Final Report

Odontocete Studies on the Pacific Missile Range Facility in February 2014:

Satellite-Tagging, Photo-Identification, and Passive Acoustic Monitoring

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Blainville's beaked whale (*Mesoplodon densirostris*) off Kaua'i. Photo taken by Brenda K. Rone under National Marine Fisheries Service permit no. 15330.

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14. ABSTRACT
A joint project in February 2014 on and around the Pacific Missile Range Facility (PMRF) was carried out utilizing combined passive acoustic monitoring and boat-based field efforts. There were 1,287 kilometers (km) (66.3 hours [hr]) of small-vessel survey effort over the course of the 10 day project, with 44.6 percent of search time (29.6 hr) spent within the PMRF instrumented hydrophone range boundaries. A total of 81.7 hr of acoustic monitoring was undertaken during the field effort. There were 26 sightings of five species of odontocetes, six of which were directed by acoustic detections from the Marine Mammal Monitoring on Navy Ranges (M3R) system. Bottlenose dolphins (Tursiops truncatus) were encountered on eight occasions, spinner dolphins (Stenella longirostris) on seven, short-finned pilot whales (Globicephala macrorhynchus) on five, rough-toothed dolphins (Steno bredanensis) on two, and Blainville's beaked whales (Mesoplodon densirostris) once. Recordings on the M3R system were made for four species (all but spinner dolphins) to improve species classification for future acoustic monitoring efforts. During the encounters 10,928 photos were taken for individual identification, six biopsy samples were obtained for genetic studies, and 12 satellite tags were deployed on four species—six short-finned pilot whales, two bottlenose dolphins, two rough-toothed dolphins, and two Blainville's beaked whales (although data were obtained from only one of the two). The Blainville's beaked whale was tagged off PMRF, but over an eight-day period the tagged animal moved onto the range three times and spent an estimated 20.5 percent of its time on PMRF. The tagged individual remained associated with the island slopes (median depth of locations = 961 meters [m]), and remained within 83 km of the tagging location. Although both of the tagged

rough-toothed dolphins remained associated with the islands (median depths of 1,463 and 1,961 m), one moved as far as western O'ahu, the first movement of a tagged rough-toothed dolphin away from Kaua'i and Ni'ihau. Both tagged bottlenose dolphins remained strongly associated with the island of Kaua'i (median depths of 56 and 88 m) over the tag attachment periods (6 and 13 days, respectively). The six tagged short-finned pilot whales included individuals from three different social clusters, one of which (HIGm0929, tag number GmTag078) had only previously been documented off Hawai'i Island. HIGm0929 remained primarily in deep water (median = 3,351 m) farther from shore (median distance from shore = 39.9 km), while individuals from the other two social clusters used shallower water (median depths from 1,635 to 2,296 m) closer to shore (median distances from 13.9 to 19.3 km). Probability density analyses of all tag location data obtained for bottlenose dolphins, rough-toothed dolphins, and short-finned pilot whales off Kaua'i indicate that core ranges (i.e., the 50 percent kernel density polygons) for all three species overlap with PMRF. Continued collection of movement and habitat use data from all species should allow for a better understanding of the use of the range as well as provide datasets that can be used to estimate received sound levels at animal locations and examine potential responses to exposure.

15. SUBJECT TERMS

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Abbreviations and Acronyms

AUTEC	Atlantic Undersea Test and Evaluation Center
BARSTUR	Barking Sands Tactical Underwater Range
BSURE	Barking Sands Underwater Range Expansion
FFT	Fast Fourier Transform
hr	hour(s)
kHz	kilohertz
km	kilometer(s)
m	meter(s)
M3R	Marine Mammal Monitoring on Navy Ranges
MFA	mid-frequency active
PAM	passive acoustic monitoring
PMRF	Pacific Missile Range Facility
RHIB	rigid-hulled inflatable boat
SWTR	Shallow Water Training Range

1. Abstract

A joint project in February 2014 on and around the Pacific Missile Range Facility (PMRF) was carried out utilizing combined passive acoustic monitoring and boat-based field efforts. There were 1,287 kilometers (km) (66.3 hours [hr]) of small-vessel survey effort over the course of the 10-day project, with 44.6 percent of search time (29.6 hr) spent within the PMRF instrumented hydrophone range boundaries. A total of 81.7 hr of acoustic monitoring was undertaken during the field effort. There were 26 sightings of five species of odontocetes, six of which were directed by acoustic detections from the Marine Mammal Monitoring on Navy Ranges (M3R) system. Bottlenose dolphins (*Tursiops truncatus*) were encountered on eight occasions, spinner dolphins (*Stenella longirostris*) on seven, short-finned pilot whales (*Globicephala macrorhynchus*) on five, rough-toothed dolphins (*Steno bredanensis*) on two, and Blainville's beaked whales (*Mesoplodon densirostris*) once. Recordings on the M3R system were made for four species (all but spinner dolphins) to improve species classification for future acoustic monitoring efforts. During the encounters 10,928 photos were taken for individual identification, six biopsy samples were obtained for genetic studies, and 12 satellite tags were deployed on four species—six short-finned pilot whales, two bottlenose dolphins, two rough-toothed dolphins, and two Blainville's beaked whales (although data were obtained from only one of the two). The Blainville's beaked whale was tagged off PMRF, but over an eight-day period the tagged animal moved onto the range three times and spent an estimated 20.5 percent of its time on PMRF. The tagged individual remained associated with the island slopes (median depth of locations = 961 meters [m]), and remained within 83 km of the tagging location. Although both of the tagged rough-toothed dolphins remained associated with the islands (median depths of 1,463 and 1,961 m), one moved as far as western Oʻahu, the first movement of a tagged rough-toothed dolphin away from Kauaʻi and Niʻihau. Both tagged bottlenose dolphins remained strongly associated with the island of Kauaʻi (median depths of 56 and 88 m) over the tag attachment periods (6 and 13 days, respectively). The six tagged short-finned pilot whales included individuals from three different social clusters, one of which (HIGm0929, tag number GmTag078) had only previously been documented off Hawaiʻi Island. HIGm0929 remained primarily in deep water (median = 3,351 m) farther from shore (median distance from shore = 39.9 km), while individuals from the other two social clusters used shallower water (median depths from 1,635 to 2,296 m) closer to shore (median distances from 13.9 to 19.3 km). Probability density analyses of all tag location data obtained for bottlenose dolphins, rough-toothed dolphins, and short-finned pilot whales off Kauaʻi indicate that core ranges (i.e., the 50 percent kernel density polygons) for all three species overlap with PMRF. Continued collection of movement and habitat use data from all species should allow for a better understanding of the use of the range as well as provide datasets that can be used to estimate received sound levels at animal locations and examine potential responses to exposure.

2. Introduction

The Marine Mammal Monitoring on Navy Ranges program (M3R) is a real-time passive acoustic monitoring (PAM) system that has been implemented at three major Navy undersea test and training ranges: the Atlantic Undersea Test and Evaluation Center (2002–present, see

Morrissey et al. 2006), the Southern California Offshore Range (2006–present, see Falcone et al. 2009), and most recently at the Pacific Missile Range Facility (PMRF) between Kauaʻi and Niʻihau (2011–present). The purpose of this report is to present results of a joint project in February 2014 undertaken on and around the PMRF instrumented hydrophone range, involving a combination of M3R passive acoustic monitoring and vessel-based field efforts including photo-identification and satellite tagging. In addition to the small-boat based satellite tagging and photo-identification efforts, a larger vessel, the R/V *Searcher*, was also working in conjunction both with M3R and the tagging vessel; results from that vessel are reported separately (Deakos and Richlen 2015).

This work addresses a specific Navy monitoring question: what are the spatial movement and habitat use patterns (e.g., island-associated or open-ocean, restricted ranges vs. large ranges) of species that are exposed to mid-frequency active (MFA) sonar, and how do these patterns influence exposure and potential responses? Additional goals include providing visual species verification for M3R acoustic detections and obtaining cetacean movement and habitat use information on and around PMRF before, during, and after a Submarine Commanders Course scheduled to be undertaken after the field efforts, using data obtained from satellite tags. In addition, Blainville's beaked whale detection archives are being collected and will be combined with previous archives to derive the spatial and temporal distribution of this species on PMRF, as well as to estimate abundance.

The M3R system consists of specialized signal-processing hardware and detection, classification, localization, and display software that provide a user-friendly interface for real-time PAM via 199 PMRF bottom-mounted hydrophones (Jarvis et al. 2014). Prior to 2014, the M3R system at PMRF was used on five occasions (**Table 1**) in collaboration with vessel-based field efforts. This combination approach provides visual species verifications for groups detected acoustically, as well as visual sightings of animals on the range that have not been acoustically detected. It also increases the encounter rate for vessel-based efforts. Increased encounter rates result in greater opportunities for deploying satellite tags (see below) as well as photo-identifying individuals and collecting biopsy samples for genetic studies.

Vessel-based field studies of odontocetes first began off Kauaʻi and Niʻihau in 2003 (Baird et al. 2003) as part of a long-term, multi-species assessment of odontocetes in the main Hawaiian Islands (Baird et al. 2013a). Studies using satellite tags to assess movements and behavior of individual toothed whales on and around the PMRF were first begun in June 2008 in association with the Rim-of-the-Pacific naval training event (Baird et al. 2008a). During that effort three melon-headed whales (*Peponocephala electra*) and a short-finned pilot whale (*Globicephala macrorhynchus*) were tagged and tracked for periods ranging from 3.7 to 43.6 days (Baird et al. 2008a; Woodworth et al. 2011). Since 2008 and prior to February 2014, there have been six additional vessel-based field projects off Kauaʻi (five in conjunction with M3R monitoring) during which satellite tags were deployed. During these six efforts, 31 satellite tags were deployed on five different species of odontocete cetaceans (**Table 1**; Baird et al. 2011, 2012a, 2012b, 2013b, 2013c).

To put the results from the February 2014 field effort into context, we also include results from previous photo-identification and satellite tagging efforts on and around PMRF. This includes matching of photos of tagged individuals and companions to long-term photo-identification catalogs (Baird et al. 2008b, 2009; Mahaffy 2012; McSweeney et al. 2007) to allow for the assessment of population identity and re-sighting history of tagged individuals, as well as presentation of location data from previously satellite-tagged individuals (Baird et al. 2013b, 2013c, 2014).

3. Methods

3.1 PMRF Undersea Acoustic Range

The PMRF instrumented hydrophone range is configured with 219 bottom-mounted hydrophones, 199 which are available for PAM. They were installed in four phases, such that each system has different acoustic monitoring capabilities (**Table 2**). The four range systems are: the Shallow Water Training Range (SWTR), the Barking Sands Tactical Underwater Range (BARSTUR), the legacy Barking Sands Underwater Range Expansion (BSURE), and the refurbished BSURE (**Figure 1**). Each range consists of several offset bottom-mounted cables (strings), with multiple hydrophones spaced along each string to create hexagonal arrays.

3.2 M3R System

Passive acoustic data pass through the range's operational signal-processing system and the M3R system in parallel. In this way, marine mammal monitoring does not interfere with range use. Signals from all of the hydrophones are processed in parallel, providing marine mammal detection, classification, and localization results for the entire range in real time. These real-time results allow a PAM analyst to isolate animal vocalizations on the range, confirm species classification and choose optimal group localizations for attempting at-sea species verification. To date, classification is accomplished using real-time embedded software with manual review by an analyst. Classification may be to the species or guild level depending on the animal in question. Hydrophones are sampled at 96 kilohertz (kHz), providing an analysis bandwidth of 48 kHz. A Fast Fourier Transform (FFT)-based detector is implemented using an adaptive threshold (exponential average) in each bin of the FFT. If the bin energy is over the adaptive threshold, the bin(s) is(are) set to a "one" and a detection report is generated. All detections are archived including the hard-limited (0/1) FFT output. Detections are classified first by type (whistle or click). Clicks are further categorized, based on the hard-limited FFT frequency content, into five descriptive categories: <1.5 kHz, 1.5–18 kHz (representative of sperm whales [*Physeter macrocephalus*]), 12–48 kHz (representative of delphinid species), 24–48 kHz (representative of beaked whales), and 45–48 kHz. Additional Support Vector Machine-based classifiers are also being tested with a focus on Blainville's and Cuvier's beaked whales (*Ziphius cavirostris*). The basic FFT-based detector adjusted for low-frequency baleen whale calls runs in parallel. It provides an analysis bandwidth of 3 kHz and a frequency bin resolution of 1.46 Hertz.

These broad automatic classifications are further refined using MMAMMAL real-time display software. MMAMMAL displays a color-coded map of the hydrophones indicating the level of detection activity for each hydrophone. The hydrophone color code indicates the number of standard deviations each hydrophone is above the mean detection rate of all the hydrophones. The PAM user can select hydrophones from the map based on detection activity and display a real-time, hard-limited FFT-based spectrogram. These spectrograms are used by trained PAM personnel to classify the whistles and clicks to species level when possible. Prior to this test, detection archives from previous PMRF species verification tests were reviewed to create a compilation of exemplar spectrograms for visually verified species including: rough-toothed dolphin (*Steno bredanensis*), spinner dolphin (*Stenella longirostris*), bottlenose dolphin (*Tursiops truncatus*), false killer whale (*Pseudorca crassidens*), short-finned pilot whale, killer whale (*Orcinus orca*), and Blainville's beaked whale. This compilation provided a reference set for PAM personnel to identify vocalizing species during the test. Unique frequency characteristics based on the MMAMMAL spectrograms were visually identified and noted to aid in providing initial discrimination between species (**Table 3**). However, due to the small visual verification sample size for most species and high overlap in signal characteristics between many odontocete species, these characteristics are far from exhaustive for feature characterization. Additional factors such as typical travel speed, habitat depth range, and dispersion of groups based on field studies (e.g., Baird et al. 2013a), were used to help determine species priority for directing the small vessel to groups when multiple groups were present in the area.

Supplementary to MMAMMAL, Worldview software also displays the hydrophone layout, color-coded for detection rate, with the addition of satellite imagery and digital bathymetry as a background. The Worldview display includes the positions of vocalizing animals (hereafter termed a posit) derived from automated localization software and frequency segmentation-based whale type similar to MMAMMAL. However, additional information is provided with each position to help the PAM user determine the accuracy of the automated localization, including the number of neighboring localizations and number of "same" localizations, where "same" is defined as the same position localized by multiple detections. Typically, a higher quantity of "near-neighbor" localizations indicates a more accurate localization. Due to the localization methodology, a single-click position is more likely to be a false positive than a cluster of click positions, each indicating several neighbors. The array, referenced by center hydrophone, is also indicated. Overlapping posits from multiple arrays also provides assurance that the posit is accurate. Automated click localizations provide the PAM user a real-time range-wide map for odontocete distribution of click classification type (e.g., beaked whale, sperm whale, small odontocete). In the absence of automatically generated positions, a MMAMMAL tool for semi-manual calculation of positions using hand-selected whistles or clicks is available. When the same click or whistle is visually observed on three or more hydrophones, the user can mark the time-of-arrival on each. These times are then used in a localization algorithm to determine the animal's position. This tool was most often used on bottlenose dolphin (indicated *Tt*) whistles to give the at-sea team a posit (within approximately 100 m) of a vocalizing individual. Typically, when a group of animals is present, a cluster of posits based on multiple vocalizing animals will be plotted around the position of the group. With time, the movement of the group is evident by the track of any one individual within the group. The Worldview display also includes several standard geographic tools such as the ability to measure distance, add points to the map, and include ship navigation data when available.

The Raven signal-analysis package (Cornell Laboratory of Ornithology) is also available for real-time analysis. An M3R interface module has been added to the program that allows selection of individual or small numbers of hydrophones for examination. The software is used to analyze selected hydrophone signals when questions arise as to signal type and origin. This is particularly useful for verifying the presence of beaked whale vocalizations. It has also proven useful for collecting time and frequency images and broadband cuts of selected signals.

Data post-processing is expedited by using the detection archives, which allow rapid evaluation of detections over long periods of time. Additionally, raw hydrophone data are recorded using the recently installed M3R disk recorder, allowing for detailed analysis of marine mammal and environmental signals. The disk recorder is capable of recording precisely time-aligned audio data from all 199 hydrophones.

Specific software tools have been developed for the automated isolation of Blainville's beaked whale click trains; then a second tool marks the position of individual foraging dives. These tools are being modified for PMRF. As the mean group size and detection statistics for Blainville's beaked whales on PMRF are determined, estimation of their density and distribution will be possible (Moretti et al. 2010).

3.3 Passive Acoustic Monitoring

PAM began at 0630 every morning and continued until the research vessel left the range, either to return directly to port or to survey in areas south of the range if weather conditions on the range were not suitable for small-boat operations or if the range was closed. At all times the PAM objective was to keep the scientists aboard the rigid-hulled inflatable boat (RHIB) and the R/V *Searcher* informed of the species and distribution of vocalizing marine mammals that had been localized on the range, focusing in areas that were known to have suitable sea conditions for small-boat operations. A typical visual verification cycle initiates with a radio communication from the PAM operator to the vessel providing the species and locations (referenced by hydrophone for ease of communication) of all known groups vocalizing within a reasonable range of the RHIB. As an example, a communication would detail groups on the SWTR and BARSTUR ranges, but not the BSURE range if the RHIB was on the southern end of the SWTR area (see **Figure 1**). The decision of what group to pursue was left to the on-board scientists so that they could prioritize the combination of species preference, weather conditions, and time of day.

Once the group of interest was radioed back to the PAM team, this group was then followed closely using the M3R system by the PAM team, and an attempt was made to provide an updated position. Most often the posits were generated automatically by M3R. PAM operators assessed the posit and relayed the coordinates via radio. Sometimes localization involved manually waiting for and selecting whistles to localize. This process was termed a "manual posit." A best effort was made to also communicate the confidence level of the posit (i.e., the number of solutions at the same location or in the nearby area). Human error can occur when calculating manual whistle localizations, but this is typically minimal with trained PAM personnel. In addition, successive whistles were used to generate multiple solutions, which provide an increased level of confidence. As the vessel approaches the group, additional position updates were communicated by the PAM team in real time until receiving confirmation that the on-the-water team had sighted the group. At that time, the PAM team remained on standby until they received additional communication to prevent disruption of tagging and photo-identification activities onboard the RHIB. While standing by, the PAM team continued to assess the entire range in the context of providing information for the next cycle.

Detection archives were collected from all hydrophones for the entire period, 24 hr per day. These archives capture all detection reports, and automated localizations generated during the test.

4. Field Methods

4.1 Tag Types and Programming

Nineteen satellite tags were available for deployment, including nine location-dive tags (Wildlife Computers Mk10-A) and 10 location-only tags (Wildlife Computers SPOT5) in the LIMPET configuration. Each tag is attached with two titanium darts with backward facing petals, using either short (4.4-centimeter) or long (6.8-centimeter) darts (Andrews et al. 2008), depending on species (e.g., short darts for rough-toothed dolphins, long darts for false killer whales).

For each tag type (location-only or location-dive) there were different programming combinations depending on species. The combinations are based on the average number of respirations per hour from previous tagging studies, while taking into account the speed of surfacing and the likelihood of the tag remaining attached for longer than approximately 30 days, which varies by species. Location-dive tags programmed for short-finned pilot whales transmitted 17 hr/day with a maximum of 700 transmissions a day, giving an estimated battery life of approximately 25 days. Location-dive tags programmed for rough-toothed dolphins transmitted for 17 hr/day with a maximum of 800 transmissions per day, giving an estimated battery life of approximately 22 days. Location-dive tags were set to record a time series (recording depth once every 1.25 minutes for rough-toothed dolphins and once every 2.5 minutes for short-finned pilot whales), as well as dive statistics (start and end time, maximum depth, duration) for any dives greater than 30 m in depth, with depth readings of 3 m being used to determine the start and end of dives, thus dive durations are slightly negatively biased. Given typical odontocete descent and ascent rates of 1–2 m/second, dive durations recorded are likely only 3–6 seconds shorter than actual dive durations. Prior to the field effort, satellite pass predictions were carried out using the Argos web site to determine the best hours of the day for transmissions given satellite overpasses for the approximately 2-month period starting at the beginning of the deployment period.

A land-based Argos receiver station was set up on Mākaha Ridge, Kauaʻi (**Figure 1**), to try to increase the amount of dive and surfacing data obtained from the location-dive tags. This is a similar system to that used in July 2013 (see Baird et al. 2014); however, the system during this effort included three Telonics TGA-100 7-element antennas, each connected to a Telonics TSUR-400 uplink receiver, rather than a single antenna/receiver system. Each system was connected to a laptop with data recorded using Telonics Uplink Logger v. 1.00. The antennas were at a 456-m elevation, one oriented to the north, one oriented to the west, and one oriented to the southwest.

4.2 Vessel, Time and Area of Operations

The vessel used was a 24-foot rigid-hulled Zodiac Hurricane, powered by twin Suzuki 140-horsepower outboard engines, and with a custom-built bow pulpit for tagging and biopsy operations. The vessel was launched each morning at sunrise, and operations continued in daylight hours as long as weather conditions were suitable. The launch site was the Kīkīaola small boat harbor, but alternative sites, including Port Allen and Nāwiliwili Harbor, were available if the prevailing weather conditions warranted. For calculating effort by depth and time within the PMRF instrumented hydrophone range boundaries, vessel locations were recorded on the global positioning system unit at 5-minute intervals. When weather conditions permitted, the primary area of operations was the PMRF hydrophone range, with a focus on deep-water areas to increase the likelihood of encountering high-priority species. When positions from the M3R system were available, the RHIB operator would transit to specific locations in response to the positions and otherwise would survey areas for visual detection of groups. When conditions on PMRF were sub-optimal and there were better conditions elsewhere, or if the range was closed due to Navy activity, the RHIB team worked in areas off the range. The RHIB team communicated each morning with the PMRF Range Control prior to entering the range and remained in regular contact with Range Control throughout the day as needed to determine range access limitations. Field operations were coordinated with the R/V *Searcher*, and for encounters where both the RHIB and R/V *Searcher* were present, photos from the R/V *Searcher* were combined with those obtained from the RHIB for the purposes of photo-identification.

4.3 During Encounters

Each group of odontocetes encountered was approached for positive species identification. Decisions on how long to stay with each group and what type of sampling (e.g., photographic, tagging, biopsy) were undertaken depending on a variety of factors, including current weather conditions and weather outlook, information on other potentially higher-priority species in the area (typically provided by M3R), and the relative encounter rates. Species encountered infrequently (short-finned pilot whales, Blainville's beaked whales) were given higher priority than frequently encountered species (spinner, bottlenose, and rough-toothed dolphins). Extended work with frequently encountered species was typically only undertaken with groups that were suitable for tagging given behavior and sea conditions, and when no other higher-priority species were in areas suitable for working.

In general, species were photographed for species confirmation and individual identification. For Blainville's beaked whales, head photos were also taken to determine sex (i.e., based on jaw morphology and the presence/absence of erupted teeth), and body photos were taken to determine age class, based on the number and extent of scarring from cookie-cutter shark bites and intra-specific interactions. For each encounter we recorded information on start and end time and location of encounter, group size (minimum, best, and maximum estimates), sighting cue (e.g., acoustic detection from M3R, splash, radio call from R/V *Searcher*), start and end behavior and direction of travel, the group envelope (i.e., the spatial spread of the group in two dimensions), the estimated percentage of the group observed closely enough to determine the number of calves and neonates in the group, the number of individuals bowriding, and information necessary for permit requirements.

If conditions were suitable for tagging, for all infrequently encountered species, we attempted to deploy at least one satellite tag per group. For frequently encountered species, we attempted to deploy one tag per group, unless the group was unusually large (e.g., >50 individuals) and thus likely comprised more than one social group. When more than one tag deployment was attempted within a single group, the second individual to be tagged was not closely associated with the first.

After tagging, or if individuals appeared un-approachable for tagging, we sometimes attempted to collect biopsy samples, either to confirm sex of tagged animals or, for species that are known or thought to exhibit population structure within Hawaiian waters (i.e., short-finned pilot whales, bottlenose dolphins, rough-toothed dolphins, Blainville's beaked whales), to help interpret results of tagging and photo-identification. Biopsy samples were sent to the Southwest Fisheries Science Center for genetic analyses.

4.4 Data Analyses

Photographs of most species were compared to individual identification catalogs (Baird et al. 2009; Mahaffy 2012; McSweeney et al. 2007) to determine sighting histories. Five-minute effort locations were processed with ArcGIS to determine depth and whether locations were inside or outside the PMRF instrumented hydrophone range boundaries. Locations of tagged individuals were estimated by the Argos System using the least-squares methods and were assessed for plausibility using the Douglas Argos-filter v. 8.5 to remove unrealistic locations, following protocols previously used (Schorr et al. 2009; Baird et al. 2010, 2011). Resulting filtered location data were processed with ArcGIS to determine depth, distance from shore, and location relative to PMRF boundaries. From this, the proportion of time spent within PMRF boundaries, as well as the number of times an individual was found inside the range boundaries, were estimated for each individual. For estimating the proportion of time within the range boundaries, when consecutive locations spanned the boundary, the time spent inside the boundary was considered to start at the last location outside the boundary and end at the time of the last location inside the boundary. The number of times an individual was found inside the range boundaries was determined by examining consecutive locations for whether they were inside or outside of the range boundary.

Probability density maps were generated using all filtered satellite tag data for all individuals of each of three species satellite tagged off Kauaʻi. No effort was made to address potential bias associated with the location where individuals were tagged, thus probability density maps should be considered preliminary. Kernel density polygons were generated using the R package adehabitatHR v. 0.4.11[1] and corresponded to the 50 percent, 95 percent and 99 percent densities. Polygons were plotted in Google Earth Pro v. 7.1.2.2041.

When more than one tag was deployed on the same species, we assessed whether individuals were acting in concert during the period of overlap by measuring the straight-line distance (i.e.,

[1] https://www.movebank.org/node/14620

not taking into account potentially intervening land masses) between pairs of individuals when locations were obtained during a single satellite overpass (approximately 10 minutes). We used both the average distances between pairs of individuals and the maximum distance between pairs to assess whether individuals were acting independently, following protocols described by Schorr et al. (2009) and Baird et al. (2010).

Data obtained from the land-based Argos uplink receivers and from the Argos System were processed through the Wildlife Computers DAP Processor v. 3.0 to obtain diving and surfacing data from the location-dive tags.

5. Results

From 1 to 10 February 2014 there were 1287.5 kilometers (km) (66.3 hr) of small-vessel field effort, with the boat on the water all 10 days (**Table 4**); although on one day (5 February 2014) effort was discontinued early due to heavy rain and lightning in the area. Over the 66.3 hr of survey effort, 44.9 percent of the time (29.8 hr) was spent within the PMRF instrumented hydrophone range boundaries (**Figure 2**), and 75.2 percent of effort (49.8 hr) was in depths less than 1,000 m (**Figure 3**). Acoustic monitoring with the M3R system was undertaken prior to the RHIB entering the PMRF range each day and concluded after the RHIB left the range, for a total of 81.7 hr of acoustic monitoring (**Table 5**).

Overall there were 26 sightings of at least five species of odontocetes, 15 of which were on PMRF (**Figure 2**, **Table 6**). Bottlenose dolphins were encountered on eight occasions, spinner dolphins on seven, rough-toothed dolphins on two, short-finned pilot whales on five, and Blainville’s beaked whales once. Six of the 15 encounters on PMRF were directed by acoustic detections from the M3R system, and two of the encounters were directed by the R/V *Searcher*.

Recordings on the M3R system to improve species classification for future acoustic monitoring efforts were made for four species of the odontocetes encountered (all but spinner dolphins). During the encounters 10,928 photos were taken for individual identification, six biopsy samples were obtained for genetic studies (sent to the Southwest Fisheries Science Center), and 12 satellite tags were deployed on four species (**Table 7**). Identification photos were obtained from two encounters with spinner dolphins for contribution to a photo-identification catalog held at the Pacific Islands Fisheries Science Center, but no attempts were made to tag this species due to the small size of their dorsal fins.

5.1 Short-finned pilot whales

Short-finned pilot whales were encountered on five occasions, with four of the five sightings on PMRF (**Figure 2**). During the five encounters 51 identifications were obtained with good or excellent quality photos, and 35 of those identifications were of distinctive individuals, with from four to 10 identifications obtained from each of the five encounters. The 35 identifications represented 29 individuals, six of which (from two different encounters) were seen twice during the field effort. All individuals were compared to our photo-identification catalog of this species (Mahaffy 2012). Twenty-seven of the 29 distinctive individuals had been photo-identified in previous years, and based on analyses of associations represented three different social clusters (**Table 8**). A social network analysis indicates that all three social clusters are linked by association with the main component of the social network of short-finned pilot whales photo-identified off Kauaʻi and Niʻihau (**Figure 4**). Satellite tags were deployed on six individuals, with deployments on individuals from each of the three social clusters. Tagged individuals from two of the three social clusters had been previously photo-identified off Kauaʻi and/or Oʻahu (social clusters W25 and W18), while all but one member of the third social cluster (H1, containing HIGm0929, tag number GmTag078) had only been previously documented off Hawaiʻi Island. An analysis of distance between locations of tagged individuals from the three social clusters obtained during the same satellite overpasses (not shown) revealed that the three clusters were acting independently. The mean distance between clusters W25 and W18 was 40.4 km (maximum of 116.0 km), while the mean distances between clusters H1 and W25 and W18 were 99 km (maximum of 263 km) and 121 km (maximum of 252 km), respectively. By contrast, the mean distance between individuals within cluster W18 ranged from 2.2 km (GmTag081 and GmTag083) to 3.4 km (GmTag082 and GmTag083), indicating that individuals within the cluster were acting in concert. Insufficient locations were available from GmTag79 to assess whether the two tagged individuals in cluster W25 were acting in concert.

Data were obtained from the tagged individuals for periods from 12.8 to 89.1 days (**Table 7**). During this period, social clusters W25 and W18 remained generally associated with the island slopes, with median depths at tagged animal locations ranging from 1,635 to 2,296 m, and median distances from shore of 13.0 to 19.3 km (**Table 9**). While data were only obtained for 12.8 days from the individual in the social cluster previously documented off Hawaiʻi Island, H1, this individual ranged more widely than the other groups, using deeper water (median depth of locations = 3,351 m) farther from shore (median distance from shore = 39.9 km; **Table 9**, **Figure 5**). A probability density map using tag data from all 13 short-finned pilot whale tag deployments off Kauaʻi indicate that the core area (50 percent density polygon) includes the channel between Kauaʻi and Niʻihau and overlaps with the southern half of PMRF (**Figure 6**).

Dive data were obtained from all four of the pilot whales tagged with depth-transmitting satellite tags, with from 20.1 to 535.1 hr of data obtained, with all four individuals exhibiting long and deep dives, with maximum dive depths ranging from 927 to 1,231 m, and maximum dive durations ranging from 16.8 to 24.6 minutes (**Table 10**).

5.2 Rough-toothed dolphins

Rough-toothed dolphins were encountered on two occasions, with both sightings outside of PMRF boundaries (**Figure 2**). One individual in each encounter was tagged, one with a location-dive satellite tag and one with a location-only satellite tag (**Table 7**). Identification photos were obtained of eight individuals (four in each encounter) and compared to our photo-identification catalog of this species (Baird et al. 2008b); seven of the eight individuals had been previously photo-identified off Kauaʻi, including both of the tagged individuals (**Table 8**). A social network analysis indicates that these individuals are linked by association with the main social cluster of rough-toothed dolphins off Kauaʻi and Niʻihau (**Figure 7**).

Location data were obtained for 12.5 (SbTag011) and 7.3 days (SbTag012), and dive data were obtained for 9.3 days from the tag deployed on SbTag011. From the shore-based receiving station, 1.4 days of dive data were obtained from SbTag011. All but 1.5 hr of the receiver data overlapped with data obtained from Argos, thus 9.36 days of data were obtained from the combined sources.

An analysis of distance between locations of the two individuals obtained during the same satellite overpasses (not shown) revealed that those distances varied widely, with a mean distance between them of 12.1 km (maximum of 42.3 km). While there were six occasions when the two individuals were within 1 km of each other, overall the movement data from the two individuals suggested they were acting independently. During the period of tag attachment the two individuals moved through the channel between Kauaʻi and Niʻihau, were associated with the west slope of the island of Niʻihau, and moved to the north of Kauaʻi into the channel to the east of Kauaʻi (**Figure 8**). One individual, SbTag011, moved to the east as far as Oʻahu (**Figure 8**). There were five different periods for SbTag011 and four periods for SbTag012 where the individuals were inside the PMRF boundary, respectively, with 13.4 percent and 17.4 percent of their time spent inside the range boundary (**Table 7**).

A probability density map using tag data from all 12 rough-toothed dolphins satellite tagged off Kauaʻi indicated that the channel between Kauaʻi and Niʻihau represents the core area for these individuals (**Figure 9**), with a large proportion of the core area overlapping with PMRF.

Dive data indicated that HISb1541 exhibited relatively shallow dives (median and maximum depths of 91.5 and 311.5 m, respectively; **Table 10**). Given that the median depths of locations for HISb1541 was 1,463 m (**Table 9**), all dives were likely to mid-water.

5.3 Bottlenose dolphins

Bottlenose dolphins were sighted on eight occasions (**Figure 2**) and good quality photographs of distinctive individuals were obtained from all eight encounters. Forty-two identifications (i.e., not excluding re-sightings) of distinctive individuals with good or excellent quality photos were obtained and compared to the long-term photo-identification catalog (Baird et al. 2009). From these 42 identifications, 25 individuals were identified. Of the 25 individuals, 20 had been previously documented, all off Kauaʻi and/or Niʻihau. Of those 20 that had been previously documented, eight had been seen in one previous year, eight had been seen in two previous years, two had been seen in three previous years, and one each had been seen in four and five previous years. Individuals from all encounters were linked by association in a single social network (**Figure 10**), indicating they were all from the island-associated population.

Two individuals were satellite tagged with location-only tags, on two different days. An assessment of distance between locations of the two individuals during the same satellite overpasses (not shown) indicated that those distances varied widely, with a mean distance between them of 11.5 km (maximum of 35.8 km). There was only one occasion when the two individuals were within 1 km of each other, thus they appeared to be travelling independently. Both individuals remained largely associated with the shallow waters around Kauaʻi (**Figure 11**), with median depths at tag locations of 56 m and 88 m for the two individuals (**Table 9**). A probability density map of tag data from all eight bottlenose dolphins tagged off Kauaʻi indicates that most of the 50 percent core area overlaps with the PMRF range (**Figure 12**).

5.4 Blainville's beaked whales

One group of five Blainville's beaked whales was encountered south of PMRF (**Figure 2**). An analysis of scarring patterns and morphology (e.g., presence of erupted teeth, highly arched jaw) revealed that the group contained one adult male (i.e., an individual with erupted teeth), one large sub-adult male (i.e., an individual with a highly arched lower jaw but no erupted teeth), two putative adult females (i.e., with lower jaws not highly arched but with considerable scarring from cookie-cutter shark bites indicating older individuals), and one juvenile (i.e., lightly-scarred with cookie-cutter shark bites). All five individuals were photo-identified and compared to our catalog[2] of this species (McSweeney et al. 2007), but no matches were found. Two satellite tags were deployed, one depth-transmitting tag on the large sub-adult male (MdTag016) and one location-only tag on the adult male (MdTag017), although no data were obtained from the depth-transmitting tag. Location data were obtained from MdTag017 for eight days. Over this period MdTag017 traveled north onto PMRF and spent a total of 20.5 percent of the eight-day period on PMRF (**Table 9**). The whale then traveled south of Ni‘ihau and spent the remaining portion of the transmission period around Ka‘ula Island (**Figure 13**).

6. Discussion and Conclusion

Over the 10-day field effort there was only one day lost in terms of access restrictions on PMRF (**Table 5**); however, weather conditions frequently limited our ability to utilize the M3R system to increase encounter rates and for visual verifications of acoustic detections (**Table 4**). Given the low densities of most species of odontocetes around the main Hawaiian Islands (Baird et al. 2013a), the amount of field effort, particularly in deep waters (**Figures 2 and 3**), was not enough to have a high likelihood of encountering many of the high priority deep-water species, such as Cuvier's beaked whales, sperm whales, or melon-headed whales. That said, for four different species of odontocetes, one of which has only been rarely encountered in previous field efforts, considerable progress was made towards addressing our primary monitoring question: what are the spatial movement patterns and habitat use (e.g., island-associated or open-ocean, restricted ranges vs. large ranges) of species that are exposed to MFA sonar, and how do these patterns influence exposure and potential responses?

Although location data were only obtained from one tagged Blainville's beaked whale over a relatively short period (eight days), this track (**Figure 13**) is the first detailed movement data available for this species around Kaua‘i and Ni‘ihau. While tagged off PMRF, the individual moved on and off the range three times before transiting southwest to the area off Ka‘ula Island. In addition, this encounter provided photos of sufficient quality to assess age/sex classes of the individuals in the group; such assessments will be of value in examining the age class distribution of individuals in the population, as has been done for this species off the Atlantic Undersea Test and Evaluation Center (AUTEC) range in the Bahamas (Claridge 2013).

[2] As of the time of writing the catalog includes 138 distinctive individuals, not including the five photo-identified in this encounter, including 14 previously documented off Kaua‘i when considering photos of fair, good and excellent quality (see McSweeney et al. 2007).

Tag and photo-identification data were also obtained from two groups of bottlenose dolphins, two groups of rough-toothed dolphins, and three groups of short-finned pilot whales. Increased sample sizes of tag deployments for all three of these species have allowed for preliminary density analyses of location data using kernel density methods. In all three species, the core areas (represented by the 50 percent kernel polygons) overlap with PMRF to varying degrees (**Figures 6, 9, 12**), reflecting the importance of the channel between Kauaʻi and Niʻihau to these species, and also having implications for exposure to MFA sonar. It should be noted that these analyses are preliminary, and do not try to minimize any potential bias associated with tagging locations. As sample sizes increase, future density analyses will address such potential biases. Preliminary acoustic propagation analyses of sonar use on PMRF during Submarine Commanders Courses suggest that MFA sonar on PMRF is generally audible to cetaceans throughout PMRF (S.W. Martin, SPAWAR Systems Center Pacific, personal communication). These high-density areas overlapping with PMRF indicate that individuals from all three populations likely have repeated exposures to audible levels of MFA sonar at PMRF. While tag deployments to date on bottlenose and rough-toothed dolphins appear to be from the known resident populations (see also Baird et al. 2008b, 2009; Martien et al. 2011), the deployments on different social groups of pilot whales, with varying re-sighting histories among the islands (**Table 8**) also illustrate that the amount of exposure to MFA sonar will likely vary by social cluster. Although the pilot whale social cluster H1 does link by association to the main component of the social network off Kauaʻi and Niʻihau, the wider-ranging movements of this group, combined with their use of deeper water farther offshore, illustrate that within a population the frequency and extent of exposure to MFA sonar likely varies by social group. Reactions to MFA sonar are likely to be influenced by prior exposure history, thus understanding potential consequences of exposure, both to the social group and the population as a whole, will benefit from an increased understanding of the social organization of the population. As sample sizes of photo-identifications also increase, the ability to estimate abundance of the respective populations with greater precision also improves, as does the potential for using these data sets to examine trends in abundance for these populations.

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9. Figures

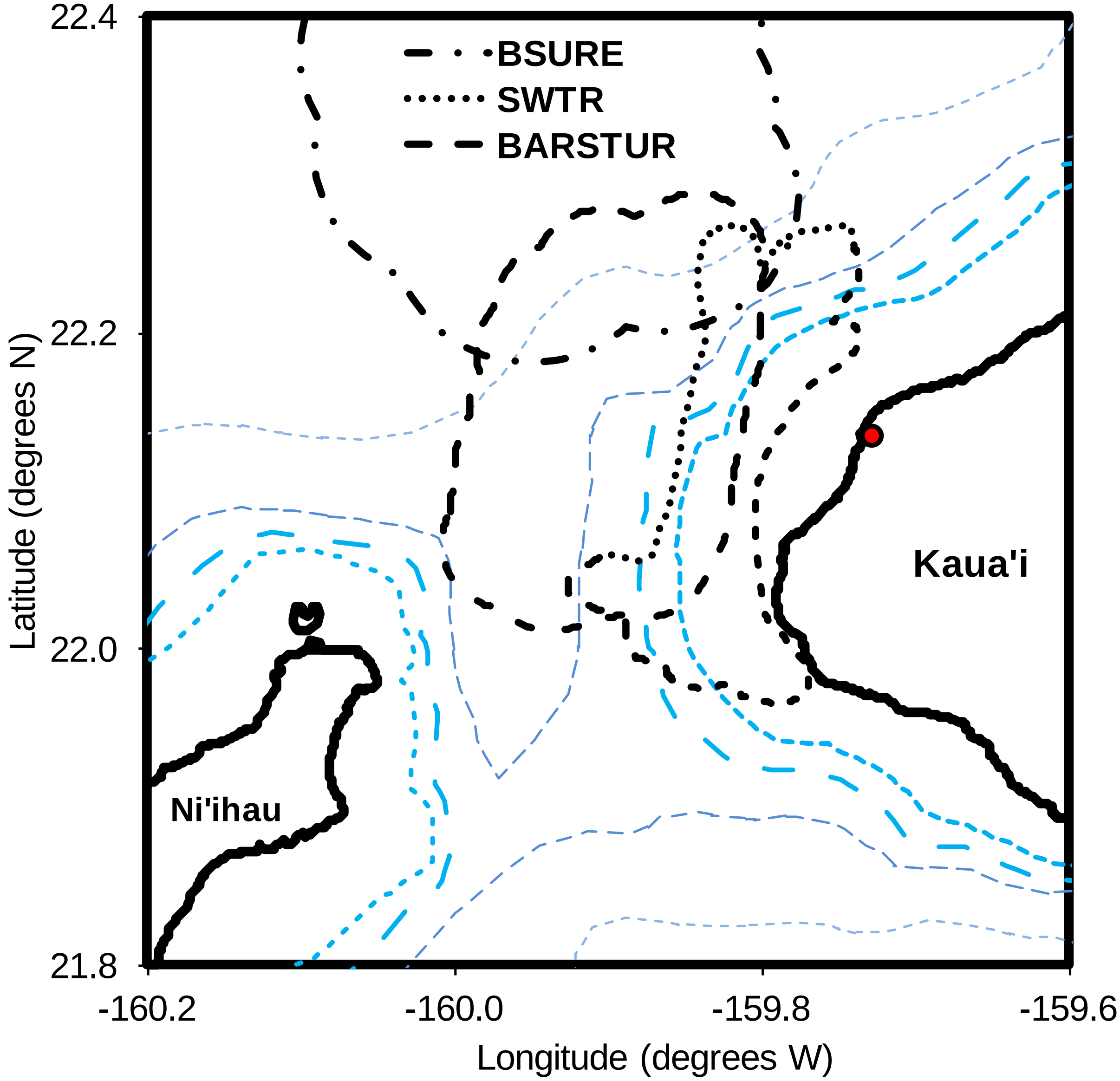


Figure 1. Map showing boundaries of instrumented hydrophone ranges. The land-based receiver station on Mākaha Ridge is indicated by a red circle. The 100-m, 500-m, 1,000-m and 2,000-m depth contours are shown.

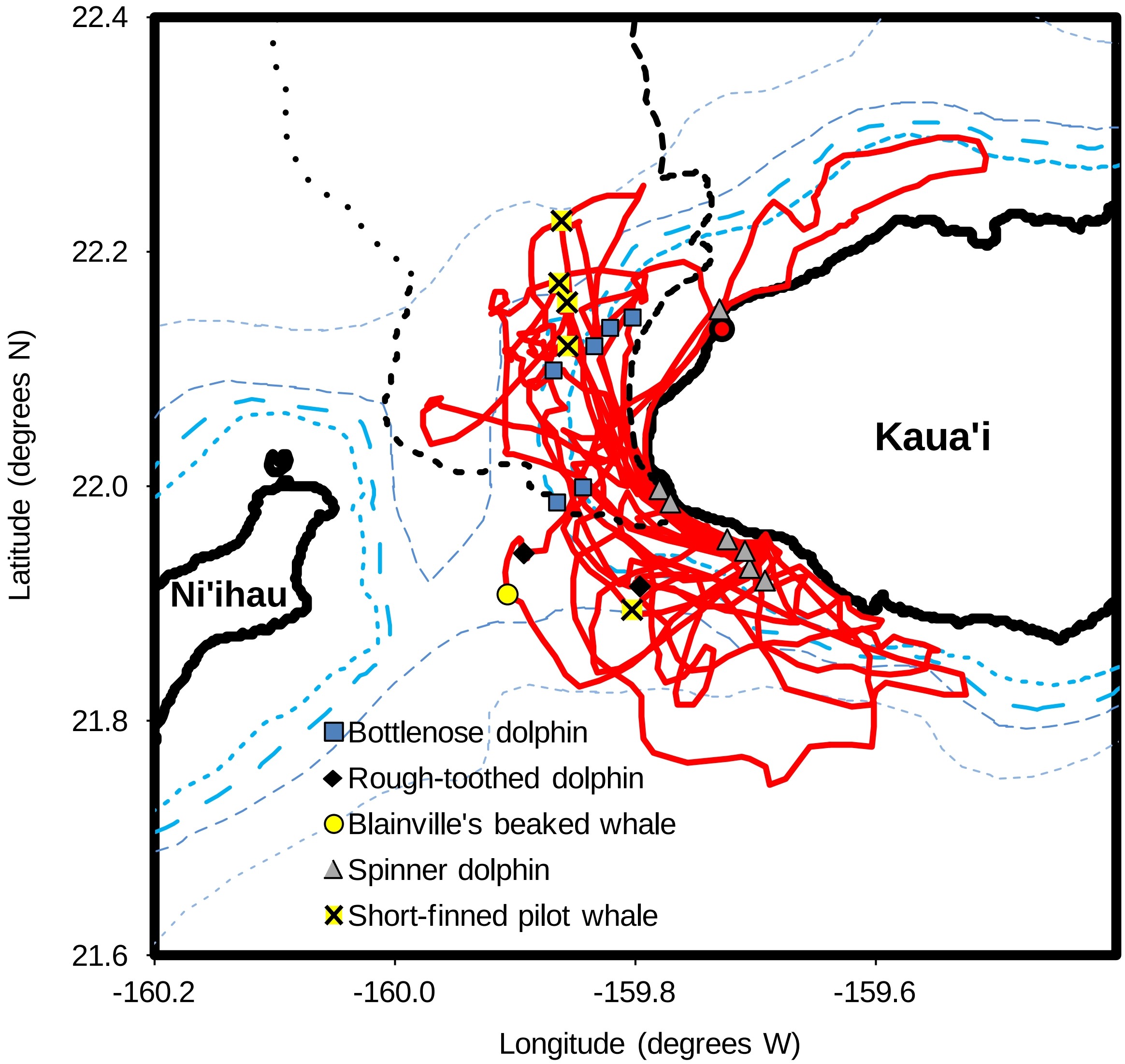


Figure 2. Tracklines of small-vessel field effort in February 2014 with sightings indicated and overall PMRF range boundary shown. The land-based receiver station on Mākaha Ridge is indicated by a red circle. The 100-m, 500-m, 1,000-m and 2,000-m depth contours are shown.

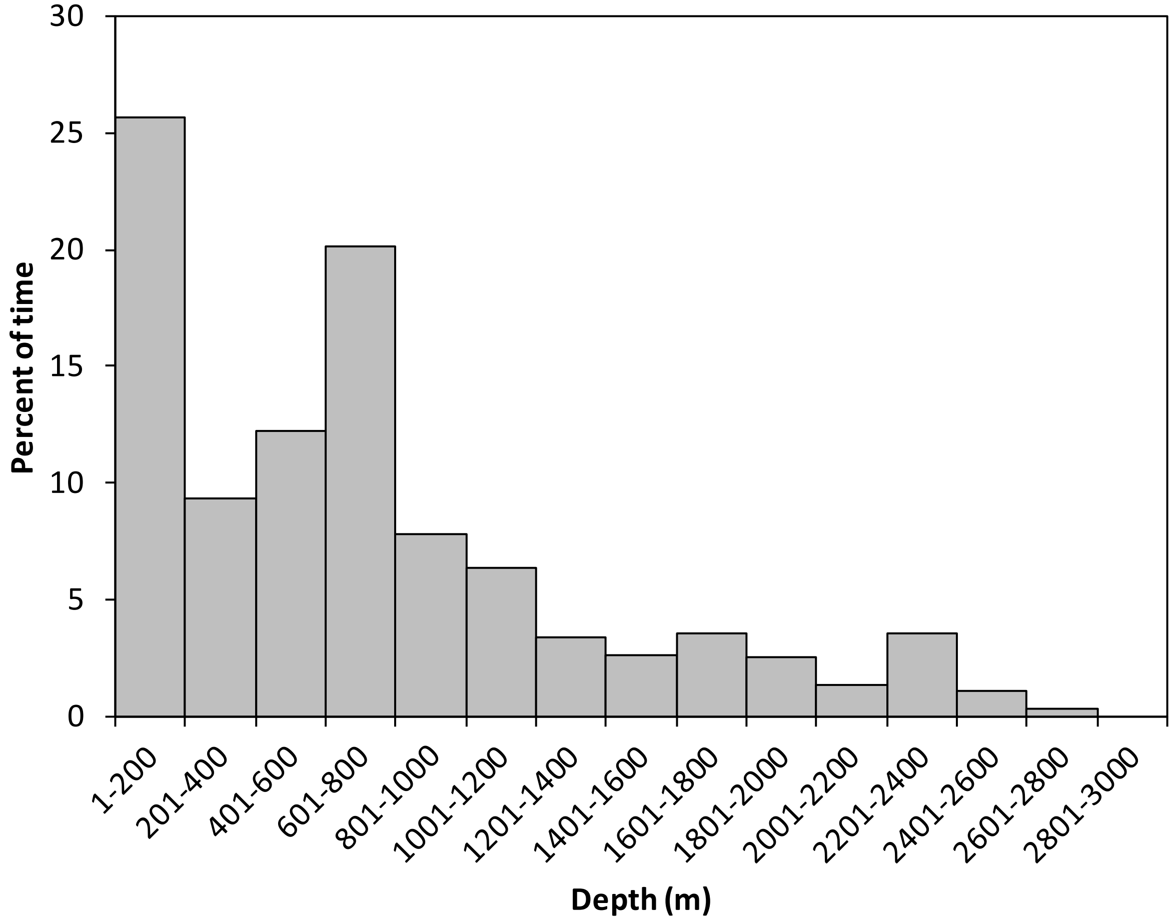


Figure 3. Depth distribution of small-vessel effort during February 2014 field effort.

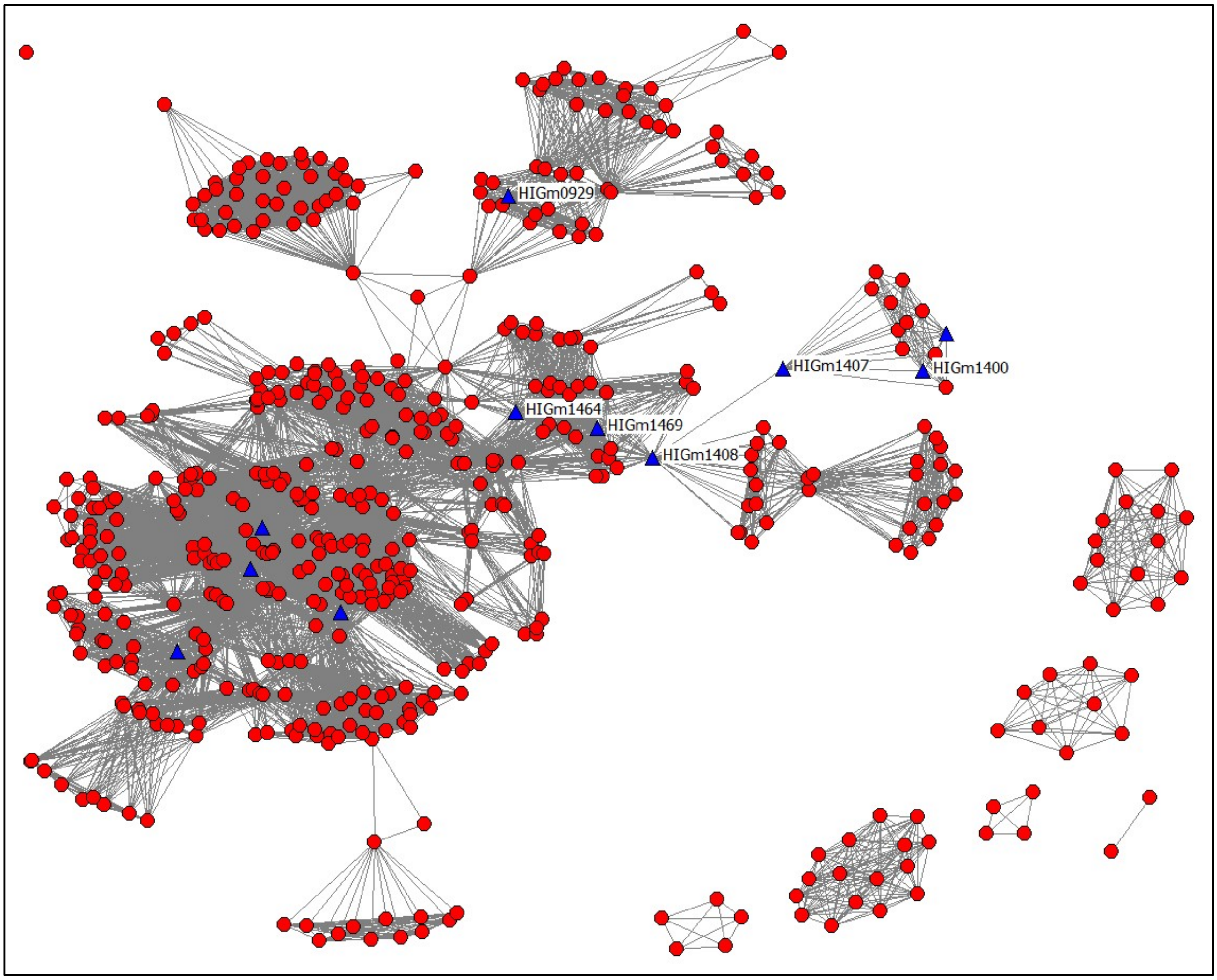
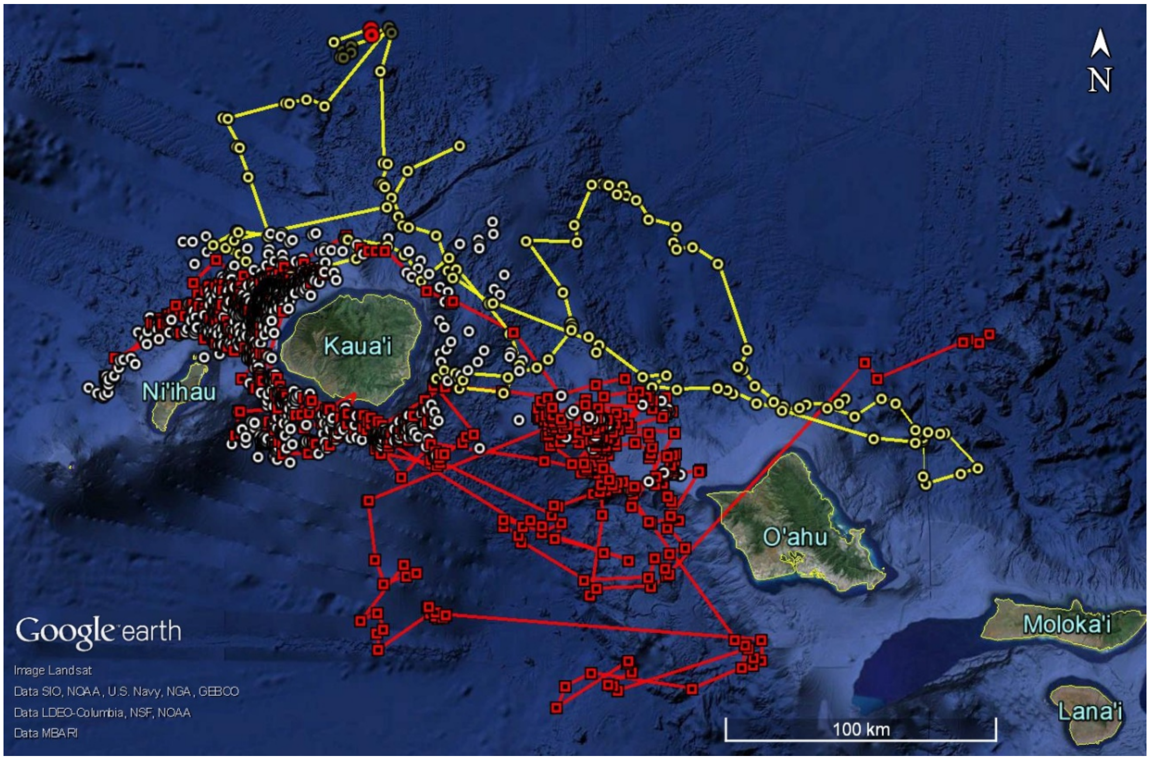


Figure 4. Social network of photo-identified short-finned pilot whales off Kaua'i and Ni'ihau, with all tagged individuals (including those tagged in previous efforts) noted by symbol type (blue triangles). Those individuals tagged in February 2014 are indicated with ID labels. This includes all individuals categorized as slightly distinctive, distinctive, or very distinctive, with fair, good, or excellent quality photographs (see Mahaffy 2012), with a total of 541 individuals shown (the main cluster contains 490 individuals).



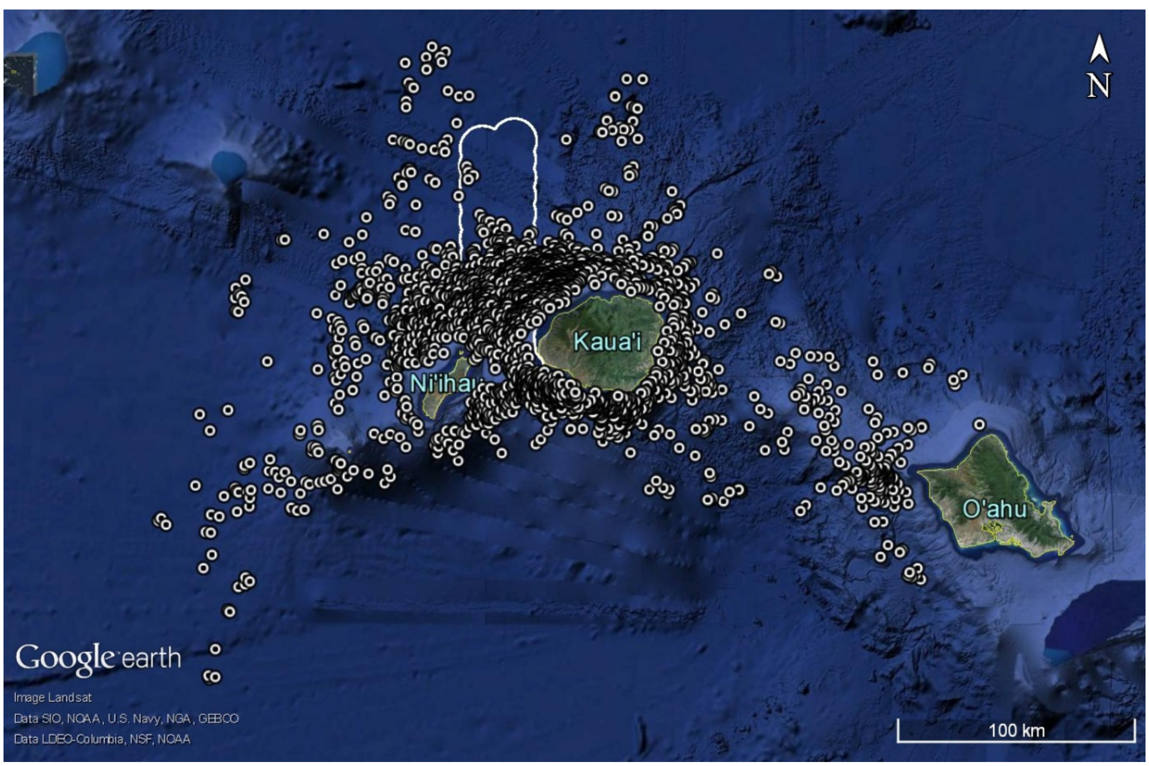


Figure 5. Top. Locations from short-finned pilot whales tagged in February 2014. Lines connecting consecutive locations of GmTag078 (yellow), a 12.8 day track, and GmTag083 (red), an 89 day track, are shown. Bottom. Locations from all seven previous short-finned pilot whales tag deployments off Kaua'i. The PMRF boundary is shown in white.

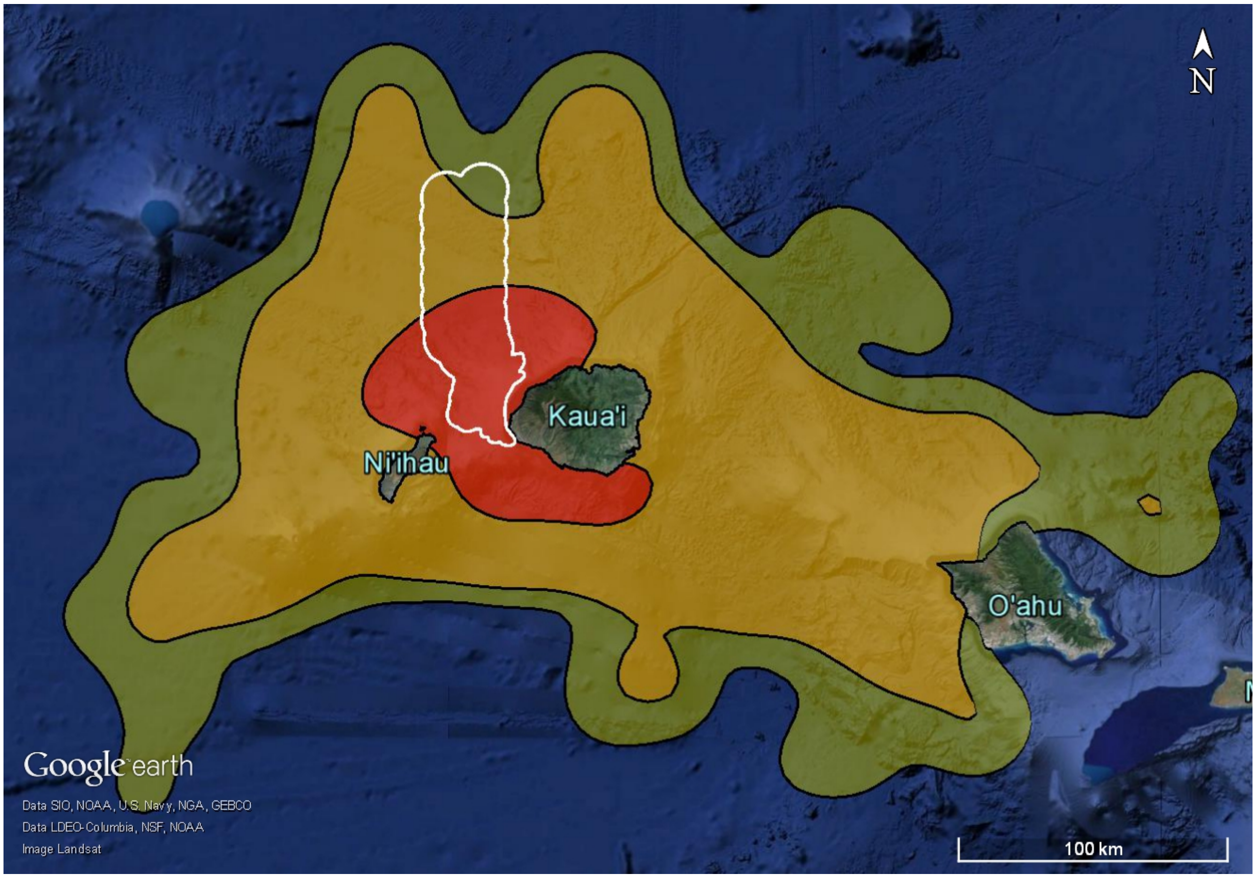


Figure 6. A probability density representation of short-finned pilot whale location data from all 13 satellite tag deployments off Kaua'i. The red area indicates the 50% density polygon, the yellow represents the 95% polygon, and the green represents the 99% polygon. The PMRF boundary is shown in solid white line.

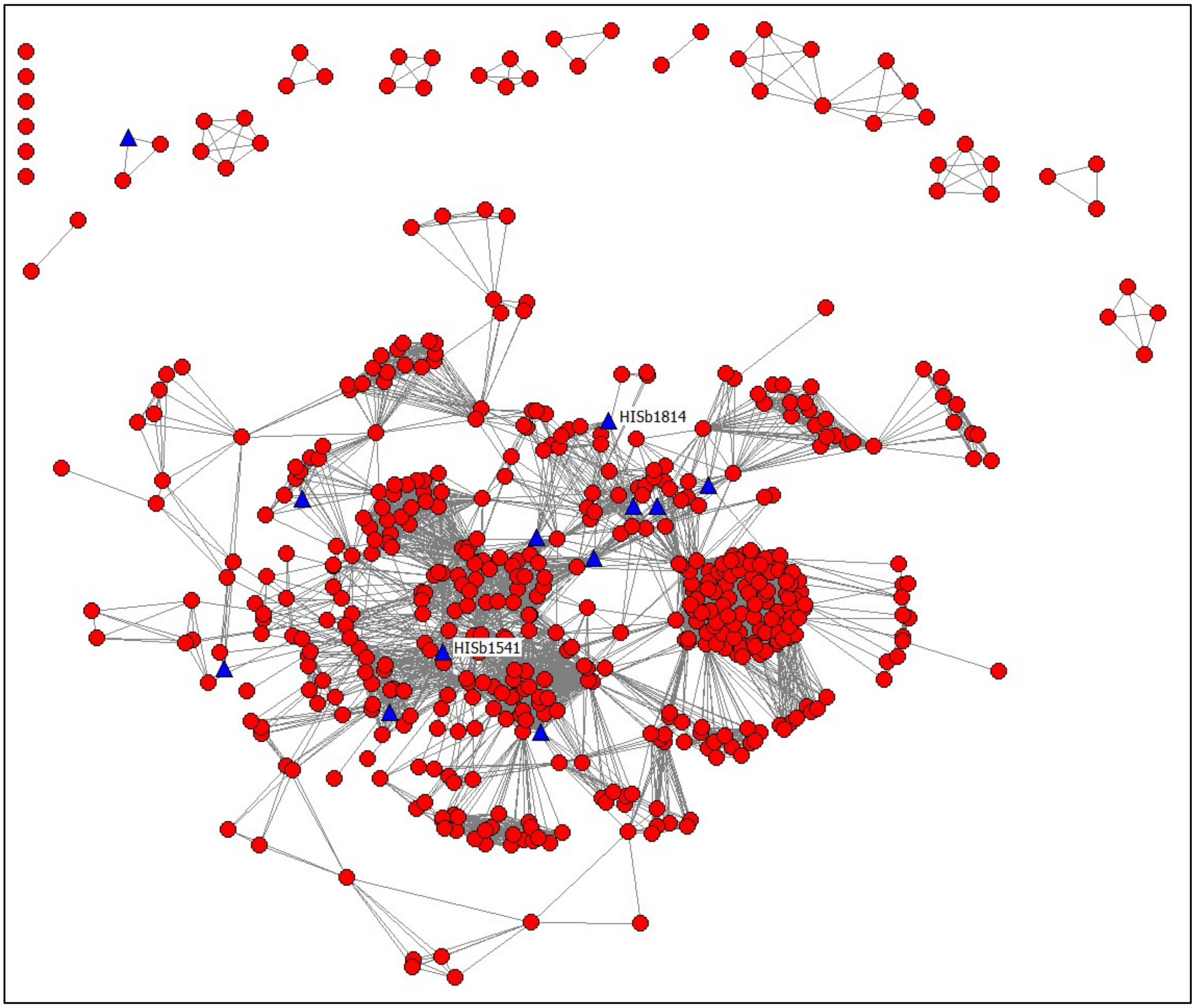


Figure 7. Social network of rough-toothed dolphins photo-identified off Kaua'i and Ni'ihau from 2003 to 2014, with tagged individuals noted by symbol type (blue triangles). Those individuals tagged in February 2014 are indicated with ID labels. This includes all individuals categorized as slightly distinctive, distinctive, or very distinctive, with fair, good, or excellent quality photographs (see Baird et al. 2008b), with a total of 548 individuals shown (the main cluster contains 495 individuals).

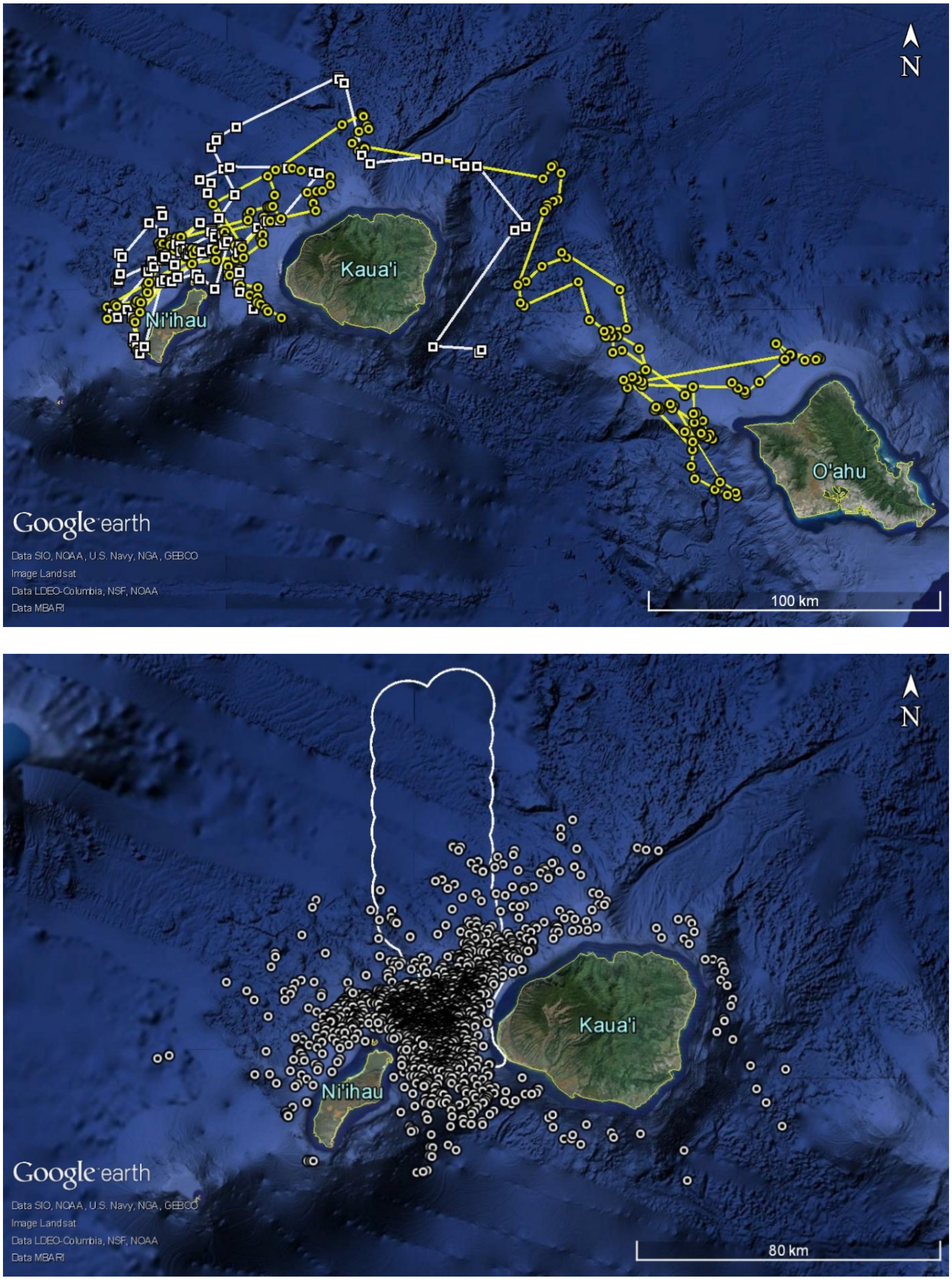


Figure 8. Top. Locations of rough-toothed dolphins satellite tagged in February 2014 (yellow circles SbTag011; white circles SbTag012), with lines connecting consecutive locations. Bottom. Locations of 10 satellite-tagged rough-toothed dolphins, including individuals tagged in July/August 2011 (three individuals), January 2012 (one individual), June/July 2012 (three individuals), February 2013 (one individual), and July 2013 (two individuals). The PMRF boundary is shown in a solid white line.

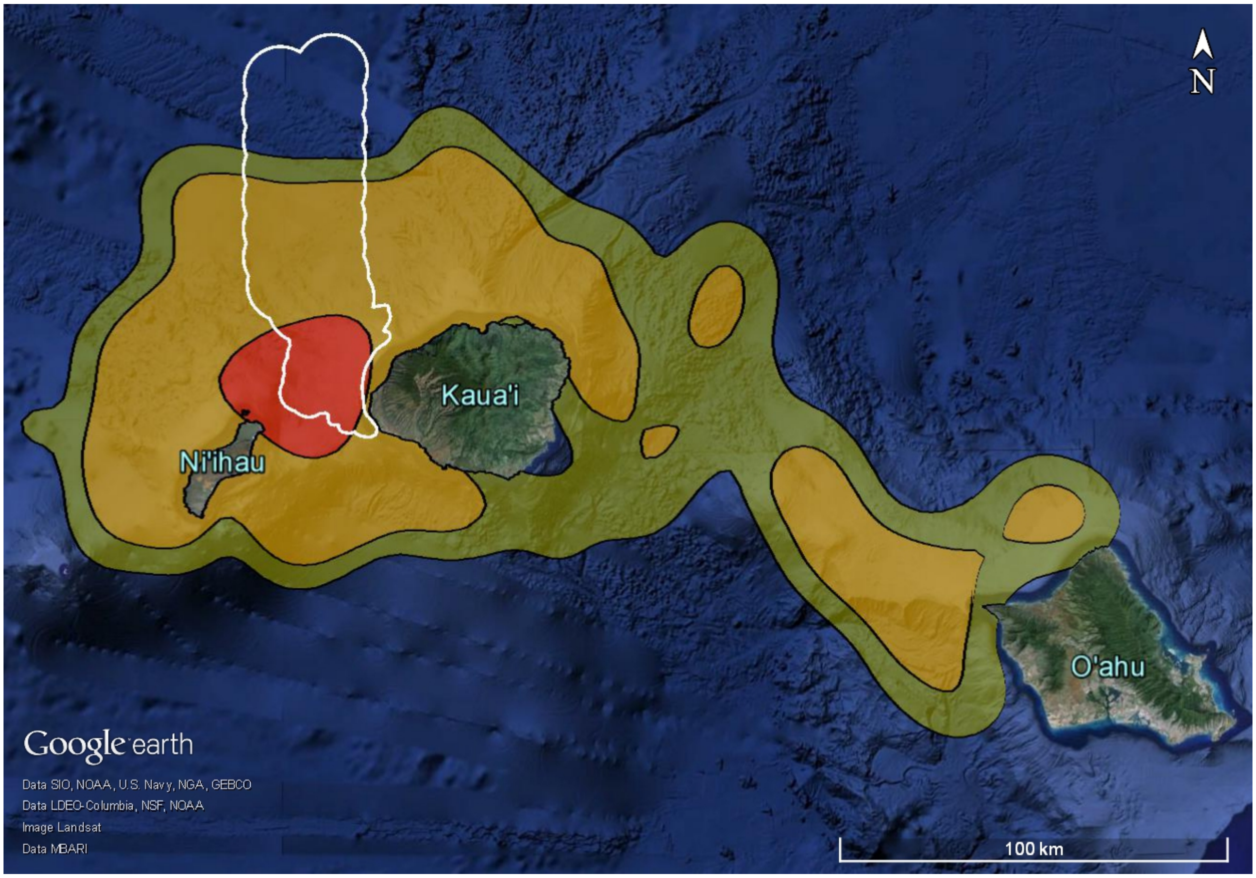


Figure 9. A probability density representation of rough-toothed dolphin location data from all 12 satellite tag deployments off Kaua'i. The red area indicates the 50 percent density polygon (the "core area"), the yellow represents the 95 percent polygon, and the green represents the 99 percent polygon. The PMRF boundary is shown in a solid white line.

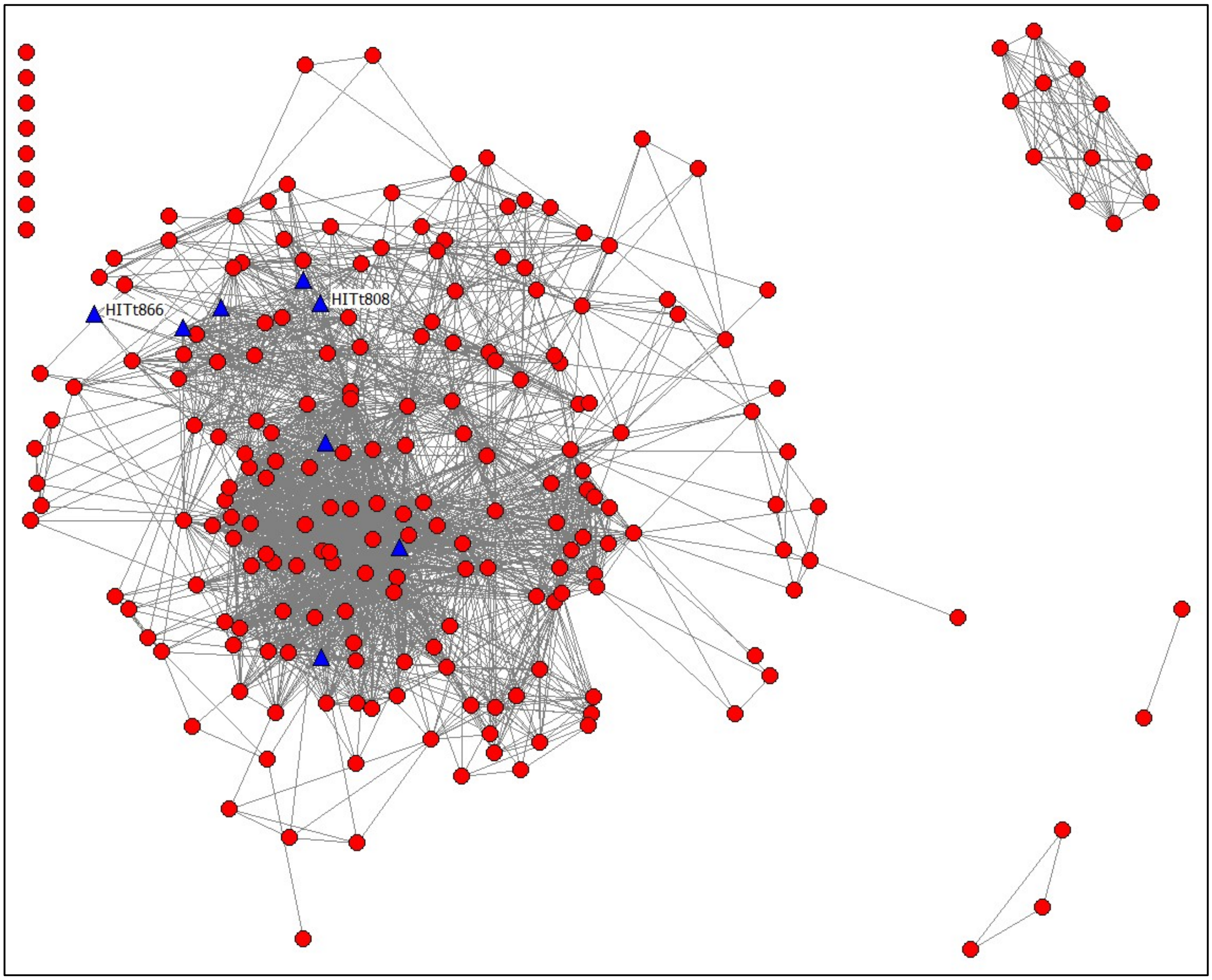


Figure 10. Social network of bottlenose dolphins photo-identified off Kaua'i and Ni'ihau from 2003 to 2014, with tagged individuals noted by symbol type and color (blue triangles), with individuals tagged in February 2014 identified with ID labels. This includes all individuals categorized as slightly distinctive, distinctive, or very distinctive, with fair, good, or excellent quality photographs (see Baird et al. 2009), with a total of 224 individuals shown (the main cluster contains 199 individuals). The cluster of 12 individuals in the upper right and three of the singletons in the upper left were photographed off Ka'ula Island to the west of Ni'ihau.

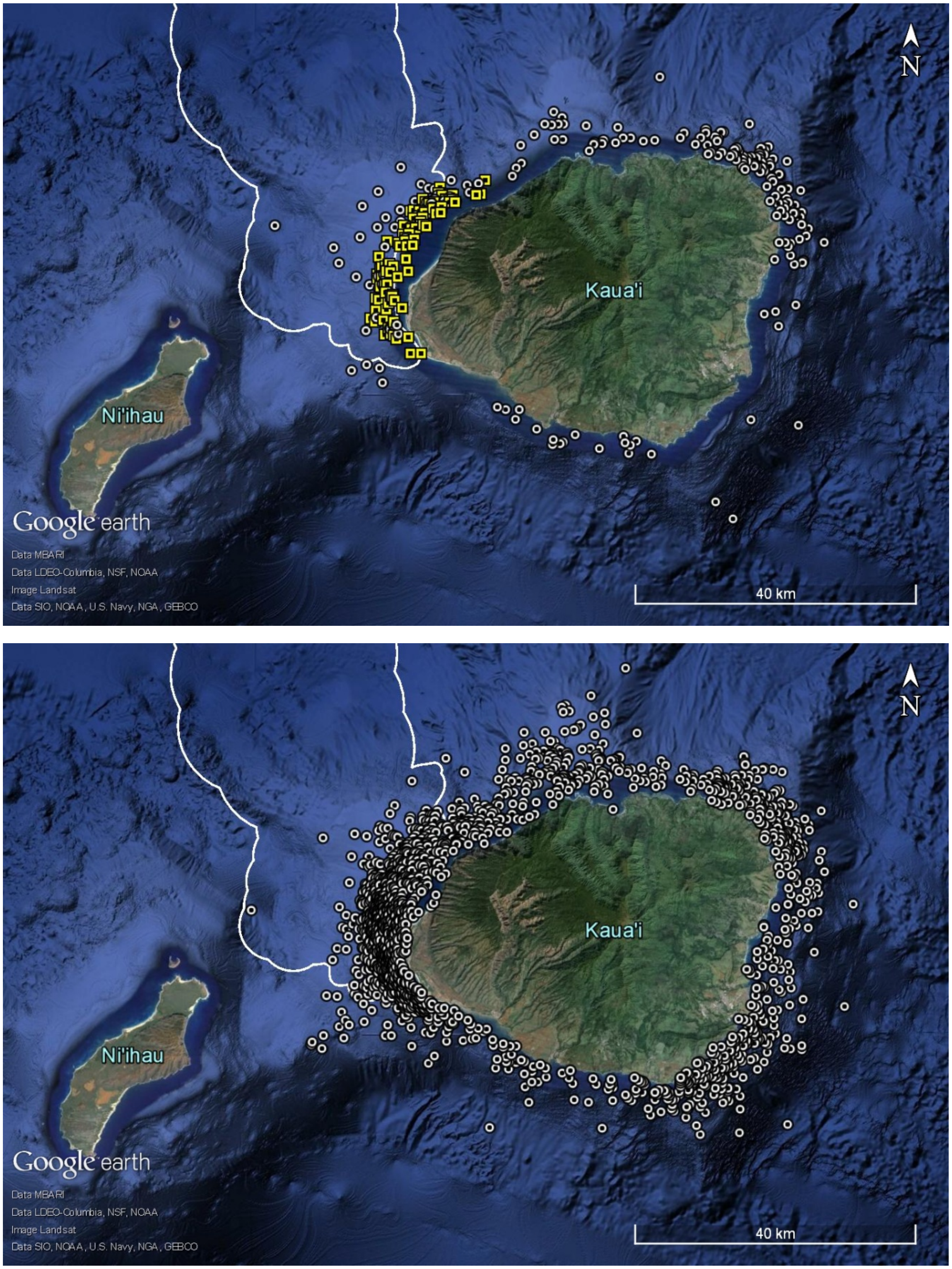


Figure 11. Top. Locations of bottlenose dolphins satellite tagged in Feb 2014 (yellow squares TtTag012; white circles TtTag013). Bottom. Locations of six satellite-tagged bottlenose dolphins, including individuals tagged in August 2011 (one individual), June 2012 (two individuals) and February 2013 (three individuals). The boundary of PMRF is shown in a solid white line.

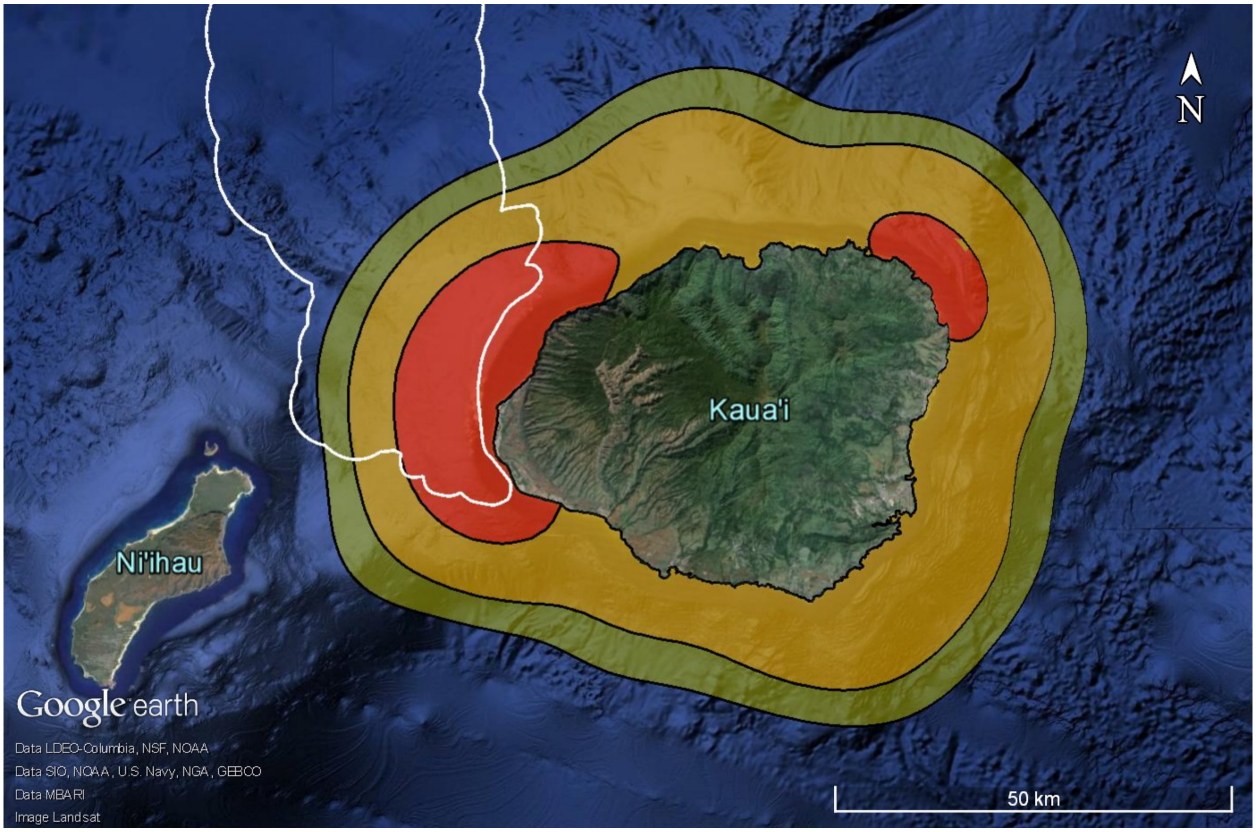


Figure 12. Kernel-density representation of bottlenose dolphin location data from all eight satellite tag deployments off Kaua'i. The red area indicates the 50 percent density polygon, the yellow represents the 95 percent polygon, and the green represents the 99 percent polygon. The PMRF boundary is shown in a solid white line.

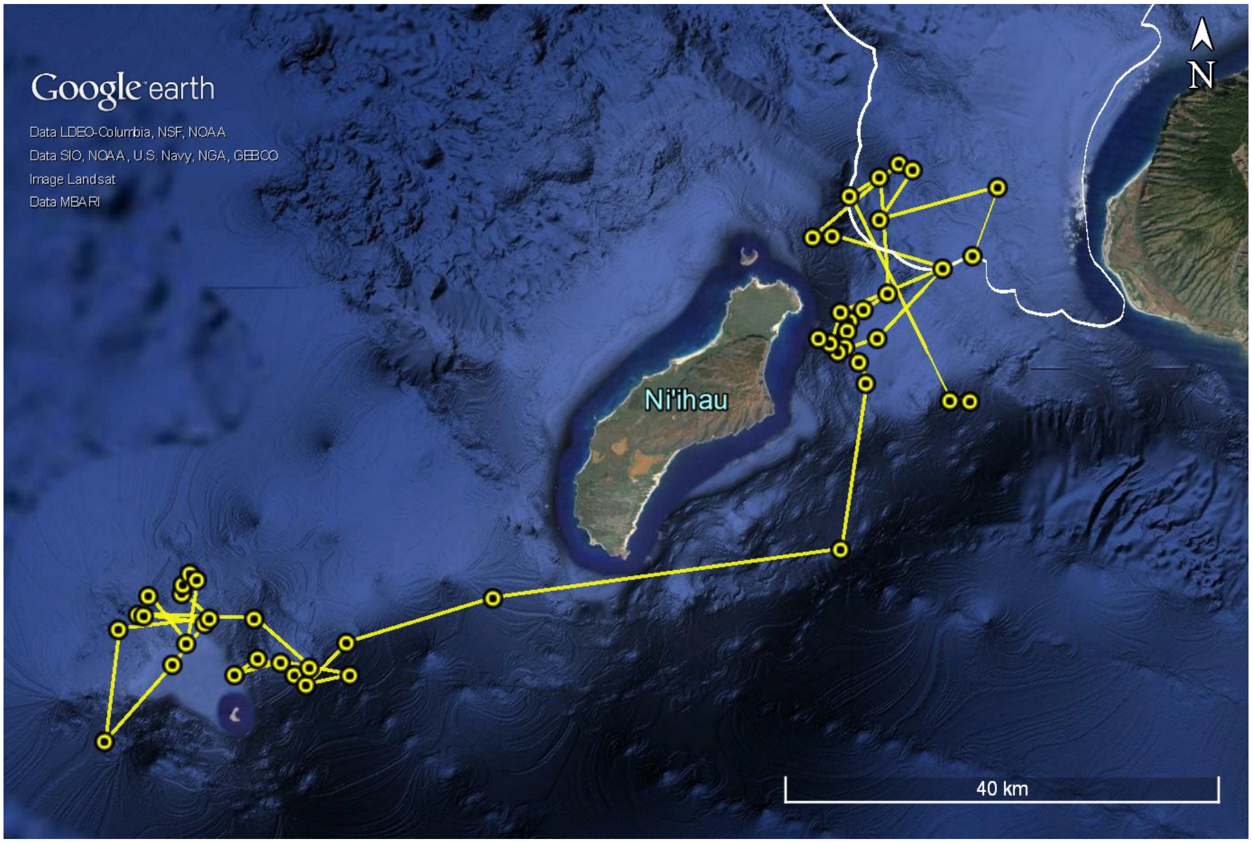


Figure 13. Locations of satellite tagged Blainville's beaked whale tagged in February 2014 over an eight-day period, with a line connecting consecutive locations. The individual, an adult male, was first tagged in deep water south of PMRF, and moved up onto the southwest corner of PMRF before moving to the area around Ka'ula Island to the southwest. The PMRF boundary is indicated by a solid white line.

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10. Tables

Table 1. Details of previous field efforts off Kaua'i involving satellite tagging or M3R passive acoustic monitoring.

Dates	Hours Effort	Odontocete Species Seen[1]	Species Tagged (number tagged)	Odontocete Species Detected on M3R
25-30 Jun 2008	53.8	*Pe, Sb, Gm, Sl*	*Gm* (1), *Pe* (3)	N/A
16-20 Feb 2011	33.9	*Tt, Sb, Gm, Sl*	*Gm* (3)	N/A
20 Jul-8 Aug 2011	118.8	*Tt, Sb, Sl, Sa, Oo*	*Tt* (1), *Sb* (3)	*Tt, Sb, Sl*
10-19 Jan 2012	42.2	*Tt, Sb, Gm, Sl, Md*	*Sb* (1), *Gm* (2)	*Tt, Sb, Gm, Sl, Md*
12 Jun-2 Jul 2012	115.7	*Tt, Sb, Gm, Sl, Sa, Pc*	*Tt* (2), *Sb* (3), *Pc* (3)	*Tt, Sb, Gm, Pc*
2-9 Feb 2013	55.9	*Tt, Sb, Sl, Gm*	*Tt* (3), *Sb* (1), *Gm* (2)[2]	*Tt, Sb, Sl, Md, Pm*
26 Jul-2 Aug 2013	36.6	*Tt, Sb, Sl, Pc*	*Sb* (2), *Pc* (1)	*Tt, Sb, Pc, Md, Zc, Pm*
Total	**456.9**		*Gm* (8)[2], *Pe* (3), *Tt* (6), *Sb* (10), *Pc* (4)	

[1]Species codes: Tt = *Tursiops truncatus*, Sb = *Steno bredanensis*, Gm = *Globicephala macrorhynchus*, Pe = *Peponocephala electra*, Sl = *Stenella longirostris*, Sa = *Stenella attenuata*, Oo = *Orcinus orca*, Pc = *Pseudorca crassidens*, Pm = *Physeter macrocephalus*, Md = *Mesoplodon densirostris*, Zc = *Ziphius cavirostris.*

[2]One tag did not transmit, thus data available from seven pilot whale tags deployed off Kaua'i.

M3R = Marine Mammal Monitoring on Navy Ranges

Table 2. PMRF undersea range characteristics.

Range Area Name	Depth Range (m)	Hydrophone Numbers (string names)	Hydrophone Bandwidth
BARSTUR	~1,000-2,000	2-42 (1-5) 1,10,21,24,37,41	8-40 kHz 50 Hz-40 kHz
BSURE Legacy	~2,000-4,000	43-60 (A,B)	50 Hz-18 kHz
SWTR	~100-1,000	61-158 (C-H)	5-40 kHz
BSURE Refurbish	~2,000-4,000	179-219 (I-L)	50 Hz-45 kHz

kHz = kilohertz; m = meters; ~ = approximately

Table 3. Observations of acoustic features used for species identification and differentiation from passive acoustic monitoring during previous M3R field efforts.

Species[1]	# Visual Verifications	Whistle Features	Click Features	Distinctive Spectrogram Features	Acoustically Similar Species
Sb	30	8-12 kHz, short sweeps centered at ~10 kHz	12-44 kHz with most energy 16-44 kHz	Short narrowband whistles centered at 10 kHz, lots of 12-44 kHz clicks	*Pc* (whistles)
Sl	5	8-16 kHz, highly variable	8-48 kHz, distinct presence of 40-48 kHz click energy, single animal similar to *Zc*	HF click energy from 40-48 kHz. Loses LF click energy first. Long ICI for single species.	*Md, Zc* (clicks) *Tt* (whistles)
Tt	24	primarily 8-24 kHz, highly variable, lots of loopy curves	16-48 kHz, short ICI	Density of clicks and whistles. Very wideband, long duration loopy whistles.	
Gm	8	Combination of short 6-10 kHz upsweeps with long 10-24 kHz upsweeps	12-44 kHz, repetitive, slowly changing ICI	Very wide band but short duration whistles. Often single up or down sweeps.	*Tt*
Pc	4	5-8 kHz upsweeps, loopy whistles 8-12 kHz	8-48 kHz, most energy 8-32 kHz, continual presence of energy to 8 kHz	Click energy at 8 kHz, extending upwards to 32-40 kHz.	*Sb* (whistles), need to pay close attention to clicks to differentiate
Md	4	n/a	24-48 kHz, 0.33 s ICI	Consistent ICI and click frequency content.	

[1]See footnote to **Table 1**.

ICI = inter-click interval; kHz = kilohertz; n/a = not applicable; ~ = approximately

Table 4. February 2014 small-boat effort summary.

Date	Total km	Total Hours on Effort	Number of Odontocete Sightings Total	Number Detected by M3R/ *Searcher*	Depart Time HST	Return Time HST	Total km Beaufort 0	Total km Beaufort 1	Total km Beaufort 2	Total km Beaufort 3	Total km Beaufort 4-5
01 Feb 2014	169.7	8.8	1	0/1	7:40	16:25	0	0	42.7	58.3	68.7
02 Feb 2014	107.3	5.7	1	1/0	7:03	12:40	0	0	8.8	71.3	27.2
03 Feb 2014	162.6	8.7	3	1/0	7:05	15:44	0	55	78.8	28.8	0
04 Feb 2014	123.1	7.1	7	1/0	7:21	14:26	0	52.4	55.2	15.5	0
05 Feb 2014	15.6	0.9	0	0/0	7:32	8:17	0	0	0	8.3	7.3
06 Feb 2014	191.0	8.2	3	1/0	7:19	16:08	0	49.6	90.3	13	38.1
07 Feb 2014	67.8	3.4	0	0	7:24	10:45	6.5	25.7	35.6	0	0
08 Feb 2014	170.4	8.5	2	0/0	7:14	15:40	5.4	115.1	46.5	3.4	0
09 Feb 2014	147.4	8.3	5	2/1	7:16	15:32	0	45.2	61.5	21.8	18.9
10 Feb 2014	132.6	6.7	4	0/N/A	7:59	14:47	0	27.9	10.9	50	43.8
Total	**1,287**	**66.3**	**26**	**6/2**							

HST = Hawai‘i Standard Time; km = kilometers; M3R = Marine Mammal Monitoring on Navy Ranges; N/A = not applicable; # = number

Table 5. February 2014 M3R effort summary.

Date	Range Availability for Small Boat Operations		PAM Effort (HST)	
	Area	Time	Start	Stop
01 Feb 2014	Unlimited	Unlimited	6:30	16:00
02 Feb 2014	Unlimited	Unlimited	6:30	16:00
03 Feb 2014	Unlimited	Unlimited	6:50	16:00
04 Feb 2014	Unlimited	Unlimited	6:30	16:00
05 Feb 2014	Unlimited	Unlimited	6:30	14:30
06 Feb 2014	Unlimited	Unlimited	6:30	16:00
07 Feb 2014	Unlimited	Unlimited	6:45	11:00
08 Feb 2014	Unlimited	Unlimited	6:45	11:45
09 Feb 2014	Unlimited	Unlimited	7:00	16:00
10 Feb 2014	Closed	Closed	6:45	15:00

HST = Hawai‘i Standard Time

Table 6. Odontocete sightings from small-boat effort during February 2014.

Date	Time (HST) of Visual Sighting	Species[1]	Group Size	Satellite Tag	Distance from PAM to visual ID position (km)	PAM Position		Visual ID Position	
						Latitude °N	Longitude °W	Latitude °N	Longitude °W
01-Feb-14	14:21	*Gm*	45	Yes	NA	NA	NA	22.226	159.861
02-Feb-14	10:44	*Gm*	25	Yes	NA*	NA	NA	22.157	159.857
03-Feb-14	11:08	*UnID*	1	No	NA	NA	NA	22.116	159.906
03-Feb-14	12:58	*Gm*	8	Yes	1.235*	22.182	159.856	22.1737	159.863
03-Feb-14	14.53	*Gm*	10	No	NA	NA	NA	21.895	159.803
04-Feb-14	7:52	*Sb*	4	Yes	NA	NA	NA	21.916	159.797
04-Feb-14	9:28	*Tt*	6	Yes	0.779*	21.993	159.799	22.000	159.799
04-Feb-14	10:00	*Tt*	2	No	NA	NA	NA	22.030	159.809
04-Feb-14	10:35	*Tt*	16	No	NA	NA	NA	22.048	159.823
04-Feb-14	11:31	*Sb*	4	Yes	NA	NA	NA	21.944	159.893
04-Feb-14	12:16	*Md*	5	Yes	NA	NA	NA	21.909	159.907
04-Feb-14	14:06	*Sl*	80	No	NA	NA	NA	21.931	159.706
06-Feb-14	14:10	*UnID*	2	No	NA	NA	NA	22.182	159.855
06-Feb-14	14:35	*Tt*	3	Yes	1.118*	22.179	159.792	22.168	159.793
06-Feb-14	15:25	*UnID*	1	No	NA	NA	NA	22.163	159.798
08-Feb-14	7:16	*Tt*	3	No	NA	NA	NA	21.949	159.696
08-Feb-14	12:28	*Sl*	45	No	NA	NA	NA	21.921	159.693
09-Feb-14	7:22	*Sl*	18	No	NA	NA	NA	21.956	159.724
09-Feb-14	8:03	*Gm*	22	Yes	NA	NA	NA	22.120	159.856
09-Feb-14	10:29	*Tt*	2	No	4.192*	22.019	159.833	22.054	159.818
09-Feb-14	13:17	*Tt*	22	No	0.785*	22.163	159.793	22.158	159.795
09-Feb-14	15:26	*Sl*	50	No	NA	NA	NA	21.946	159.709
10-Feb-14	9:09	*Sl*	35	No	NA	NA	NA	22.152	159.731
10-Feb-14	12:02	*Tt*	9	No	NA	NA	NA	22.233	159.617
10-Feb-14	14:17	*Sl*	3	No	NA	NA	NA	21.999	159.781
10-Feb-14	14:22	*Sl*	8	No	NA	NA	NA	21.987	159.771

[1]See footnote to **Table 1**, UnID = unidentified odontocete; HST = Hawai'i Standard Time; ID = identification; km = kilometer; NA = not available; PAM = passive acoustic monitoring; °N = degrees North; °W = degrees West; *Sighting a result of being directed to the location of PAM detections.

Table 7. Details on satellite tags deployed during February 2014 field effort.

Species[1]	Tag ID	Individual ID	Date Tagged	Sighting #	Duration of Signal Contact (days)	Lat (°N)	Long (°W)	Tag Type	Sex
Md	MdTag016	HIMd215	04 Feb 2014	7	0	21.91	159.90	Mk10A	Male
Md	MdTag017	HIMd218	04 Feb 2014	7	7.97	21.91	159.90	SPOT5	Male
Tt	TtTag012	HITt0866	04 Feb 2014	2	6.06	22.00	159.80	SPOT5	Male
Tt	TtTag013	HITt0808	06 Feb 2014	2	13.25	21.16	159.79	SPOT5	Unknown
Sb	SbTag011	HISb1541	04 Feb 2014	1	12.47	21.92	159.80	MK10A	Unknown
Sb	SbTag012	HISb1814	04 Feb 2014	5	7.29	21.94	159.89	SPOT5	Unknown
Gm	GmTag078	HIGm0929	01 Feb 2014	1	12.78	22.22	159.85	MK10A	Male
Gm	GmTag079	HIGm1400	02 Feb 2014	2	14.46	22.15	159.86	MK10A	Male
Gm	GmTag080	HIGm1407	02 Feb 2014	2	15.99	22.15	159.86	SPOT5	Male
Gm	GmTag081	HIGm1464	03 Feb 2014	3	25.84	22.17	159.86	MK10A	Male
Gm	GmTag082	HIGm1469	09 Feb 2014	2	30.44	22.11	159.87	MK10A	Female
Gm	GmTag083	HIGm1408	09 Feb 2014	2	89.07	22.12	159.89	SPOT5	Unknown

[1]See footnote to **Table 1**. °N = degrees North; °W = degrees West; # = number

Table 8. Details on previous sighting history of individuals satellite tagged in February 2014.

Individual ID	Date First Seen	# Times Seen Previously	# Years Seen Previously	Islands Seen Previously	Social cluster
HIMd215	04 Feb 2014	0	0	N/A	N/A
HIMd218	04 Feb 2014	0	0	N/A	N/A
HITt0866	04 Feb 2014	0	0	N/A	N/A
HITt0808	04 Feb 2013	2	1	Kaua‘i	N/A
HISb1541	31 Jul 2011	1	1	Kaua‘i	N/A
HISb1814	29 Jul 2013	1	1	Kaua‘i	N/A
HIGm0929	06 Oct 2007	1	1	*Hawai‘i*	H1
HIGm1400	19 Feb 2011	3	3	Kaua‘i, O‘ahu	W25
HIGm1407	07 Jan 2009	3	3	Kaua‘i, O‘ahu	W25
HIGm1464	11 Nov 2004	4	3	O‘ahu	W18
HIGm1469	14 Jul 2009	4	2	O‘ahu	W18
HIGm1408	07 Jan 2009	4	2	O‘ahu	W18

ID = identification; # = number; N/A = not applicable

Table 9. Information from GIS analysis of satellite-tag location data from February 2014 field effort.

Individual ID	Social Cluster	# Locations	# Periods Inside PMRF Boundaries	% Time Inside PMRF Boundaries	Total Minimum Distance Moved (km)	Median / Maximum Distance from Deployment Location (km)	Median / Maximum Depth (m)	Median / Maximum Distance from Shore (km)
HIMd218	na	48	3	20.5	290.7	21.7 / 83.3	961 / 1,915	8.4 / 16.8
HITt0866	na	92	16	38.6	352.3	12.1 / 24.8	56 / 403	3.5 / 6.7
HITt0808	na	208	7	15.8	955.1	43.8 / 62.0	88 / 2265	2.7 / 18.5
HISb1541	na	183	5	13.4	1,180.0	63.8 / 183.9	1,463 / 4,148	16.2 / 62.9
HISb1814	na	93	4	17.4	756.1	39.4 / 96.7	1,961 / 4,567	17.6 / 47.5
HIGm0929	H1	130	2	16.3	1,249.8	103.8 / 296.5	3,351 / 4,947	39.9 / 97.9
HIGm1400[1]	W25	7						
HIGm1407	W25	181	8	13.1	1,149.0	32.4 / 101.5	2,296 / 4,582	16.7 / 44.0
HIGm1464	W18	327	17	46.4	1,470.4	16.2 / 76.1	1,646 / 3,616	13.9 / 30.5
HIGm1469	W18	167	13	39.4	1,451.8	24.0 / 162.9	1,635 / 3,543	15.4 / 57.6
HIGm1408	W18	587	18	14.1	4,492.3	62.8 / 269.9	1,777 / 4,728	19.3 / 88.9

[1]Locations received from this tagged individual (n=7) were primarily poor location classes, thus location data from this individual is not considered further. ID = identification; km = kilometers; m = meters; # = number; % = percent; na = not applicable.

Table 10. Dive data information from satellite tags deployed during February 2014 field effort.

Individual ID	# Hours Data ARGOS Only	# Hours Data Land Receiver only	# Hours Data Combined ARGOS/ Land Receiver	# Dives ≥ 30 m	Median Dive Depth (m) for Dives ≥ 30 m	Maximum Dive Depth (m)	Median Dive Duration[1] (min)	Maximum Dive Duration[1] (min)
HISb1541	223.8	34.7	225.3	382	91.5	311.5	3.43	6.83
HIGm0929	109.4	0	109.4	231	335.5	1,103.5	10.07	19.73
HIGm1400	18.3	1.8	20.1	54	395.5	927.5	11.90	21.70
HIGm1464	535.1	234.4	535.1	1,363	123.5	1,231.5	9.00	24.60
HIGm1469	13.3	7.8	20.1	65	112.0	751.5	9.03	16.80

[1]Duration of dives underestimated as time spent in top 3 m not included. Typical rates of ascent/descent are in the 1-2 m/second range, so durations likely only underestimated by 3-6 seconds.

m = meters; min = minutes; # = number; ≥ = greater than or equal to