. Tracklines of 4-hour *crawl* positions of satellite-tagged Blainville's beaked whales from Hawai'i Island (n=13) and O'ahu (n=1), re-routed around land (with 300-m isobath) where necessary to avoid tracks crossing land. Tag deployment locations are shown as green circles. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

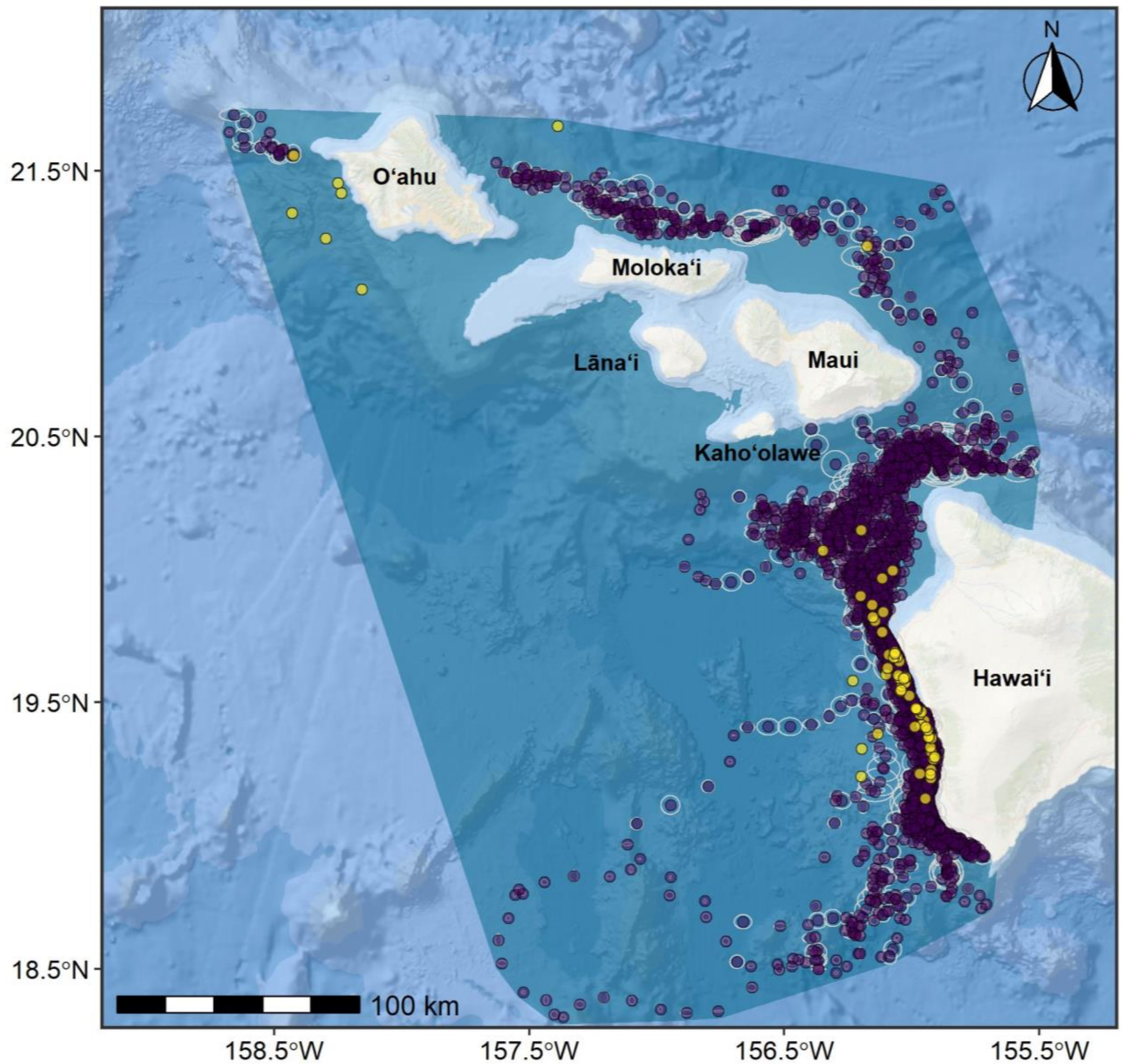

Figure 3. Parent BIA (blue polygon) for the OMNHI Blainville's beaked whale population. This parent BIA is represented as a minimum convex polygon (MCP) encompassing all *crawl*-predicted satellite tag locations (purple circles) and sighting locations (yellow circles), extended by 3 km on the outer boundary to include *crawl* standard error (68% confidence interval) ellipses (light grey ellipses). Points are partially transparent to highlight high density areas (i.e., where multiple points overlap). The inner (shoreward) boundary is defined as the 300-m isobath. Total area of the parent BIA = 78,714 km^2. Note: not all error ellipses are visible, as their size may be smaller than that of the mapped point. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

BIA: Scoring
Intensity
Abundance:
There are no abundance estimates specific to the OMNHI population nor either of the island-associated communities (Hawai'i Island or O'ahu) 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 Hawai'i 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 O'ahu 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 O'ahu and Hawai'i 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).

Range size:
The size of the modified MCP representing the BIA is 78,714 km^2.

Scoring criteria:
Intensity scoring: First, abundance and range size are scored independently as follows for each population based on the best available information:

Abundance: **(3)** = 125 or fewer individuals; **(2)** = 126 to 500 individuals; **(1)** = 501 to 2,000 individuals.

Range size: **(3)** = less than 2,000 km^2; **(2)** = 2,001-10,000 km^2; **(1)** = greater than 10,001 km^2

Abundance and range size scores are combined to generate an overall Intensity score using the matrix below:

S-BIA Intensity

Range				
	3	**2**	**3**	**3**
	2	**1**	**2**	**3**
	1	**1**	**1**	**2**
		1	2	3
		Abundance		

Abundance = 126-500; **score = 2**
Range size = 78,714 km^2; **score = 1**

<u>Overall Intensity score = 1</u>

Rationale

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; Figure 2). 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.

Data Support:

Amount and quality of information used to delineate BIA; justified in the narrative.

(3) = high confidence in both the fact that the population is small and resident and the abundance and range size estimates of population

(1) = notably lower confidence

(2) = represents the remainder of situations that are not notably high or low confidence

Data Support notes:

- 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

<u>Data Support score = 3 (high confidence)</u>

Rationale

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 Hawai‘i Island and O‘ahu, and movements between these regions, is only recently beginning to emerge (Baird, 2019; CRC unpublished). In addition, one of the 13 satellite-tagged Hawai‘i 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 O‘ahu and Maui Nui (Figure 3). However, the spatial extent of the boundary is supported by the data through the MCP method. Further, knowing that some movement occurs between Hawai‘i and O‘ahu, and known residents have made offshore “excursions”, these whales likely use these areas.

Importance score

Importance Score Matrix				
Intensity	3	2	3	3
	2	1	2	2
	1	0	1	1
		1	2	3
		Data Support		

Intensity = 1
Data support = 3
<u>Importance score = 1</u>

Boundary Certainty:
Describe the factors used in the boundary delineation.

- **(3)** = high confidence in boundary location
- **(1)** = notably lower confidence
- **(2)** = represents the remainder of situations that are not notably high or low confidence

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 Hawai‘i Island resident (Figure 2). 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 Hawai‘i 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 (Figures 1, 3).
Boundary Certainty score = 2

Spatiotemporal Variability indicator:
Dynamic (d), ephemeral (e), or static (s). If the area is dynamic or ephemeral, describe the factor(s) that drive the change in location or timing.
Spatiotemporal variability indicator **is static**. No information to suggest the area is used dynamically or ephemerally.

OMNHI Blainville's beaked whale: Child BIA boundary delineation

Although there has been recent evidence for movements between O‘ahu and Hawai‘i Island and in offshore waters (Baird, 2019), such movements have rarely been documented and long-term sighting histories and satellite tag data indicate that Hawai‘i Island Blainville's beaked whales generally remain near the leeward slopes of the island (Figures 2-3). Therefore, we delineated a child BIA for Hawai‘i Island Blainville's beaked whales with the intent to highlight the primary range of this community. We acknowledge that a core range off O‘ahu may also exist, yet due to limited information on the distribution and movements of individuals belonging to the O‘ahu community we did not delineate a child BIA for this community. The hierarchical BIA for Hawai‘i 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 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; Figure 4).

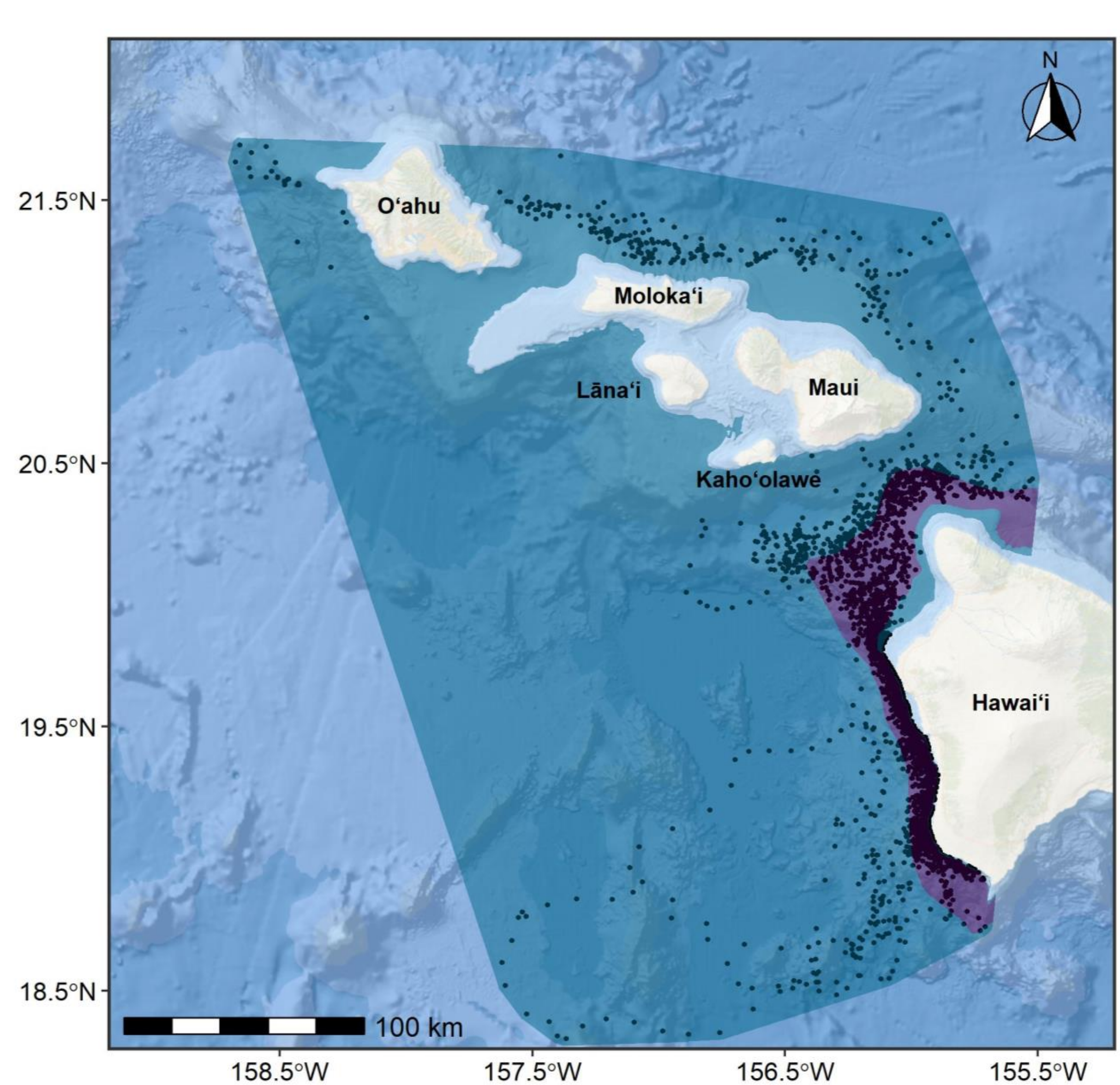

Figure 4. Parent OMNHI BIA for Blainville's beaked whales (blue polygon, area = 78,714 km^2) and child BIA for the Hawai‘i Island community (purple polygon, area = 4,214 km^2). *Crawl* locations of satellite-tagged Blainville's beaked whales and sighting locations are shown as points under the polygons. Basemap image is the intellectual property of Esri and is used herein with permission.

Child BIA: Scoring

Intensity

Abundance:

As noted above, 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 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 Oʻahu tagged whale) used the child BIA. Based on these lines of evidence, we assign an Intensity score of 3 to this child BIA.

Range size:

Area of child BIA: 4,214 km^2

<u>Overall Intensity score = 3</u>

Rationale

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 (Figures 2- 4). 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 (Table 2; Abecassis et al., 2015; Baird et al., 2010; Schorr et al., 2009).

Data Support

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.

Data Support score = 3 (high confidence)

Importance score:

Importance Score Matrix				
Intensity	3	2	3	3
	2	1	2	2
	1	0	1	1
		1	2	3
		Data Support		

Importance score = 3

Boundary Certainty:
We have high certainty in the boundary for the Hawai'i 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 (Figure 1) and satellite-tagged individuals generally remained off the leeward side of the island (Figure 2).
Boundary certainty score = 3

Summary of BIA scoring for OMNHI Blainville's beaked whale population (see Figure 3)

		Scoring				
	S-BIA	**Intensity**	**Data support**	**Importance**	**Boundary certainty**	**Spatiotemporal variability**
Parent BIA	MCP	1	3	1	2	s
Child BIA- HI	500-2,000 m isobath	3	3	3	3	s

Hierarchical BIA labels:
Parent: **S-BIA1-s-b2-HI033-0a**
Child-HI: **S-BIA3-s-b3-HI033-a**

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Humpback whale (*Megaptera novaeangliae*)

Background

The Hawaiian Archipelago is an important winter breeding ground for humpback whales (*Megaptera novaeangliae*) in the North Pacific (Barlow et al., 2011). Although observations of births are rare (Patton and Lawless, 2021; Ransome et al., 2022), mating behaviors (e.g., singing, competitive groups) are common and newborn calves are regularly seen (Cartwright and Sullivan, 2009; Craig and Herman, 2000; Craig et al., 2002). Calambokidis et al. (2008) estimated that over 50% of the humpback whales in the North Pacific (approximately 20,000 individuals in total) winters in Hawaiian waters. Although humpbacks can be found in Hawaiʻi as early as late fall and through spring, with stragglers into summer, numbers are high from January through March and peak in February and March (Mobley et al., 1999). In the main Hawaiian Islands (MHI), humpback whales are typically found in shallow waters, and particularly high densities of whales occur off Maui Nui (Mobley et al., 2001), although inter-island movements within the MHI are extensive (Cerchio et al., 1998; Calambokidis et al., 2008; Mate et al., 1998; Palacios et al., 2020; Henderson et al., 2021, 2022). Habitat use varies between sexes: females with calves preferentially use shallower waters (e.g., the Auʻau Channel of Maui Nui) relative to groups without calves and adult males (Craig and Herman, 2000; Craig et al., 2014; Cartwright et al., 2012; Pack et al., 2018). Less is known on humpback whale presence in the Northwestern Hawaiian Islands (NWHI) largely due to their remoteness. However, visual sightings from shipboard surveys (Johnston et al., 2007; Yano et al., 2019), passive acoustic detections (Allen et al., 2021; Lammers et al., 2011; Johnston et al., 2007), and movements from a small proportion of humpback whales satellite tagged in the MHI (Henderson et al., 2019, 2022; Palacios et al., 2019, 2020) provide evidence on the importance of the NWHI for wintering humpback whales. The NWHI region may serve as a final breeding ground destination before whales begin their migration north to feeding grounds, or it may represent additional breeding habitat, although the degree of connectivity between the MHI and NWHI regions is poorly understood (Allen et al., 2021; Henderson et al., 2022; Palacios et al., 2019, 2020). In this assessment, we revised the R-BIA for humpback whales in the MHI and defined a watch list area for humpback whale reproductive activities in the NWHI.

MHI: BIA boundary delineation

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 Hawai‘i 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.

MHI: Sighting and photographic data

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 from 2000 to 2021 (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 to 2020, with humpback whale sightings within the MHI breeding area perimeter (during Dec-May breeding season) in2009, 2019, and 2020 (see Barlow, 2006; Bradford et al., 2017; Yano et al., 2018, 2020 for details on surveys); (3) dedicated small-boat survey efforts conducted by NIWC Pacific and HDR, Inc. off Kaua‘i/Ni‘ihau from 2017 to 2019 (Figure 1, Table 1); and (4) aerial surveys conducted throughout the main Hawaiian Islands during February through April by Marine Mammal Research Consultants, Ltd. (MMRC) from 1993 to 2003, collected by J. Mobley (MMRC; Mobley et al., 2001; Mobley, 2004) and provided by PacIOOS (Pacific Islands Ocean Observing System[1]). There were 11 NMFS sightings outside of the MHI breeding area perimeter defined in this assessment, and as such, these sightings were excluded from the BIA revision process (Figure 1). Survey 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 combined to approximately 123,000 km of effort, with a total of 2,911 humpback whale sightings (1993-2020; Table 1; Figure 1).

[1] Data provided by PacIOOS (www.pacioos.org), which is part of the U.S. Integrated Ocean Observing System (IOOS), funded in part by National Oceanic and Atmospheric Administration (NOAA) Awards #NA11NOS0120039 and #NA16NOS0120024.

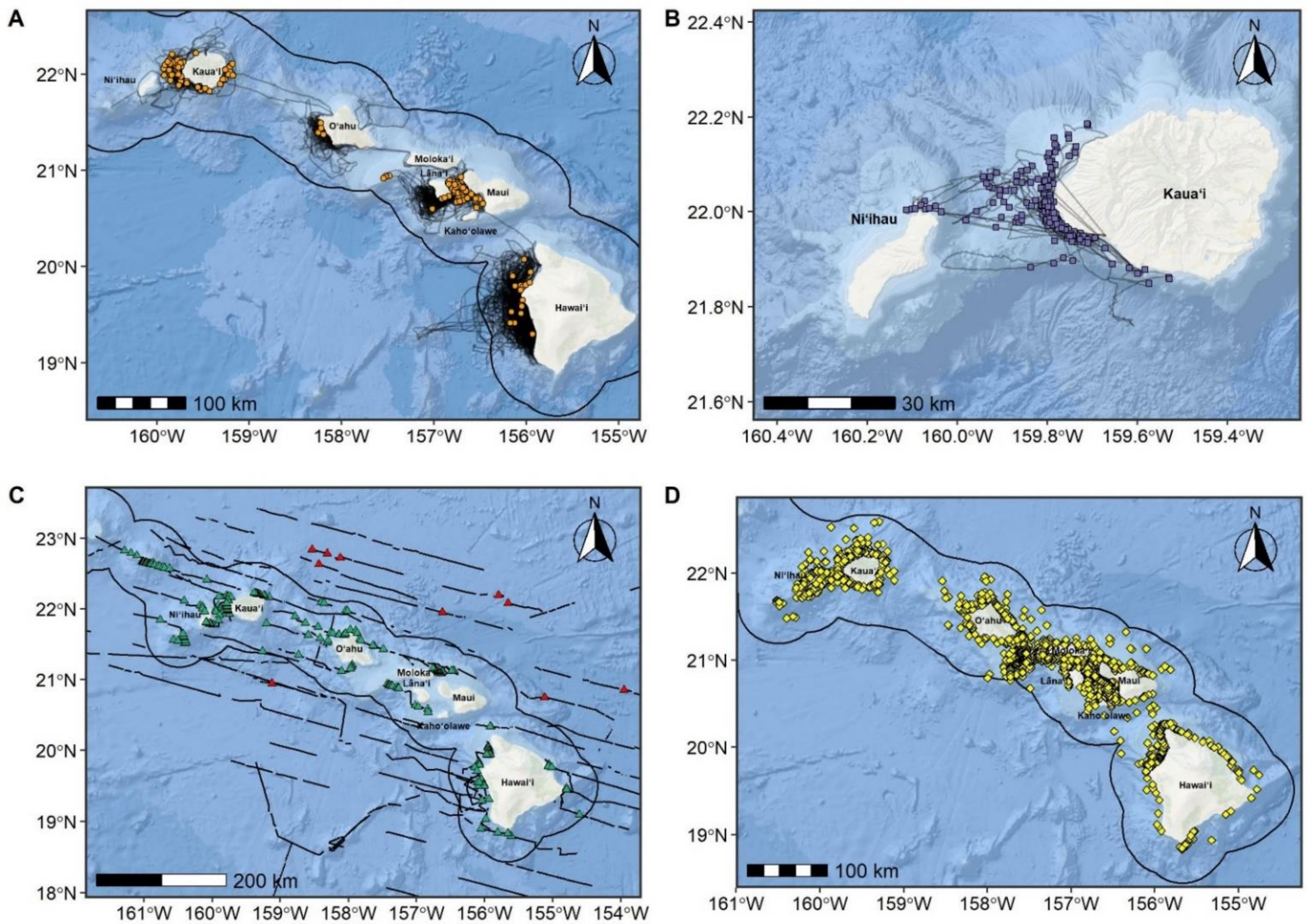


Figure 1. Humpback whale sighting locations overlaid on research vessel tracklines from (A) CRC during small-boat surveys from 2000-2021 (orange circles; n=199); (B) NIWC Pacific and HDR, Inc. during small-boat surveys from 2017-2019 (purple squares; n=202); (C) NMFS during ship-based line-transect surveys from 2002-2020 (green triangles; n=213; red triangles are sightings outside the MHI breeding area perimeter and excluded from BIA, n=11); and (D) MMRC aerial surveys from 1993-2003 (yellow diamonds, n=2,297; see Mobley et al., 2001; 2004 for effort tracklines). The MHI breeding area perimeter considered in this revised assessment is shown as a solid black outline around the islands; only data collected within the perimeter boundary and around the main Hawaiian Islands were included in this revised assessment. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Table 1. MHI humpback whale sighting data during the breeding season (December-May) within the MHI breeding area perimeter (see Figure 1).

Source	Study duration (first sighting – last sighting)	# unique years with sightings	Total # sightings	Median group size (range)
CRC	2000-2021	10	199	2 (1-11)
HDR Inc.	2017-2019	3	202	2 (1-6)
NMFS	2009-2020	4	213	2 (1-66)
MMRC	1993-2003	5	2,297	1 (1-8)
Total	1993-2021	21	2,911	2 (1-66)

MHI: Satellite tag data

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 (NIWC Pacific; 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, raw 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 band using the *pathroutr* package (London, 2021) to prevent tracks from crossing over land.

Residence time within the BIA boundaries established in 2015 was calculated as the sum of 10-minute *crawl* locations contained within the BIA boundaries from 2015 (rounded and expressed in units of days). Residence time outside of the established BIA boundaries was calculated in the same manner, using all 10-minute *crawl* locations within the breeding area perimeter excluding the BIA boundaries from 2015. 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.

To visualize where tagged whales spent the most of their time, or their occupancy pattern, we calculated a spatially-explicit residence time for each tagged whale on a common hexagonal grid (cell size = 10 km) encompassing the entire study area (i.e., MHI breeding area perimeter) and summarized distributions across all tagged whales (Figure 3). Residence time was calculated by aggregating each whale's 10-minute *crawl* locations into the hexagonal grid cells and summing the total number of locations contained within each cell (represented as time in cell, in days). To account for varying track durations and mitigate bias associated with short tracks near deployment sites, we weighted residence time in each cell by the whale's track duration (within MHI breeding area perimeter) divided by the longest whale track duration in the dataset (within the breeding area perimeter), following Möller et al., (2020), and as described in Equation (1) where T is unweighted residence time, W is weighted residence time, i indexes cell ID, j indexes each individual whale (whale ID), D_j represents track duration for whale j within the MHI breeding area perimeter, and D_{max} is the longest whale track duration within the MHI breeding area perimeter in the dataset. The total weighted time-in-cell across the sample population was calculated as the sum of all n individual weighted time-in-cell values (Figure 3; Eq. 2).

Eq. (1)

$$W_{ij} = T_{ij} \cdot \left(\frac{D_j}{D_{max}}\right)$$

Eq. (2)

$$W_i = \sum_{j=1}^{j=n} W_{ij}$$

Table 2. Humpback whale MHI satellite tag data summary*.

# deployments	Study duration (first tag – last tag)	# unique years with deployments	Range of months with data	Median (range) tagging date	Median (range) # days data	Total # filtered Argos/GPS locations
71	1995-2019	9	Dec-May	Feb-7 (Dec-13-Apr-15)	13 (5-42)	4,873

***Summaries are derived from filtered Argos/GPS locations within the MHI breeding area perimeter only; tags with less than five days of data within this area were excluded

MHI: Use of established BIA boundaries

Of the total 71 tags analyzed, 69 tags were deployed or first transmitted within BIA boundaries as defined by Baird et al., (2015), and all but two of the 71 satellite tagged humpback whales included in this analysis used those BIAs. Those two individuals were tagged off Kauaʻi and only transmitted about five days within the MHI breeding area perimeter before moving from Kauaʻi towards the northwestern edge of the MHI breeding area perimeter. Of the 69 tagged individuals that used any of the six BIAs from 2015, the mean time spent within BIA boundaries was 68% (SD=25%), with one individual spending 100% of its time (7.3 days) within a BIA (Maui Nui). The Maui Nui BIA was the most intensely used 2015 BIA (Table 3; Figure 3); however, over 70% of all satellite tags used in this analysis were deployed in this region (Figure 2). Only one satellite-tagged individual spent time in the 2015 Hawaiʻi Island BIA (Table 3; Figure 3).

Table 3. Summaries of individual use of Hawaiʻi humpback whale R-BIAs^ from 2015.

		Residence time (# days)		Residence time (% days)	
2015 BIA Area	**Area size (km^2)**	**Median**	**Range**	**Median**	**Range**

Kaua‘i	666	0.75	0.03-3.8	5.8	0.08-30
Ni‘ihau	333	0.76	0.06-5.5	5.5	0.47-73
NE O‘ahu	542	0.62	0.14-3.6	5.4	0.68-61
SE O‘ahu	243	0.27	0.03-1.4	1.2	0.23-6.3
Maui Nui	3,348	9.7	0.76-27	67	8.8-100
Hawai‘i Island*	713	9.8	9.8	25	25
Outside BIAs	102,356	3.2	0.01-29	28	0.12-100

^Calculated summaries do not include R-BIAs with zero values.

*Only one satellite-tagged individual included in the analyses used the 2015 Hawai‘i Island BIA.

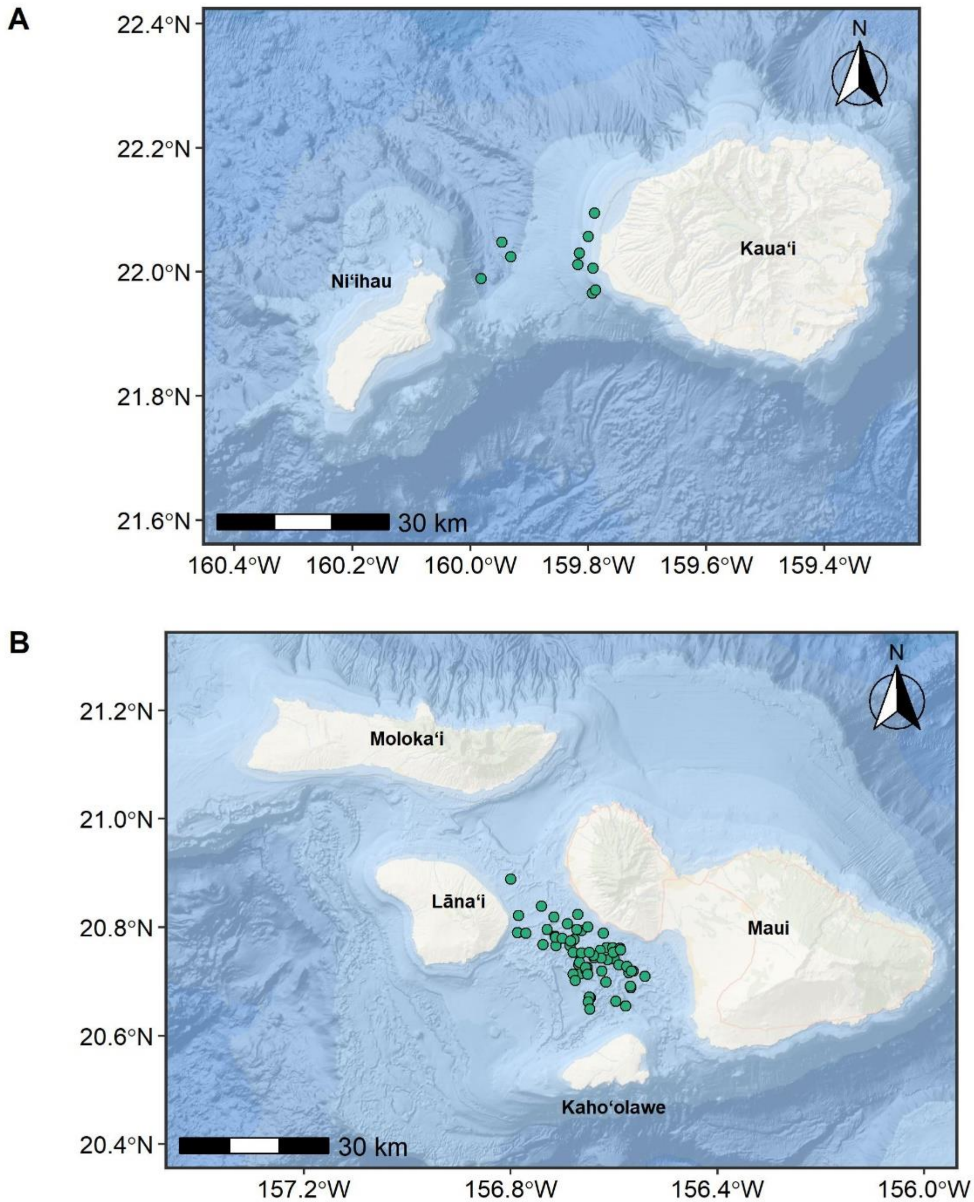


Figure 2. Satellite tag deployment locations off (A) Kaua‘i/Ni‘ihau (n=11) and (B) Maui Nui (n=60) for all tags included in this analysis (i.e., had at least 5 days of data within the breeding area perimeter around the main Hawaiian Islands). Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

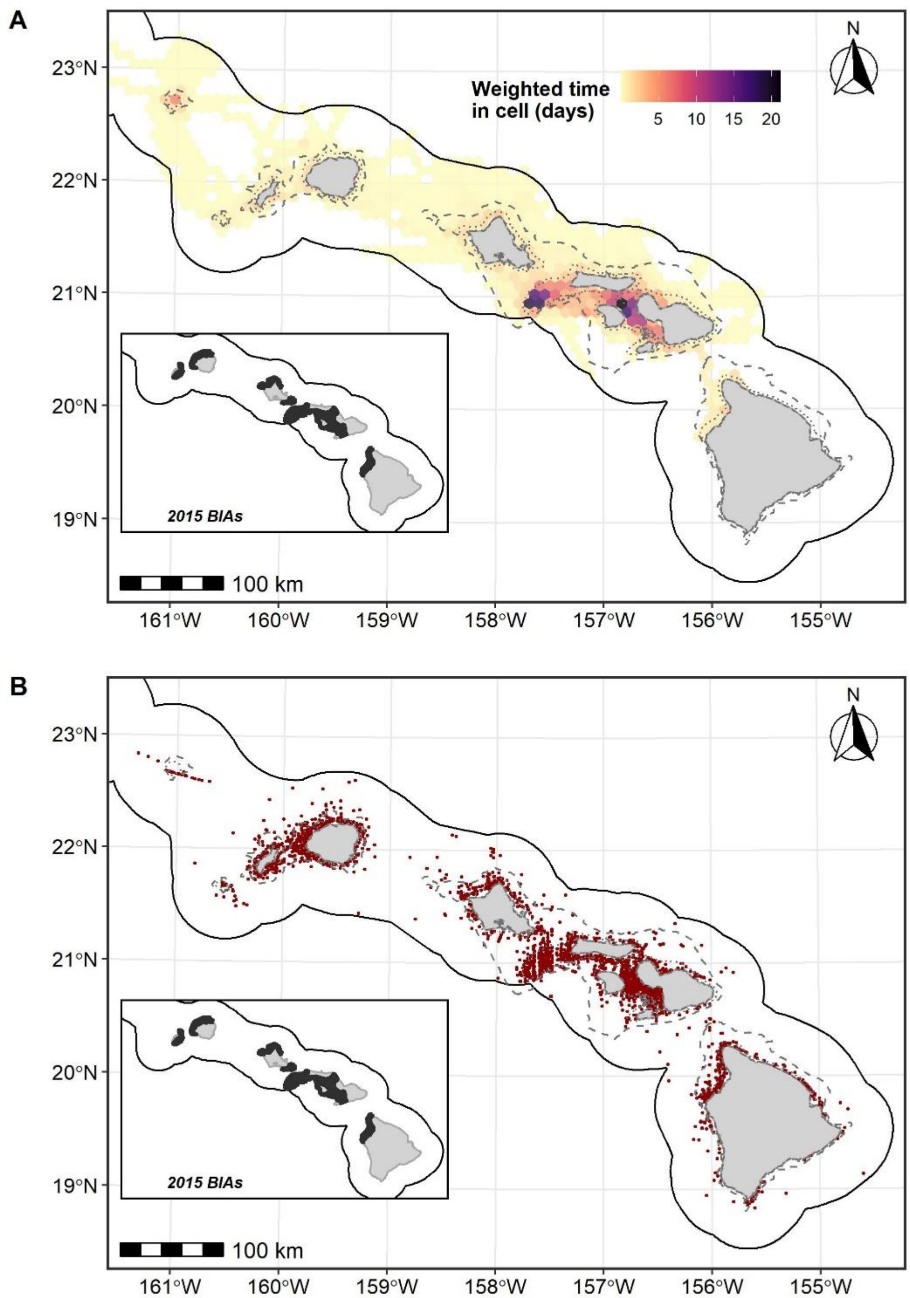


Figure 3. (A) Weighted occupancy pattern of satellite-tagged humpback whales (n=71) throughout the main Hawaiian Islands and (B) CRC, NIWC Pacific/HDR, Inc., NMFS, and MMRC visual sighting locations (n=2,911, red circles). The solid black line represents the breeding area perimeter. The grey dashed lines and dotted lines represent the 1,000-m and 200-m isobaths, respectively, in each map. Established humpback whale R-BIA boundaries as described by Baird et al. (2015) are shown in the inset maps as black-filled polygons. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

MHI BIA boundary: Range size

Based on the spatial distribution of sightings and occupancy pattern of satellite-tagged whales (Figure 3), we revised the BIA from 2015 by extending the boundary to the 1,000-m isobath around all MHI, including Middle Bank and Ka‘ula (Figure 4). 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 (Figure 3). The revised BIA is hereafter referred as the ‘parent’ BIA (Figure 4). 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 (Figure 3). For both parent and child BIA boundaries, the inner (shoreward) boundary was defined as a 50-m distance band from shore (Figure 4). The area of the parent BIA is 23,042 km^2 and the area of the child BIA is 6,679 km^2. 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.

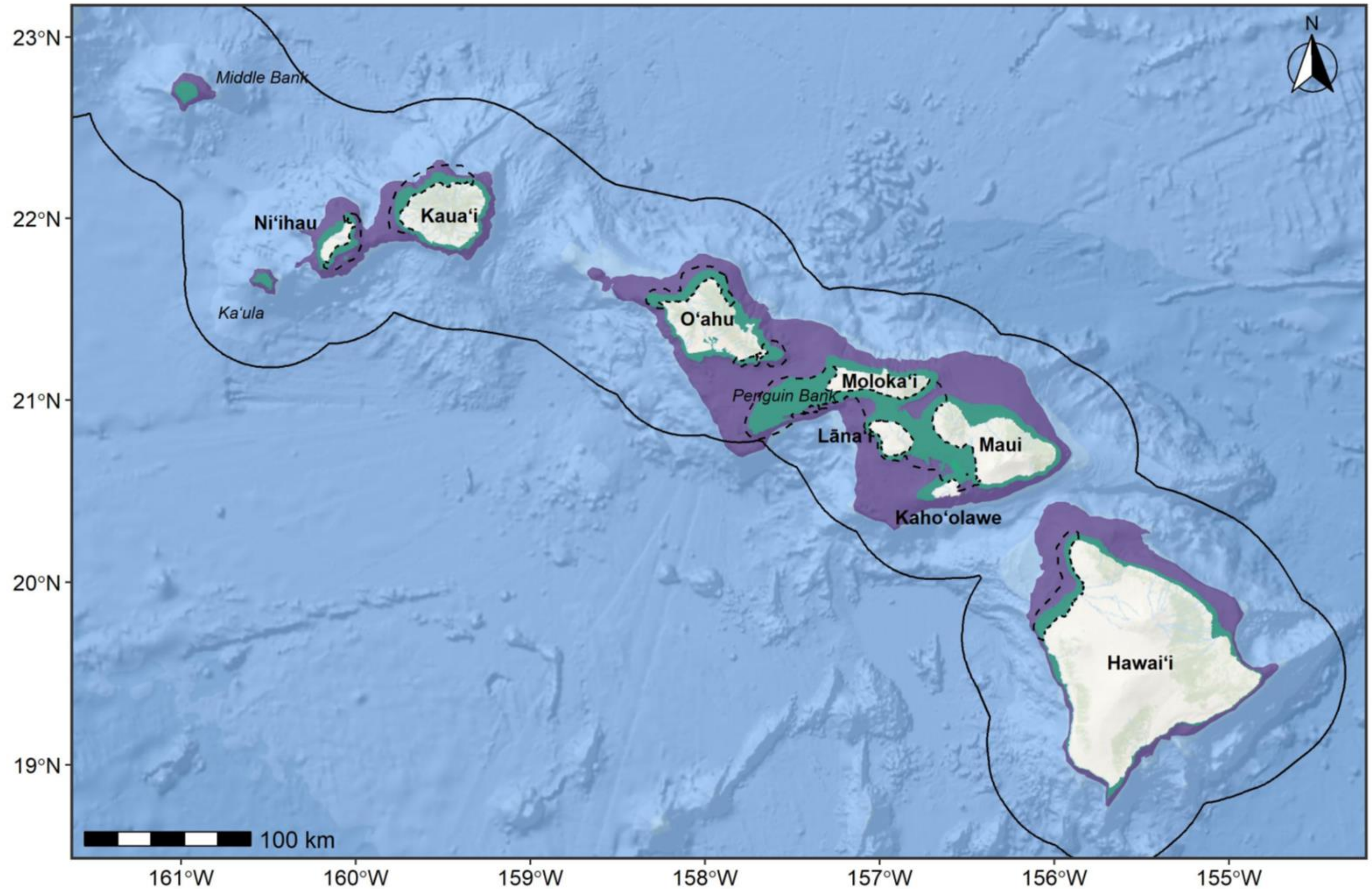


Figure 4. Revised parent BIA boundary (purple polygon) for humpback whales represented as the 1,000-m isobath around all main Hawaiian Islands and Middle Bank. The child BIA boundary (core range; green polygon) is represented as the 200-m isobath within this area. BIAs span months December through May. The inner (shoreward) boundary for both BIAs is defined by a 50-m distance band from shore. The humpback whale MHI breeding area perimeter is represented by the solid black line. Established R-BIA boundaries delineated in Baird et al. (2015) are shown in dashed black lines. Total area of the parent BIA = 23,042 km^2 and child BIA is 6,679 km^2. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

MHI BIA: Scoring
Intensity:
Parent BIA = 2 (intermediate Intensity)
Child BIA = 3 (high Intensity)

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). This estimate includes both NWHI and MHI regions, with higher estimated densities in the MHI (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 estimate 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 (Figure 8). High-density areas identified by satellite tag data (leeward Maui Nui, Penguin Bank; Figures 7, 8) 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 (Figures 7, 8). 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.

Data Support:

Parent BIA = 2 (intermediate support)
Child BIA = 3 (high support)
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.

Importance score

Importance Score Matrix				
Intensity	3	**2**	**3**	**3**
	2	**1**	**2**	**2**
	1	0	**1**	**1**
		1	2	3
		Data Support		

Importance scores:
Parent BIA = 2
Child BIA = 3

Boundary Certainty:
Describe the factors used in the boundary delineation.

- **(3)** = high confidence in boundary location
- **(1)** = notably lower confidence
- **(2)** = represents the remainder of situations that are not notably high or low confidence

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 (Figure 3), 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.

Boundary Certainty scores:
Parent BIA = 2
Child BIA = 3

Spatiotemporal Variability indicator:
Dynamic (d), ephemeral (e), or static (s). If the area is dynamic or ephemeral, describe the factor(s) that drive the change in location or timing.
Spatiotemporal variability indicator **is static**. No information to suggest either area is used dynamically or ephemerally; boundaries based on static (bathymetric) features.

Summary of BIA scoring for MHI humpback whales (see Figure 4)

		Scoring				
	R-BIA	**Intensity**	**Data Support**	**Importance**	**Boundary Certainty**	**Spatiotemporal Variability**
Parent BIA	1,000-m isobath	2	2	2	2	s
Child BIA	200-m isobath	3	3	3	3	s

BIA labels for MHI humpback whale R-BIAs:
Parent BIA: R-BIA2-s-b2-HI024-0a
Child BIA: R-BIA3-s-b3-HI024-a

NWHI watch list area: boundary delineation

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).

NWHI watch list area: Sighting data

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 (Table 4; Figure 5).

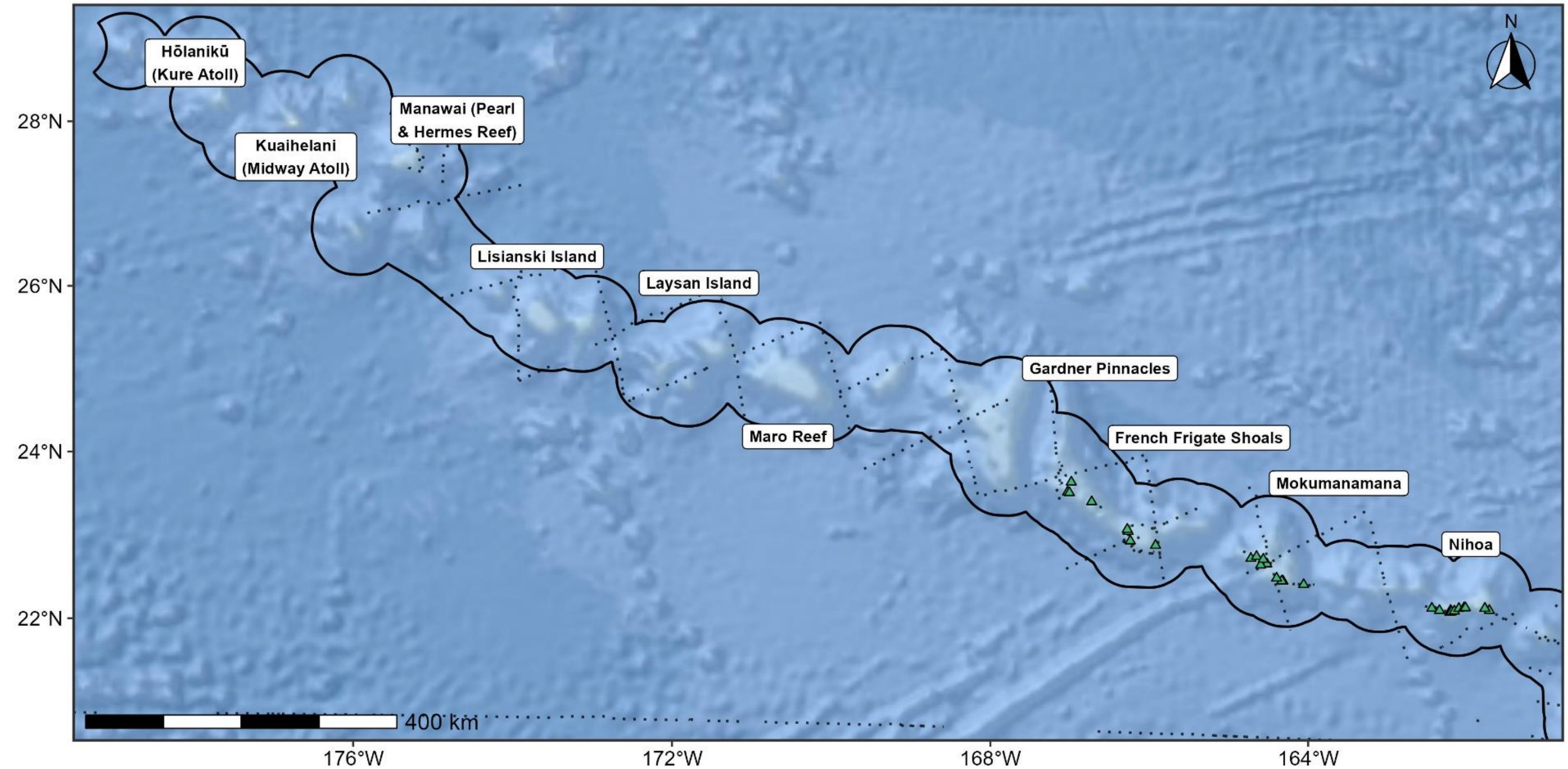


Figure 5. Humpback whale sighting locations (green triangles, n=30) overlaid on research vessel tracklines (dotted lines) from NMFS during ship-based line-transect surveys in the Northwestern Hawaiian Islands (2002-2020, sightings in 2013 and 2019 only). The NWHI breeding area perimeter considered in this revised assessment is shown as a solid black outline around the islands; only data collected within the perimeter boundary and around the Northwestern Hawaiian Islands were included in this assessment. Only effort undertaken during the December-May breeding season are shown here (approximately 5,190 km of effort, as mapped here). Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Table 4. NWHI humpback whale sighting data during the breeding season (December-May) within the NWHI breeding area perimeter (see Figure 5).

Source	Study duration (first sighting – last sighting)	# unique years with sightings	Total # sightings
NMFS-PACES	2013	1	1
NMFS-TRIALS	2019	1	29
Total	2013, 2019	2	30

NWHI watch list area: Satellite tag data

A total of three individuals out of 84 whales satellite tagged (Maui, n=61; Kaua‘i/Ni‘ihau, 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 (Figure 6).

Watch list area boundary: Range size

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 (Figures 5-7). The area of the watch list area is 13,305 km^2.

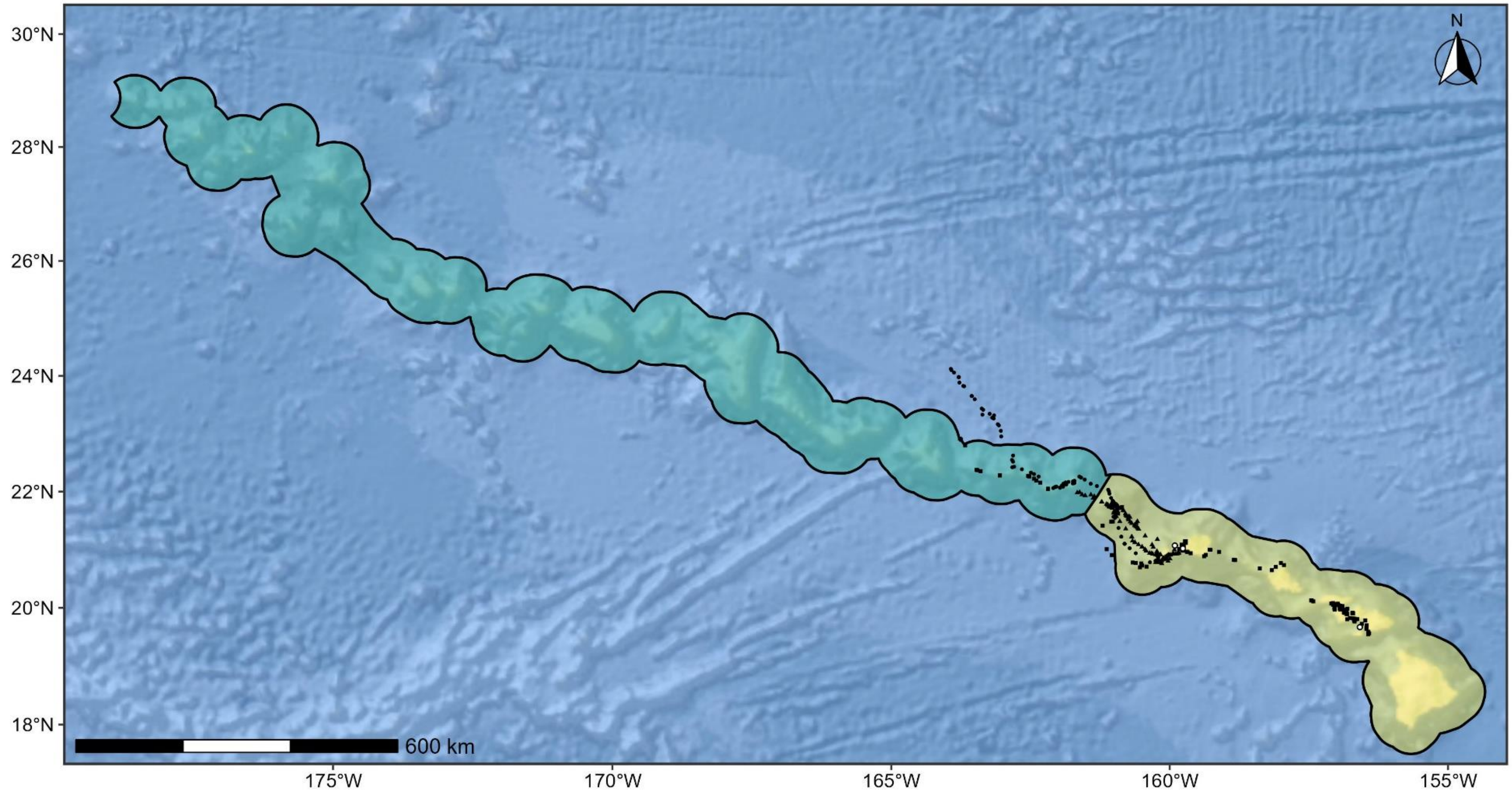


Figure 6. Satellite tag locations (black points) from three humpback whales that moved into the Northwestern Hawaiian Islands region (green shaded area = Northwestern Hawaiian Islands breeding area perimeter; yellow shaded area = main Hawaiian Islands breeding area perimeter). Points corresponding to each unique tagged whale are indicated by the different shapes. Tag deployment locations are shown as white points. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

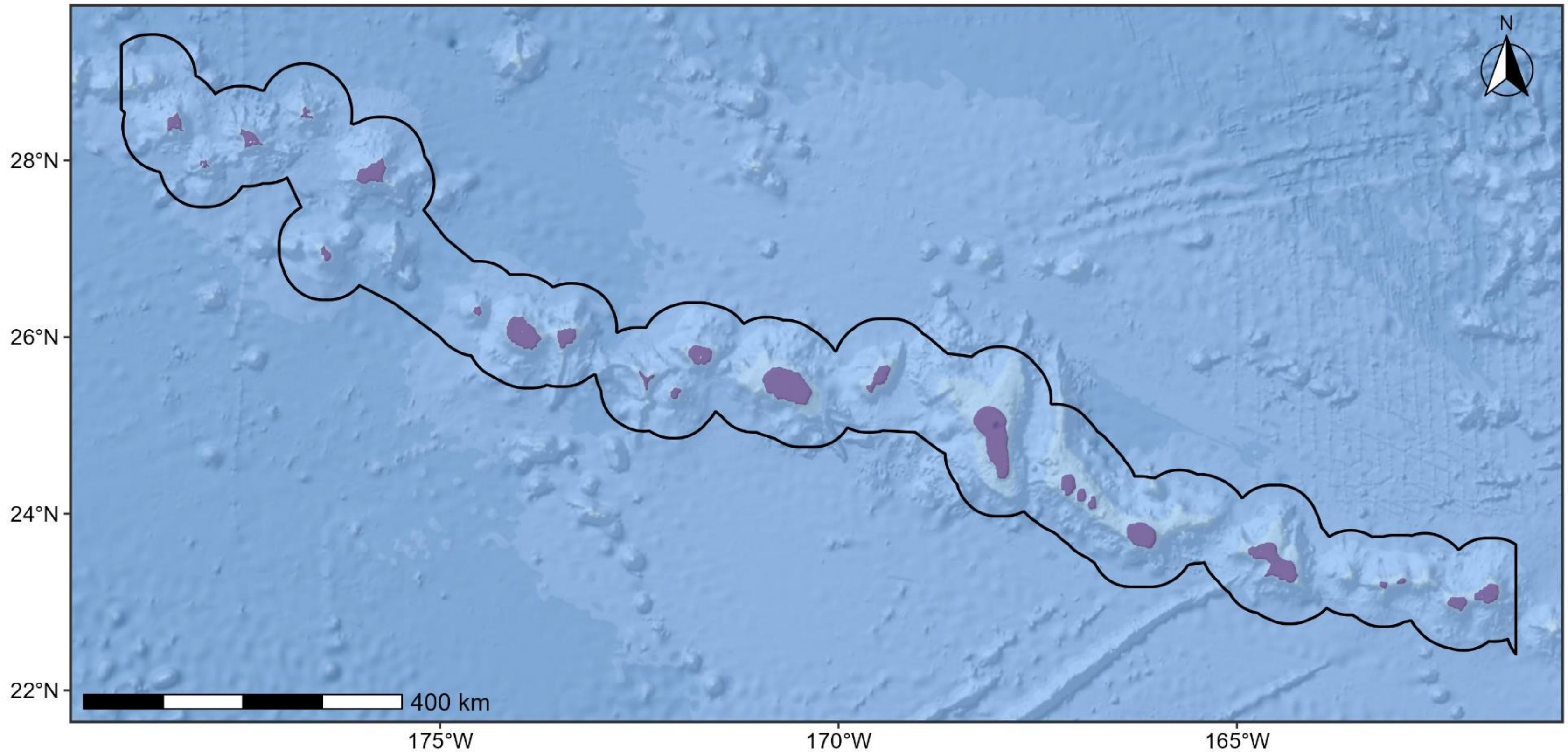


Figure 7. Watch list area for humpback whale reproductive activities in the Northwestern Hawaiian Islands (NWHI), represented as the 200-m isobath within this area (purple polygons; total area = 13,305 km^2). The watch list area spans months December through May. The inner (shoreward) boundary for both BIAs is defined by a 50-m distance band from shore. The humpback whale NWHI breeding area perimeter is represented by the solid black line. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

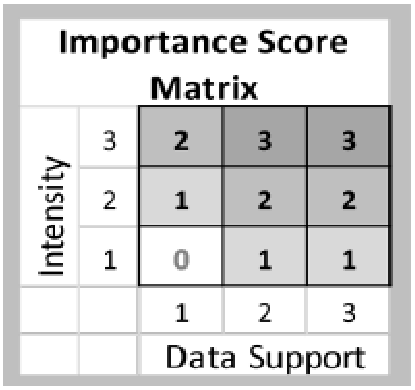
NWHI watch list area: Scoring
Intensity: 1 (low intensity)

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 Hawai‘i 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 Hawai‘i 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.

Data Support: 1 (low support)

- 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 (Figure 6); 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; Figure 5).
- 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)

Importance score



Importance score: 0

Boundary Certainty:
Describe the factors used in the boundary delineation.

- **(3)** = high confidence in boundary location
- **(1)** = notably lower confidence
- **(2)** = represents the remainder of situations that are not notably high or low confidence

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.

Boundary Certainty score: 1

Spatiotemporal Variability indicator:
Dynamic (d), ephemeral (e), or static (s). If the area is dynamic or ephemeral, describe the factor(s) that drive the change in location or timing.
Spatiotemporal variability indicator **is static**. No information to suggest either area is used dynamically or ephemerally; boundaries based on static (bathymetric) features.

Summary of watch list area scoring for NWHI humpback whales (see Figure 7)

		Scoring				
	Boundary	**Intensity**	**Data Support**	**Importance**	**Boundary Certainty**	**Spatiotemporal Variability**
Watch list area	200-m isobath	1	1	0	1	s

BIA label for NWHI humpback reproductive watch list area:
R-BIA0-s-b1-HI036-0

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Common minke whale (*Balaenoptera acutorostrata*)

Background

Common minke whales (*Balaenoptera acutorostrata*; hereafter minke whales) are rarely observed in Hawaiian waters; their apparent offshore habits and inconspicuous nature (e.g., cryptic surface behavior, typically travel alone or in small groups) makes visual survey efforts generally ineffective. However, their presence in the archipelago during winter and spring months has been documented from passive acoustic monitoring methods and limited visual sightings (Balcomb, 1987; Barlow, 2006; Bradford et al. 2017, 2021; Martin et al. 2020; Norris et al. 2012; Oswald et al. 2011; Rankin and Barlow, 2005; Rankin et al. 2007; Yano et al. 2018, 2020). Minke whales have been acoustically detected in Hawaiian waters as early as October and as late as May, with the number of detections peaking from January through March (Martin et al. 2020; Oswald et al. 2011; Thompson and Friedl, 1982; Yano et al. 2018, 2020). Information from the small number of visual sightings have not noted the presence of calves or breeding behavior; however, it is believed that this seasonal presence of minke whales in Hawaiian waters is linked to reproductive purposes much like other migratory baleen whales, such as humpback whales (Baker and Herman, 1981; Oswald et al. 2011). Further, the unique “boing” call minke whales produce during winter and spring months in the North Pacific has been suggested to be produced by males engaged in courtship and reproductive behaviors similar to other baleen whale species (Croll et al. 2002; Herman et al. 2013; Rankin and Barlow, 2005). Although the majority of available data on minke whale presence in Hawaiʻi occurs around the main Hawaiian Islands (MHI), minke whales have also been detected and sighted in the Northwestern Hawaiian Islands (NWHI; Bradford et al. 2017, 2021; Yano et al. 2018; Shallenberger, 1981). In consideration of the amount of information (or lack thereof) available on minke whale occurrence in Hawaiian waters for reproductive purposes, we delineated a reproductive watch list area for minke whales in this region rather than a BIA.

Watch list area boundary delineation

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.

Sighting data

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 (Table 1, Figure 1; 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 (Table 1, Figure 1), as were three minke whale sightings corroborated with photographs contributed to CRC through their Hawaiʻi community science photo contribution program.

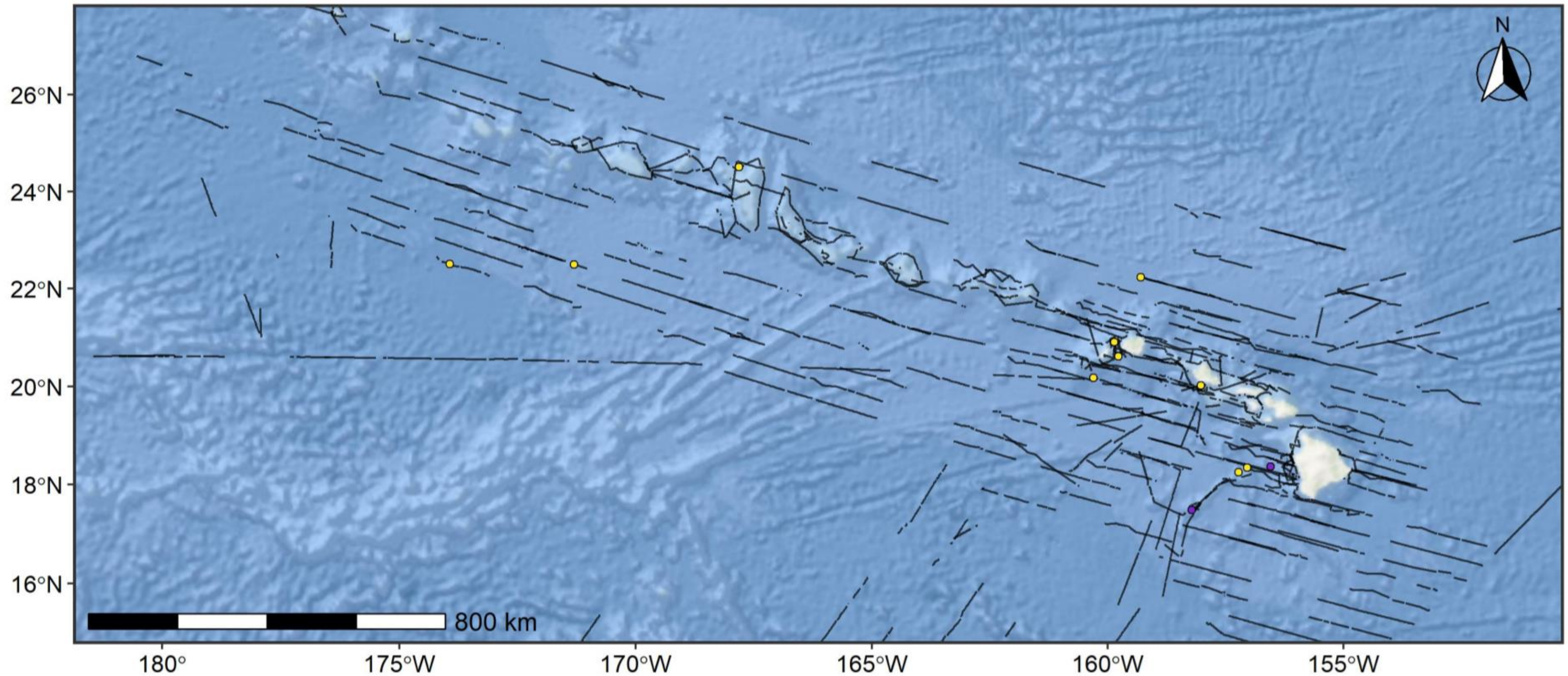

Figure 1. Minke whale sightings (yellow circles; n=10 Table 2) overlaid on survey tracklines from all of NMFS's ship-based line-transect survey efforts around the Hawaiian Islands (2002-2020); tracklines from HDR, Inc. surveys were not available and thus not shown. Three sightings from community scientists are also shown as purple circles; these locations are not exact but relative area is known (two at Cross Seamount (overlapping points) and one offshore of Kona, Hawai‘i Island; CRC unpublished). Only visual sightings and effort tracklines that occurred within the minke whale breeding season considered for this watch list area are shown (Oct-Apr). Combined survey effort tracklines shown here (i.e., around or passing through the Hawaiian Islands) total 38,282 km. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

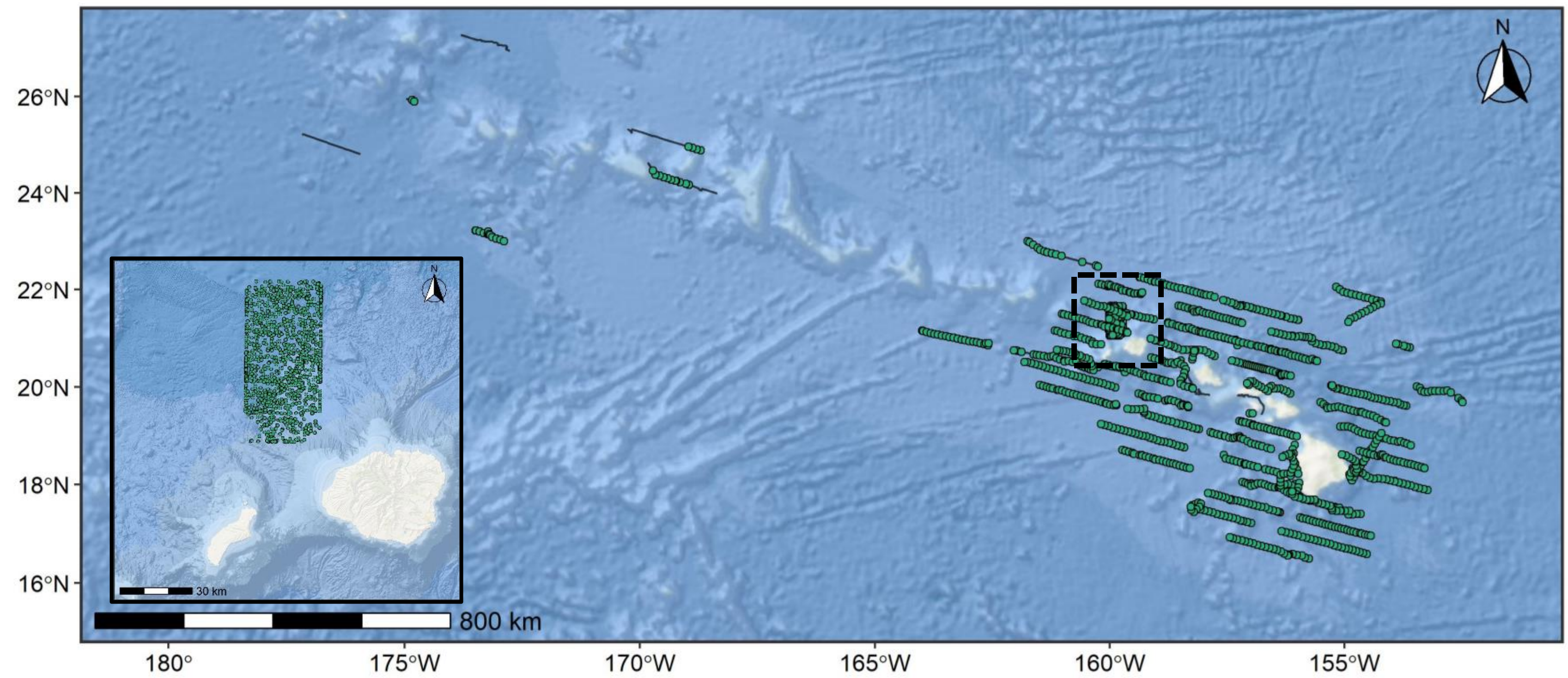

Figure 2. Minke whale acoustic detections (green circles; n=2,324, Table 2) from both PMRF and NMFS surveys overlaid on line-transect survey tracklines from NMFS's 2017 HICEAS survey and 2020 WHICEAS survey. Tracked minke whale detections from PMRF are shown in the inset figure corresponding to the area outlined in dashed black lines. Only acoustic detections and effort tracklines that occurred within the minke whale breeding season considered for this watch list area are shown (Oct-Apr). Combined survey effort tracklines total 12,803 km. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Table 1. Minke whale visual sighting data

Locality	Source*	Study duration (first sighting – last sighting)	# Unique years with sightings	Total # sightings
NWHI	NMFS	2002-2017	3	3
Offshore N Kaua‘i	NMFS	2020	1	1
Kaua‘i/Ni‘ihau	HDR, Inc. NMFS	2005-2012	3	3
O‘ahu	HDR Inc.	2010	1	1
Offshore S Maui Nui	HDR, Inc. NMFS	2009-2010	2	2
Cross Seamount	CRC-CS	2021	1	2
Offshore Hawai‘i	CRC-CS	2021	1	1
Total		2002-2021	8	13

*CRC-CS = Cascadia Research Collective-Community Science

Acoustic detection data

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 (Figure 2). 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 (Figure 2). 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.

Table 2. Minke whale acoustic detection data

Source	Array type	Years with detections	Breeding season months with detections*	Total # detections^
PMRF	Seafloor-mounted	2012-2017	Oct-Apr	1,261
NMFS HICEAS	Towed	2017	Oct-Nov	150
NMFS WHICEAS	Towed	2020	Jan-Mar	913

Total	2,324

**Only detections during watch list area breeding season (Oct-Apr) included in summaries*
^# detections from PMRF reflect individual, tracked minke whale calls whereas # detections from NMFS reflect all recorded detections occurring within 30-minute binned intervals

Watch list area boundary: Range size

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 (Figure 3). 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 Kaua‘i, Hawai‘i 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 km^2.

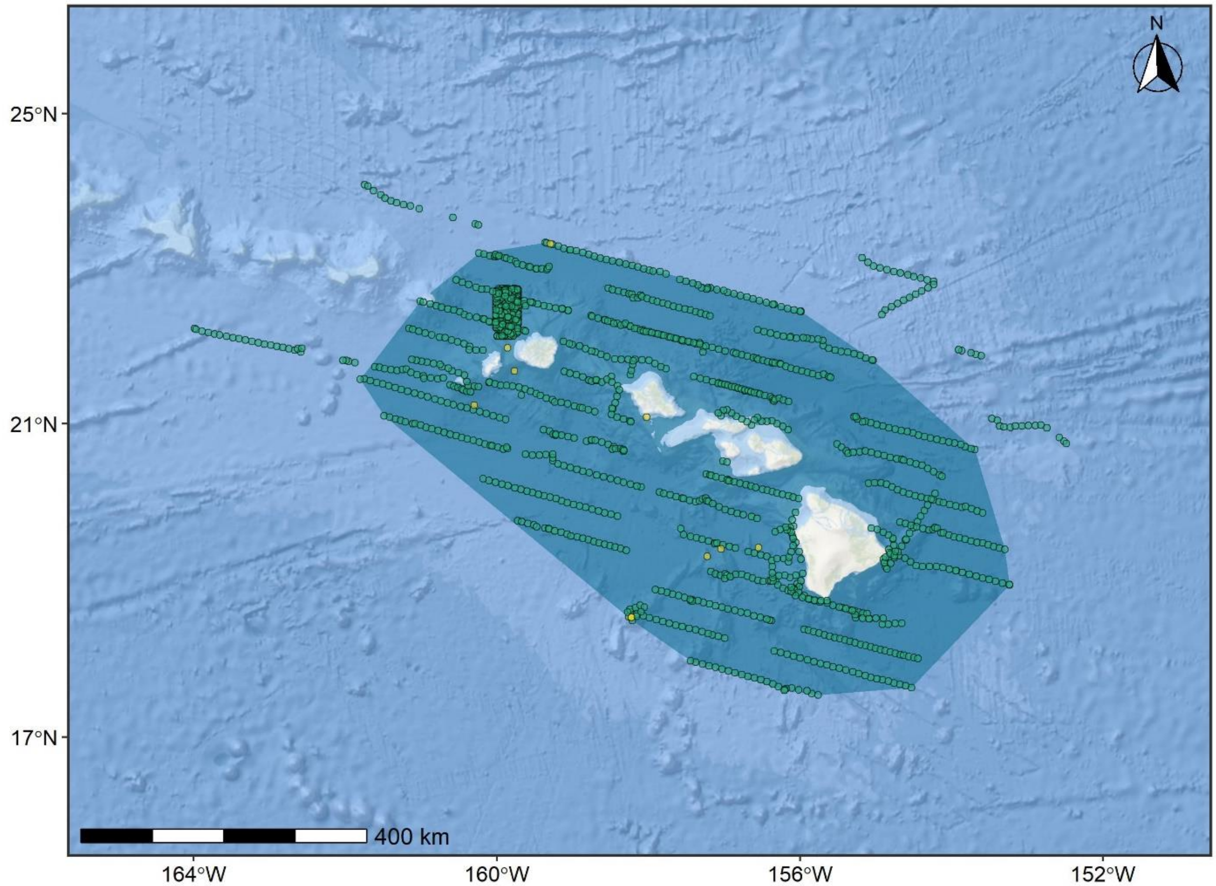

Figure 3. Watch list area boundary (blue polygon) for minke whales spanning October through April represented as a minimum convex polygon (MCP) encompassing the majority of acoustic detection locations (green circles) and all sighting locations (yellow circles) around the main Hawaiian Islands. The inner (shoreward) boundary is defined by a 500-m isobath. The size of the watch list area is 333,658 km^2. Basemap image is the intellectual property of Esri and is used herein with permission. Copyright © 2022 Esri and its licensors. All rights reserved.

Watch list area: Scoring

Intensity: 1 (low intensity)

- 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 U.S. waters is being delineated for minke whales

Data Support: 1 (low confidence)

- 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.

Importance score

Importance Score Matrix

Intensity	3	2	3	3
	2	1	2	2
	1	0	1	1
		1	2	3
		Data Support		

Intensity: 1
Data Support: 1

<u>Importance scores: 0 (watch list area)</u>

Boundary Certainty:
Describe the factors used in the boundary delineation.

- **(3)** = high confidence in boundary location
- **(1)** = notably lower confidence
- **(2)** = represents the remainder of situations that are not notably high or low confidence

<u>Boundary Certainty: 1 (lower confidence)</u>
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.

Spatiotemporal Variability indicator:
Dynamic (d), ephemeral (e), or static (s). If the area is dynamic or ephemeral, describe the factor(s) that drive the change in location or timing: static.

Summary of scoring for MHI minke whale watch list area (see Figure 2)

		Scoring				
	Boundary	**Intensity**	**Data Support**	**Importance**	**Boundary Certainty**	**Spatiotemporal Variability**
Watch list area	MCP around majority of data points	1	1	0	1	?

Labels for MHI minke whale reproductive watch list area:
R-BIA0-s-b1-HI027-0

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