ODONTOCETE MOVEMENTS OFF THE ISLAND OF KAUA'I: RESULTS OF SATELLITE TAGGING AND PHOTO-IDENTIFICATION EFFORTS IN JANUARY 2012

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Introduction

There are 18 species of odontocetes that may be found around the islands of Kauaʻi and Niʻihau. Using individual photo-identification and genetic analyses of biopsy samples, previous small-boat-based field efforts off Kauaʻi and Niʻihau have provided evidence of a demographically-isolated resident population of common bottlenose dolphins (*Tursiops truncatus*) off the islands (Baird et al. 2009; Martien et al. 2011), and a high-degree of site fidelity by rough-toothed dolphins (*Steno bredanensis*) (Baird et al. 2008a). Limited satellite tagging work has been undertaken with several species of odontocetes off of Kauaʻi and Niʻihau, with deployments of tags on melon-headed whales (*Peponocephala electra*) in 2008 (Woodworth et al. 2011); short-finned pilot whales (*Globicephala macrorhynchus*) in 2008 and 2011 (Baird et al. 2008b, 2011), and bottlenose dolphins and rough-toothed dolphins in 2011 (Baird et al. 2012). The satellite tag deployments have provided unbiased and longer-term information on movements and habitat use of all these species, although sample sizes for all species remain small.

As part of an assessment of habitat use and movements of odontocetes being undertaken in the western half of the main Hawaiian Islands (see Baird et al. 2011, 2012), field operations funded by Commander, U.S. Navy Pacific Fleet were undertaken off of Kauaʻi in January 2012. There were two primary goals of these operations: 1) providing species verification for acoustic detections by the Marine Mammal Monitoring on Navy Ranges (M3R) project on the Pacific Missile Range Facility (PMRF) hydrophone range (see Moretti et al. 2012); and 2) deploying satellite tags prior to a Submarine Commanders Course (SCC) training event to be undertaken off Kauaʻi in February 2012. Such tag deployments would provide movement data before, during, and after the SCC, to allow for an assessment of changes in movement patterns/habitat use associated with the event, as well as providing baseline data on movements and habitat use that may be relevant to understanding stock structure and use of the Navy's PMRF range. Secondary goals included obtaining identification photos of individuals to assess site fidelity and movements, and biopsy samples to contribute to genetic studies of stock structure. This report summarizes methods and results from small-boat-based field efforts, satellite tagging, and photo-identification matching of tagged individuals during this project, including information on habitat use and movements. Assessment of potential changes in movement patterns/habitat use associated with the SCC will be undertaken separately.

Methods

Surveys were undertaken off Kauaʻi between 10 and 19 January 2012. A 7.3 meter (m) rigid-hulled inflatable boat (RHIB) with a custom-made bow pulpit was used in conjunction with the 70 m USNS Sioux, with operations coordinated between the two vessels when weather conditions allowed. When the PMRF range was open to vessel traffic, survey efforts were coordinated with the M3R program with the research vessel directed to areas with acoustic identifications of odontocetes. Observers on the RHIB scanned 360 degrees around the research vessel, which transited typically at speeds of 15-30 kilometers/hour (km h^{-1}). Efforts were made to obtain photographs of all individuals in groups of odontocetes encountered and deploy satellite tags when conditions allowed.

Satellite tagging was to be undertaken with any of a number of priority target species encountered, including beaked whales, sperm whales (*Physeter macrocephalus*), melon-headed whales, false killer whales (*Pseudorca crassidens*), short-finned pilot whales, pygmy killer whales (*Feresa attenuata*), rough-toothed dolphins, or common bottlenose dolphins (hereafter bottlenose dolphins). The satellite tags used were location-only SPOT5 tags (Wildlife Computers, Inc., Redmond, WA), in the LIMPET configuration (Andrews et al. 2008; Schorr et al. 2009; Baird et al. 2010). Attachment darts penetrated a maximum of 4.2 centimeter (cm) into the dorsal fin for smaller species (i.e., rough-toothed dolphins) or 6.5 cm into the dorsal fin for larger species (i.e., short-finned pilot whales). Given previous attachment durations on short-finned pilot whales (Cascadia Research, unpublished data), tags programmed for this species were set to transmit 10 hours per day, to conserve battery life to allow for transmission beyond the anticipated SCC in February 2012, while still providing sufficient temporal resolution of data to examine movements. Transmission hours were spread throughout the day, corresponding with the periods with the best satellite overpasses, while also attempting to broadly cover the 24-hour cycle to facilitate analyses of movements. Given previous attachment durations for rough-toothed dolphins (see Baird et al. 2012) it was unlikely that tags deployed on this species would remain attached long enough to transmit through the SCC. Thus tags were set to transmit 14 hours per day, with transmission hours corresponding with the best satellite overpasses and spread throughout the 24-hour cycle. This deployment schedule would still allow for transmissions of approximately 32 days, potentially allowing for some overlap with the SCC if the tag remained attached for a long enough period.

Data obtained from the Argos system was processed with the Douglas Argos-Filter v. 7.08 (available at Alaska.usgs.gov/science/biology/spatial/douglas.html) using two independent methods: distance between consecutive locations, and rate and bearings among consecutive movement vectors. Each location is assigned a “location class” by Argos, which reflects the estimated precision of the location, with the most precise locations being classes 3 and 2 (estimated error of <250 m and < 500 m, respectively). We set the Douglas Argos-Filter to automatically retain location classes 3 and 2. Maximum rate of movement was set at 20 km h^{-1} for rough-toothed dolphins and 15 km h^{-1} for short-finned pilot whales, following earlier analyses (Baird et al. 2011, 2012). Depth, distance from shore, and whether locations were inside or outside the PMRF boundary were determined for all locations which passed the Douglas Argos-filter using ArcGIS v. 9.2 (ESRI, Redlands, California). Depths were determined using a 50 m x 50 m multibeam synthesis bathymetry model from the Hawai‘i Mapping Research Group (available at www.soest.hawaii.edu/HMRG/multibeam/index.php).

In one case when two tags were deployed on individuals in the same group, to determine whether individuals with overlapping tag data were acting in concert or independently, we calculated the straight-line distance (i.e., not taking into account potentially intervening land masses) between the pair of individuals when locations were obtained during a single satellite overpass. We used both the average distances between the individuals and the maximum distance between them to assess whether the individuals were acting independently.

Photographs of individuals (both tagged and non-tagged) were compared to individual photo-identification catalogs for each species maintained by Cascadia Research Collective (Baird et al. 2008a; Mahaffy 2012). Previous sighting histories of individuals within groups were examined to assess whether individuals were: 1) part of resident populations from the areas they were tagged (or whether the group they were in included known resident individuals); 2) potentially part of offshore populations; or 3) individuals moving from other islands. Whether individuals had been previously tagged was also noted to assess wound healing of tag sites.

Social networks were generated using good or excellent quality photos of all distinctive and very distinctive individuals photo-identified off Kauaʻi, Niʻihau, and Oʻahu, using Netdraw 2.097 (Analytic Technologies, Needham, MA) with a spring embedding layout. For rough-toothed dolphins, photos from 2003 through 2005 (250 identifications, from Baird et al. 2008a) as well as an additional 114 identifications from 2007 through January 2012 were used. For short-finned pilot whales, all photographs available through January 2012 were included. To assess whether two pilot whales tagged within the same group were part of the same social unit, versus together temporarily, we assessed social groupings and membership within groups (termed social clusters) with an analysis of network modularity (Q) in SOCPROG 2.4, which "indicates how well a population can be delineated into communities or social units" (Whitehead 2008). All pilot whales identified off Kauaʻi, Niʻihau, or Oʻahu from 2002 through January 2012 (in a variety of different field projects) were included in these analyses.

Results and Discussion

Field operations were undertaken on nine days in January 2012, with the small vessel covering 656 km of trackline in 42.2 hours of survey effort (Figure 1). Survey conditions were generally poor, with 69.4% of the kilometers covered in Beaufort 3 or greater. Sighting rates were limited by the poor sea conditions, with a total of 13 sightings of five species of odontocetes during the project (Table 1). Four of the sightings (of four species) were cued by the M3R acoustic system, providing species verification for two species that had not been previously visually confirmed with simultaneous acoustic detections on the PMRF range: Blainville's beaked whale and short-finned pilot whale. Although none of the sightings were cued by the USNS Sioux, coordination between the Sioux and the RHIB facilitated tracking of several groups of individuals. Photos of sufficient quality for identifying individuals were available from 10 of the 13 encounters. Photos of spinner dolphins were provided to other researchers (J. Tyne, Mudoch University) for studies of this species, and bottlenose dolphin and rough-toothed dolphin photos have not yet been completely matched. Comparisons of the five Blainville's beaked whales photo-identified (Figure 2) to our catalog for this species revealed no matches of photos taken prior to this project. Comparison of photos of short-finned pilot whales (Figure 2) from three of the encounters to our photo-identification catalog resulted in 49 identifications of 43 individuals (six were seen in two different encounters), all of which had previously been documented in the western main Hawaiian Islands (Table 1).

We were able to deploy three satellite tags on two different species, two on short-finned pilot whales and one on a rough-toothed dolphin, with location data from these tags obtained over periods from 11.7 to 73.2 days (Table 2). Both of the tagged short-finned pilot whales had been previously photo-identified, with sightings of both individuals as early as 2003 off of Oʻahu or Kauaʻi (Table 3). The two individuals were together in the same large aggregation of individuals when they were tagged (with an estimated group size of 85 individuals). Association analyses of all pilot whales documented off Kauaʻi, Niʻihau and Oʻahu from 2002 through

January 2012 indicate these two individuals are part of a social network of pilot whales that includes individuals previously documented from O‘ahu to Ni‘ihau (Figure 3). However, network analyses indicate these two individuals are part of different social clusters (see Mahaffy 2012; Table 3). Location data from the satellite tags were obtained from these individuals for periods of 11.7 days (HIGm0036) and 73.2 days (HIGm0209). During the period of tag overlap the two whales remained within ~15 km of each other for approximately half the time, and were separated (by up to 77.1 km) for the remainder of the time (Figure 4), further suggesting these two individuals were acting as part of different social groups. During the 11.7 day track of HIGm0036, this individual circumnavigated Kaua‘i, remaining a median distance from land of 12.0 km (maximum = 35.8 km). During the 73.2 day track of HIGm0209, this individual circumnavigated both Kaua‘i and Ni‘ihau and also moved to off of west O‘ahu. While remaining a median distance from land of 15.9 km, the maximum distance offshore documented was 122.2 km, with the tagged individual crossing into areas where long-line fishing may be undertaken (Figure 5). A comparison of the cumulative minimum distance travelled for this individual (4,246 km) versus the median distance from the tagging location (48.5 km) illustrates that the individual is generally resident to the area, despite the movements offshore. In other words, HIGm0209 stayed relatively close to the tagging location (an average of <50 km) while covering over 4,000 km of linear distance in about 73 days.

A single rough-toothed dolphin was satellite tagged, providing 27.5 days of movement data. This individual, HISb0431 in our catalog, had previously been documented both off Kaua‘i (in 2005 and 2011), and off the island of Hawai‘i (in 2006; see Table 3), one of only two individual rough-toothed dolphins known to have made large-scale movements within the main Hawaiian Islands (Baird et al. 2008a). This individual was part of the main social network of rough-toothed dolphins that has been documented off the islands of Kaua‘i and Ni‘ihau (Figure 6), which includes the three rough-toothed dolphins satellite tagged in 2011 (Baird et al. 2012). Location data were obtained from this individual over a 27.5 day period, providing the most extensive track available for a satellite-tagged rough-toothed dolphin in Hawai‘i (see Baird et al. 2012). This individual ranged more broadly than previous tagged rough-toothed dolphins, circumnavigating Kaua‘i and covering a broad range of area off Ni‘ihau (Figure 7).

When HISb0431 was documented off Kaua‘i in August 2011 one of the other individuals in the same group was satellite tagged (HISb0908, see Baird et al. 2012). Both individuals were again photographically documented together in January 2012, during which HISb0431 was satellite tagged. Such photos allow for an assessment of wound healing, and demonstrated healing of the tag attachment site for HISb0908, with only a small amount of scarring visible (Figure 8).

Despite the sub-optimal sea conditions and the relatively short duration of this field effort, there were several important accomplishments, including providing visual species verifications of four species acoustically detected on the M3R range, most importantly Blainville’s beaked whales and short-finned pilot whales. In addition, the satellite tag data obtained from both short-finned pilot whales and a rough-toothed dolphin greatly increased what is known about the movements and habitat use of these two species off the islands of Kaua‘i and Ni‘ihau, including use of the PMRF range by these species. Photo-identification data will also be important to augment existing knowledge of site fidelity and residency to the area, given the relatively small sizes available from previous work in the western main Hawaiian Islands. As well, one of the pilot whale tags did record data through the period in mid-February during which the Submarine Commanders Course was undertaken, which may provide a valuable dataset for examining potential changes in movements or habitat use associated with Navy activities.

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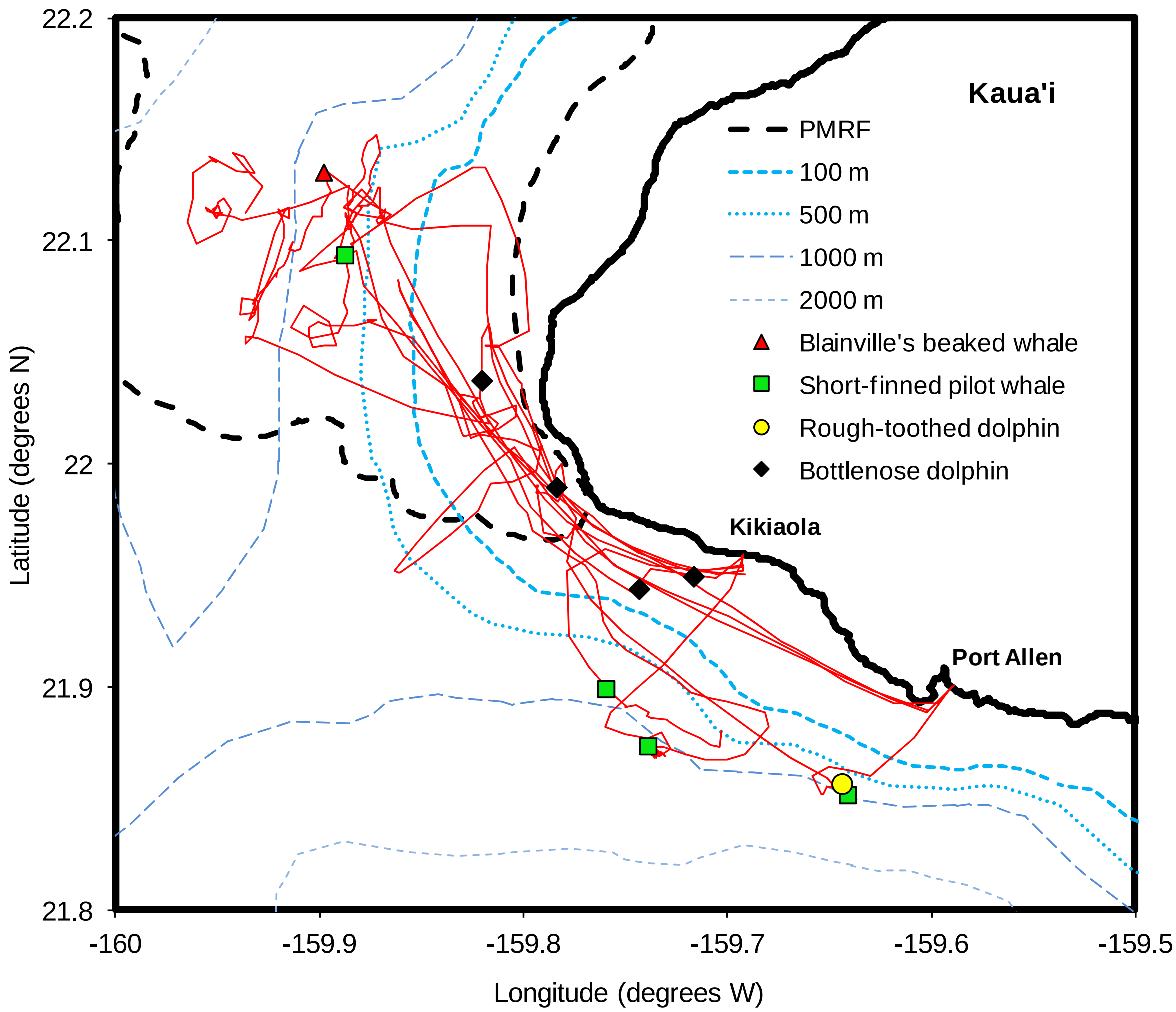

Figure 1. Map showing tracklines of 7.3 m RHIB and sightings of four species of odontocetes in January 2012. GPS data from two days (with a total of 65.2 km of effort, with no sightings) were lost due to GPS malfunction. The Pacific Missile Range Facility (PMRF) boundary is shown.

Figure 2. Top. Identification photograph of an adult female Blainville's beaked whale seen 19 January 2012. This individual had not been previously documented in our catalog and was assigned catalog number HIMd200. The individual is identifiable based both on notches on the dorsal fin and scarring patterns caused by cookie-cutter shark bites. Bottom. Identification photo of adult male short-finned pilot whale HIGm0178 seen 14 January 2012. This individual had previously been documented off O‘ahu (in 2003 and 2009) and Kaua‘i (in 2011). Both photos © Jessica Aschettino/Cascadia Research Collective.

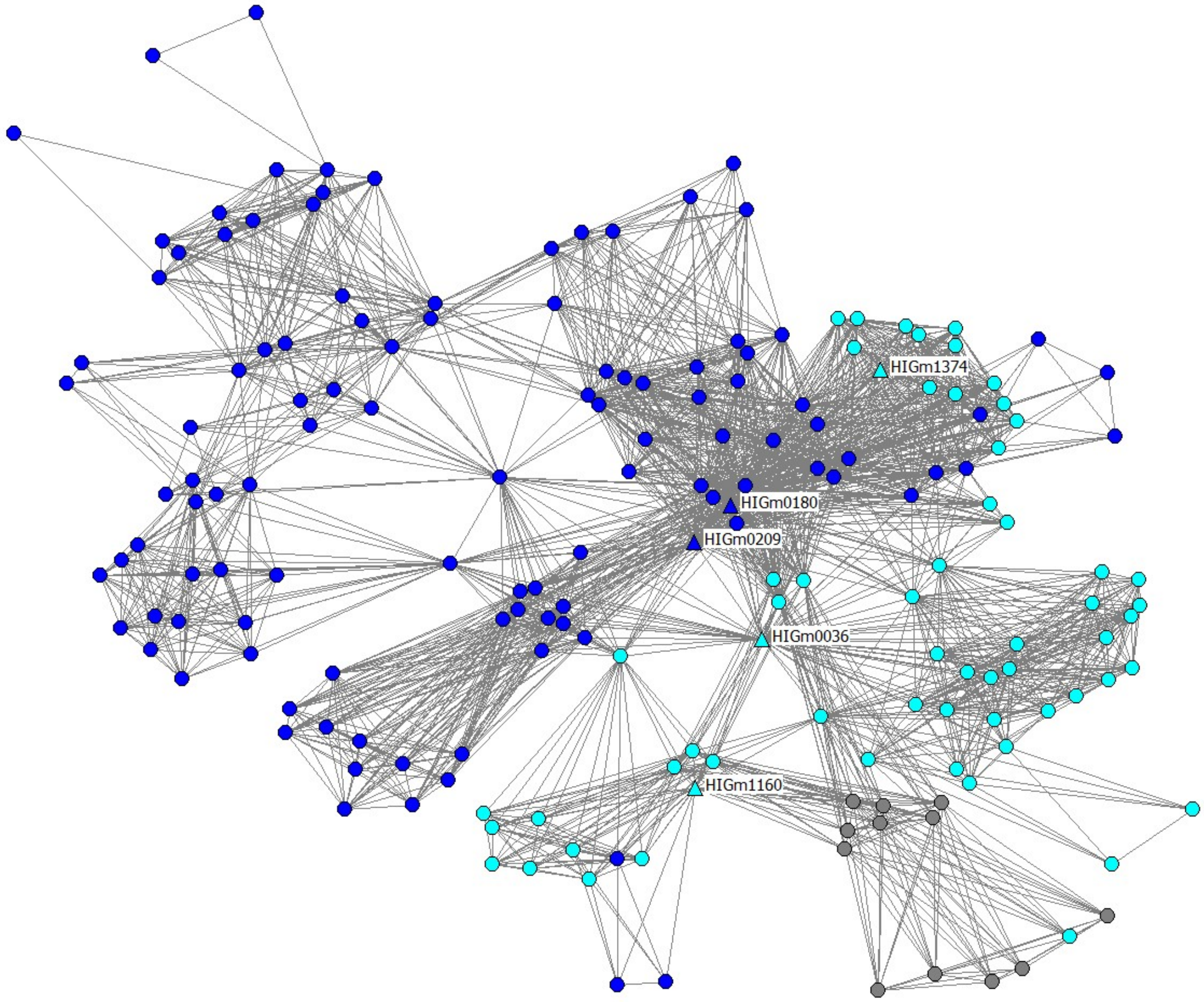

Figure 3. Main component of social network of short-finned pilot whales documented in the western main Hawaiian Islands (O‘ahu, Kaua‘i or Ni‘ihau) from 2003 through January 2012, with satellite tagged individuals indicated. Produced with Netdraw with a spring-embedded layout. Dark blue = individuals first documented off O‘ahu; pale blue = individuals first documented off Kaua‘i; gray = individuals first documented off Ni‘ihau. Tagged individuals are indicated with triangles. Individual HIGm1160 was tagged off Kaua‘i in June 2008 (see Baird et al. 2008), while individuals HIGm0180 and HIGm1374 were tagged off Kaua‘i in February 2011 (see Baird et al. 2011). Individuals HIGm0036 and HIGm0209 were tagged in January 2012.

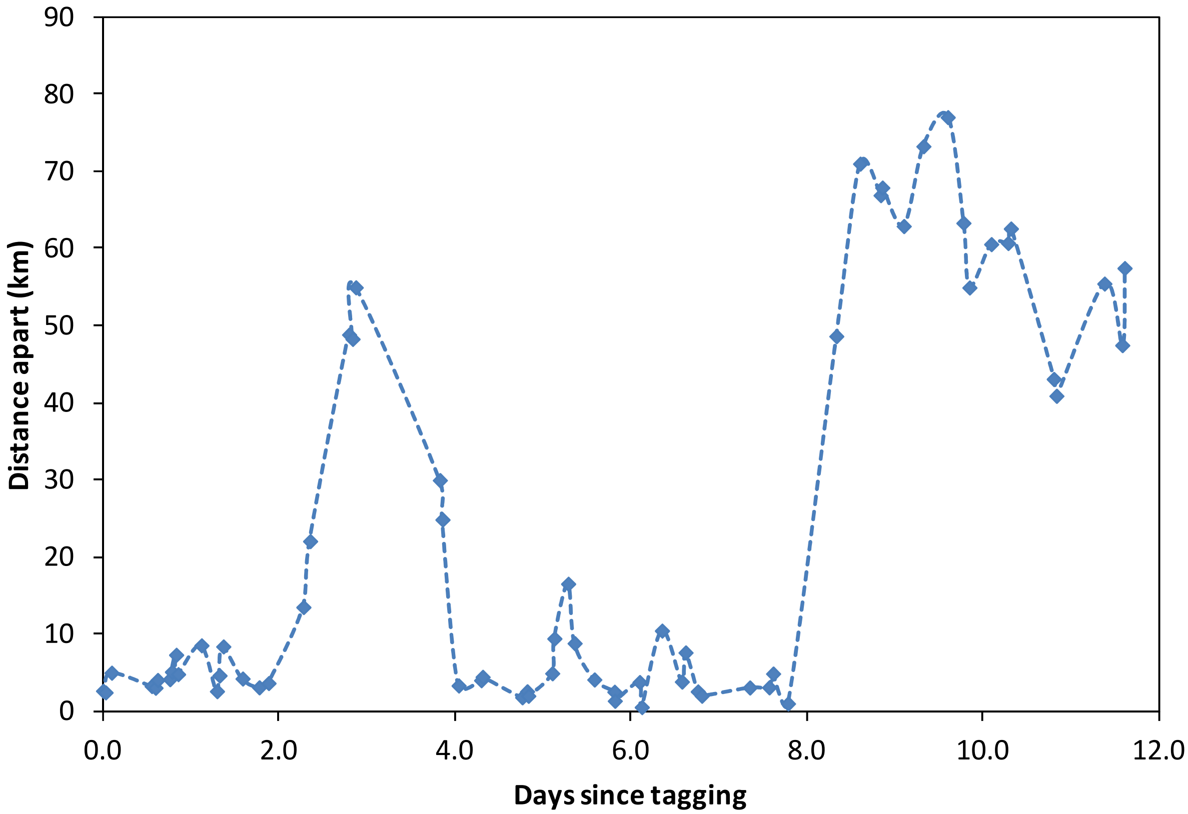

Figure 4. Straight-line distance between two short-finned pilot whales satellite-tagged in the same group on 14 January 2012, during the period of tag overlap. The median distance apart was 5.12 km, with a maximum straight-line distance apart of 77.1 km, suggesting the two individuals were largely acting independently.

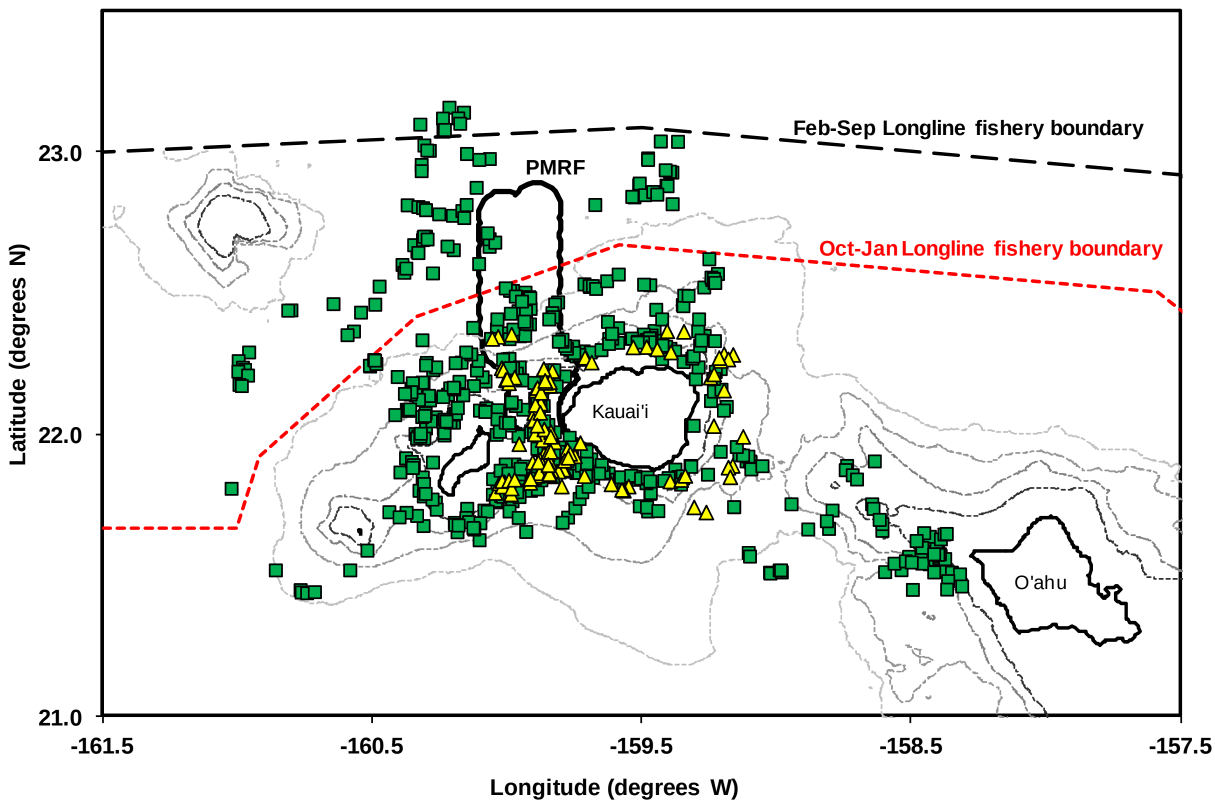

Figure 5. Filtered locations from two satellite-tagged short-finned pilot whales, with longline fishery boundaries and the outline of the Pacific Missile Range Facility (PMRF) shown. The green squares are from a 73.2 day track of HIGm0209 while the yellow triangles are from an 11.7 day track of HIGm0036 (see Table 2).

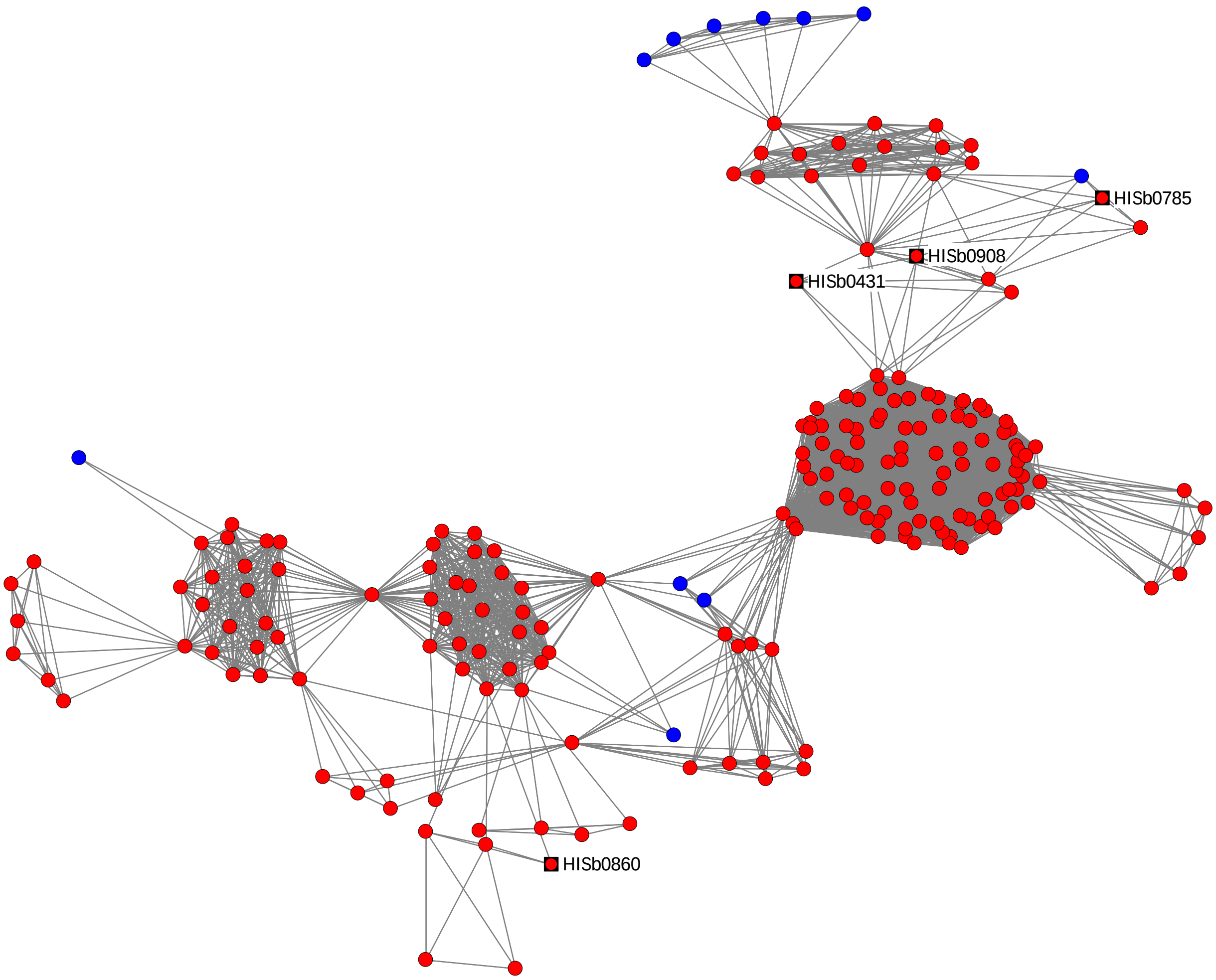

Figure 6. Main component of the social network of rough-toothed dolphins photo-identified off of Kaua'i or Ni'ihau from 2003 through 2008 and in January 2012, with tagged individuals indicated, including three individuals tagged in July 2011 (see Baird et al. 2012) and the one individual tagged in January 2012 (HISb0431). Individuals first documented off Kaua'i are shown in red while those first documented off Ni'ihau are shown in blue. Presence in the same social network indicate that all four tagged individuals through January 2012 are part of the same population of rough-toothed dolphins.

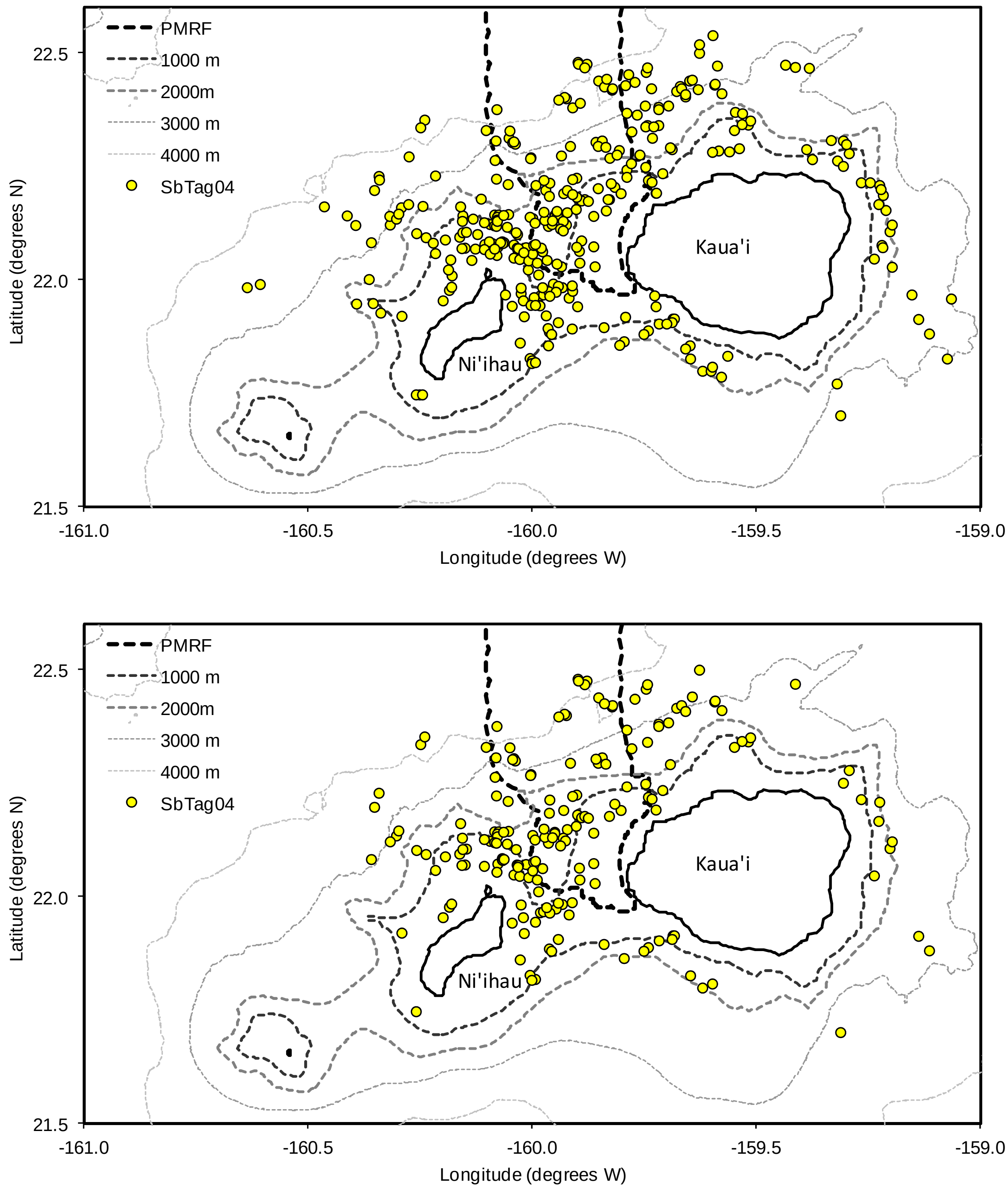

Figure 7. Locations of the rough-toothed dolphin satellite-tagged 14 January 2012 over a 27-day period. The top map shows all locations that passed the Douglas Argos-Filter; the bottom map shows only location classes 3, 2 and 1.

Figure 8. Top. Rough-toothed dolphin HISb0906 on the date of tagging (2 August 2011), photo © Elisa A. Weiss. Bottom. HISb0906 on 14 January 2012, photo © Jessica Aschettino/Cascadia Research Collective. Scar tissue associated with the tag dart location is only visible at the site of the forward-most dart.

Table 1. Details of sightings from the small-boat field effort off Kauaʻi in January 2012.

Species	Date	Sighting #	Sighting Cue[1]	Group size (best)	# photos	# biopsies	# tags	# IDs[2]
Blainville's beaked whale	19-Jan-12	2	AD	5	99	0	0	5
Bottlenose dolphin	14-Jan-12	1	SBF	11	14	0	0	NYD
Bottlenose dolphin	19-Jan-12	1	SBF	7	83	0	0	NYD
Bottlenose dolphin	19-Jan-12	3	AD	16	105	0	0	NYD
Bottlenose dolphin	19-Jan-12	4	SBF	5	0	0	0	0
Rough-toothed dolphin	14-Jan-12	5	SBF	14	366	2	1	NYD
Short-finned pilot whale	13-Jan-12	1	SBF	5	30	0	0	0
Short-finned pilot whale	14-Jan-12	2	AD	85	668	0	2	30
Short-finned pilot whale	14-Jan-12	4	SBF	12	160	0	0	7
Short-finned pilot whale	18-Jan-12	1	RT	17	491	0	0	12
Spinner dolphin	10-Jan-12	1	SBF	55	0	0	0	0
Spinner dolphin	11-Jan-12	1	AD	70	31	0	0	NYD
Spinner dolphin	14-Jan-12	3	SBF	120	76	0	0	NYD

[1]Sighting cue: AD = Acoustic Detection from M3R; SBF = Splash, Blow or Fin; RT = Radio (satellite) tag. [2]# IDs = number of individuals photo-identified from encounter: NYD = Not Yet Determined.

Table 2. Details of individuals satellite-tagged off Kauaʻi in January 2012

Species	Tag #	ID #	Age/ Sex[1]	Date tagged	Date last signal	Total days
Short-finned pilot whale	GmTag063	HIGm0209	A/U	14-Jan-12	28-Mar-12	73.2
Short-finned pilot whale	GmTag064	HIGm0036	A/M	14-Jan-12	26-Jan-12	11.7
Rough-toothed dolphin	SbTag004	HISb0431	A/U	14-Jan-12	11-Feb-12	27.5

[1]Age/Sex: A = adult, U = undetermined, M = male.

Table 3 Sighting histories of individuals satellite-tagged off Kauaʻi in January 2012.

ID #	Date	Island	Social Cluster[1]	Source[2]
HIGm0209	24-May-03	Oʻahu	14	CRC
HIGm0209	4-Oct-09	Oʻahu	14	PIFSC
HIGm0209	15-Oct-09	Oʻahu	14	PIFSC
HIGm0209	20-Oct-09	Oʻahu	14	WDF
HIGm0209	18-Feb-11	Kauaʻi	14	CRC
HIGm0209	14-Jan-12	Kauaʻi	14	CRC
HIGm0209	18-Jan-12	Kauaʻi	14	CRC
HIGm0036	3-Jun-03	Kauaʻi	10	CRC
HIGm0036	16-Oct-05	Kauaʻi	10	CRC
HIGm0036	11-Nov-05	Kauaʻi	10	CRC
HIGm0036	20-Oct-09	Oʻahu	10	WDF
HIGm0036	14-Jan-12	Kauaʻi	10	CRC
HISb0431	4-Nov-05	Kauaʻi	-	CRC
HISb0431	9-Sep-06	Hawaiʻi	-	WWRF
HISb0431	2-Aug-11	Kauaʻi	-	CRC
HISb0431	14-Jan-12	Kauaʻi	-	CRC

[1]Social Cluster: - = not yet analyzed. [2]Source: CRC = Cascadia Research Collective; PIFSC = Pacific Islands Fisheries Science Center; WDF = Wild Dolphin Foundation; WWRF = Wild Whale Research Foundation.

Table 4. Information on habitat use of individuals satellite-tagged off Kauaʻi in January 2012 based on GIS analysis of filtered locations. See Table 2 for details of tagging.

ID #	# filtered locations/% within PMRF	Median/ Max Depth (m)	Median/ Max distance from shore (km)	Cumulative minimum distance travelled (km)	Median/ Max distance from deployment location (km)
HIGm0209	563/14.9	2,033/4,870	15.9/122.2	4,246	48.6/177.5
HIGm0036	109/22.9	1,416/4,375	12.0/35.8	866	27.3/78.6
HISb0431	329/27.6	1,512/4,460	12.7/40.7	2,174	51.9/103.1