

Odontocete Studies on the Pacific Missile Range Facility in August 2018: Satellite Tagging, Photo-Identification, and Passive Acoustic Monitoring

Interim field survey report to U.S. Pacific Fleet by HDR, under Federal contract number N62470-15-D-8006 under Task Order No. N6274218F0107

Prepared by

Robin W. Baird, Sabre D. Mahaffy, Daniel L. Webster, Brittany D. Guenther, Jordan K. Lerma, Colin J. Cornforth, and David B. Anderson

Cascadia Research Collective
218 ½ W. 4th Avenue
Olympia, WA 98501

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Executive Summary

As part of a long-term U.S. Navy-funded marine mammal monitoring program, from 6-20 August 2018, a combined boat-based field effort and passive acoustic monitoring was carried out on and around the underwater hydrophone ranges of the Pacific Missile Range Facility (PMRF). This interim field survey report provides a summary of survey effort, encounters and preliminary results of photo-identification analyses and tag data. A final report on this effort including full details of the results and analyses will be available in 2019. During the project there were 1,597 kilometers (100.0 hours) of small-vessel survey effort, resulting in 57 sightings of seven species of odontocetes (and two sightings of unidentified odontocetes), 24 of them on PMRF. Of those 24, five were directed by acoustic detections using the Marine Mammal Monitoring on Navy Ranges (M3R) system. Melon-headed whales (*Peponocephala electra*) were encountered on two occasions, short-finned pilot whales (*Globicephala macrorhynchus*) on five, common bottlenose dolphins (*Tursiops truncatus*) on six, rough-toothed dolphins (*Steno bredanensis*) on 34, spinner dolphins (*Stenella longirostris*) on eight, pantropical spotted dolphins (*Stenella attenuata*) once, and sperm whales (*Physeter macrocephalus*) once. During the encounters, we took 33,452 photographs for individual identification, with photographs being added to long-term CRC regional photo-identification catalogs for short-finned pilot whales, common bottlenose dolphins, and rough-toothed dolphins. Eighteen biopsy samples, of five species, were collected for genetics, with blubber samples stored for later analyses. Eight satellite tags were deployed on four species, including six Fastloc-GPS-dive tags, one location-dive tag, and one location-only tag. The Fastloc-GPS-dive tags were programmed to maximize obtaining Fastloc-GPS locations and dive data for a 10-day window spanning a Submarine Command Course (SCC) scheduled to start on 21 August 2018. Fastloc-GPS tags deployed on two different groups of pilot whales produced more than twice as many Fastloc-GPS locations than Argos locations during the 10-day window, and behavior data coverage during that period ranged from 77.4 to 99.3%. One of these groups was on or near PMRF during the period of the SCC, so data should be available to assess exposure and response to mid-frequency active sonar.

As part of a long-term U.S. Navy-funded marine mammal monitoring program, from 6-20 August 2018 a combined boat-based field effort and passive acoustic monitoring was carried out on and around the underwater hydrophone ranges of the Pacific Missile Range Facility (PMRF). Commander, Pacific Fleet (PACFLT) funded 13 days of small-boat effort and the National Marine Fisheries Service funded an additional two days of effort. The effort was meant to assess the spatial movement patterns and habitat use of marine mammal species that are exposed to mid-frequency active sonar (MFAS), and how those patterns influence exposure and potential responses to MFAS, using a combination of satellite tagging, photo-identification, and genetic sampling. The effort was timed to occur immediately prior to a Submarine Command Course (SCC) that was scheduled to start 21 August 2018. This interim field survey report provides a summary of survey effort, encounters and preliminary results of photo-identification analyses and tag data. A final report on this effort including full details of the results will be available in 2019.

During this effort the primary tags to be deployed were Wildlife Computers SPLASH10-F tags, providing information on behavior (depth and duration of dives¹ and surfacing intervals), as well as both Argos locations and Fastloc-GPS locations. Tags were programmed to maximize the likelihood of obtaining behavior and location information over a 10-day period that spanned the scheduled SCC (3.5 days before and after and the 3 days during the SCC). SPLASH10-F tags were set to transmit up to 900 times per day, over the 17 hours of the day that corresponded to all but one hour during which there were Argos satellite overpasses. Land-based receiving stations (Wildlife Computers Motes, see Jeanniard-du-Dot et al. 2017) on both Kaua'i and Ni'ihau were also used to intercept tag transmissions to help minimize gaps in Fastloc-GPS locations and behavior data. In terms of transmissions, tags were set with Fastloc-GPS locations as high priority and behavior logs (i.e., dive data) as low priority, with a 6-day buffer. Behavior data and Fastloc-GPS locations were only collected up to 3.5 days past the scheduled end of the SCC, to maximize throughput of both location and behavior data during the period of interest (i.e., before, during and after the SCC). For tags that remained transmitting after this period, this allowed for prioritization of transmitting existing tag data, rather than collection of new data, in order to minimize gaps in the location and dive record during the period of interest. Fastloc-GPS location data were filtered by removing locations with residual values greater than 35 (Dujon et al. 2014) and those with time errors >10 seconds. Argos locations were filtered through the Douglas Argos-filter following protocols noted in Baird et al. (2018). Sighting information obtained during the surveys was compared to previous sightings during small-boat effort by Cascadia Research Collective (CRC) off Kaua'i and Ni'ihau, during 1,196 hours of effort (20,307 km) over 10 different years from 2003 through 2017 (see Baird 2016, Baird et al. 2018).

From August 6-20, 2018 there were 1,597 kilometers (100.0 hours) of small-vessel survey effort. Search effort was primarily restricted to the southern-most part of PMRF and areas south of PMRF due to high seas associated with easterly trade winds, with 78.7% of effort in waters less than 1,000 m depth (median depth = 685 m; Figure 1). There were 57 sightings of seven species of odontocetes (and two sightings of unidentified odontocetes), 24 of them on PMRF (Figure 2). Of those 24, five were directed by acoustic detections using the Marine Mammal Monitoring on Navy Ranges (M3R) system. Melon-headed whales (*Peponocephala electra*) were encountered on two occasions (median depth = 1,360 m), short-finned pilot whales (*Globicephala macrorhynchus*) on five (median depth = 1,500 m), common bottlenose dolphins (*Tursiops truncatus*) on six (median depth = 460 m), rough-toothed dolphins (*Steno*

¹ Only periods where the animal dove to ≥ 50 m were considered a dive. This change from previous field efforts was made to increase the likelihood of obtaining more complete dive records.

bredeanensis) on 34 (median depth = 800 m), spinner dolphins (*Stenella longirostris*) on eight (median depth = 84 m), pantropical spotted dolphins (*Stenella attenuata*) once (depth = 1,500 m), and sperm whales (*Physeter macrocephalus*) once (depth = 800 m). During the encounters, we took 33,452 photographs for individual identification, with photographs being added to long-term CRC regional photo-identification catalogs for short-finned pilot whales, bottlenose dolphins, and rough-toothed dolphins. Eighteen biopsy samples, of five species, were collected for genetics, with blubber samples stored for later analyses. Eight satellite tags were deployed on four species, with seven tag deployments funded by PACFLT (six SPLASH10-F and one SPLASH10) and one (a location-only SPOT6) by another grant to CRC.

As expected based on previous efforts off Kaua'i and Ni'i'hau, rough-toothed dolphins were the most frequently-encountered species, with 34 of 59 encounters (57.6%) being of this species. Group sizes ranged from 1 to 18 individuals (median=4). During the encounters 9,167 photos were taken and will be compared to CRC's photo-identification catalog for this species (Baird et al. 2008). Rough-toothed dolphins were a low-priority species for this effort, thus encounter durations were short (median=6.6 minutes). The only encounter that exceeded one hour in duration was with a mixed group of rough-toothed dolphins and melon-headed whales, and the encounter was extended in order to attempt tag deployments on melon-headed whales. Nineteen of the 34 encounters were on PMRF (Figure 2), and three of those groups were found in response to acoustic detections from M3R (60% of all encounters that occurred in response to acoustic detections). One sighting was of a mixed group of rough-toothed and bottlenose dolphins, only the third sighting of a mixed-species group involving those two species in a combined 756 sightings of the two species in CRC's Hawai'i dataset. One SPOT6 satellite tag was deployed on a rough-toothed dolphin and five days of locations were obtained. However, the tag stopped transmitting prior to the start of the SCC. During this period the individual moved across the southern part of PMRF several times and remained associated with Kaua'i and Ni'i'hau (Figure 3), at a median distance from shore of 11.9 km and at a median depth of 1,002 m. Six biopsy samples were collected from rough-toothed dolphins, from individuals from five different groups.

Short-finned pilot whales were encountered five times over three days from 17-19 August 2018, with three of the encounters south of PMRF, and two on PMRF (Figure 2). Group sizes ranged from 22 to 35 individuals (median=26). This was a high priority species, so encounter durations were extended (median=55.8 minutes, maximum=3.3 hours), and attempts were made to deploy satellite tags during all encounters. From the five encounters 11,723 photos were taken and compared to CRC's photo-identification catalog for this species (Mahaffy et al. 2015). From these there were 140 identifications representing 85 individuals, and the five sightings represented three different groups, with two of the three groups each seen twice. One of the groups seen twice was seen on two consecutive days, but individuals could not be approached close enough for tagging. The first sighting on 19 August 2018 on PMRF was in response to an acoustic detection, and that group was re-located later in the same day using information from a satellite tag deployed on an individual in the group. Overall four satellite tags (all SPLASH10-F) were deployed, with two tags deployed in each of two groups, one south of PMRF on 17 August 2018, and one on PMRF on 19 August 2018. Argos location data were obtained from three of the four tags, for periods of 13.6 and 37.2 days for the group tagged 17 August 2018, and for 23.0 days for the group tagged 19 August 2018. These sightings represent the first CRC sightings of pilot whales from the month of August off of Kaua'i or Ni'i'hau, despite 132 hours (1,996 km) of prior CRC research efforts there (in August 2013, August 2015, and August 2017). Five biopsy samples were collected from short-finned pilot whales, two from the first group encountered on 17 August 2018, and three from the group encountered on 19 August 2018.

Of the 85 photo-identified individuals, 63 had been previously documented, including individuals from all three groups. Twenty-one individuals were photo-identified in the group tagged on 17 August 2018, and of those 12 had been previously documented, all off the island of Hawai'i. Of the 12, four had been documented almost 11 years earlier (in October 2007), and eight had been documented 14 months prior (in June 2017). This group has been linked by association with individuals from the resident eastern community of short-finned pilot whales. However, the tagged individuals spent most of their time offshore (filtered Argos locations, median distance from shore = 73.3 km, maximum = 204.2 km), at a median depth of 4,215 m. The two tagged individuals in this group remained closely associated over the period the tags were attached (Figure 4). This group moved from south of Kaua'i to north of O'ahu, between O'ahu and Moloka'i and then into deep water to the southwest of O'ahu, before moving to off of Hawai'i Island (Figure 5). This group was far to the southeast of Kaua'i when the SCC started, thus it will not be possible to assess MFAS exposure and response of this group. From the two tags deployed on individuals in this group, 278 (GmTag212) and 308 (GmTag213) Fastloc-GPS locations were obtained that met filtering criteria. We compared the resolution of data from Argos and the Fastloc-GPS for GmTag213 for the period of overlap of these two data streams. After filtering there were 114 Argos locations (median interval = 1 hr, 25 min, max = 9 hr, 5 min) versus 308 Fastloc-GPS locations (median interval = 37 minutes, maximum = 4 hr, 19 min). Behavior data (dives and surfacing periods) were obtained for 8.1 (GmTag212) and 10.2 days (GmTag213), representing 77.4% and 98.8% coverage for the period that behavior data were collected (Figure 6). The relatively high number of Fastloc-GPS locations and behavior coverage reflects that these tags transmitted well after the period that Fastloc-GPS locations and behavioral data were being collected (4 and 28 days, respectively), thus allowing for the transmission of data stored in the buffer for extended periods.

Thirty-seven individuals were photo-identified in the group tagged on 19 August 2018, 30 of which had been previously documented off either Kaua'i, O'ahu, or both islands. Individuals from this group had been previously documented in up to four different years and up to five previous times, and were linked by association with the western community of short-finned pilot whales (Baird 2016). Tag data were received from one of the two individuals (GmTag214) for a period of 23 days, during which time the individual remained associated with Kaua'i and Ni'ihau (Figure 7, filtered Argos locations median distance to shore = 6.9 km, median depth = 906 m). We compared the resolution of data from Argos and the Fastloc-GPS for GmTag214 for the period of overlap of these two data streams. After filtering there were 91 Argos locations (median interval = 1 hr, 4 min, max = 11 hr, 11 min) versus 196 Fastloc-GPS locations (median interval = 45 minutes, maximum = 5 hr, 24 min). Behavior data were available for 8.3 days, representing 99.3% coverage for the period that behavioral data were collected (Figure 6). As with the tags deployed on 17 August 2018, the high number of Fastloc-GPS locations and almost complete behavioral coverage for the period of interest around the SCC reflects the long period (15 days) that the tag continued to transmit after the period that Fastloc-GPS and behavioral data were being collected. This individual was on or near PMRF from 21-22 August 2018, the period of the SCC, so data should be available to assess exposure and response to mid-frequency active sonar.

No tags were deployed on individuals in the group seen on both 17 and 18 August 2018. During these two encounters a combined 27 individuals were photo-identified, and of those 21 had been previously documented, all off the island of Ni'ihau during a CRC research effort there in September 2015. During the 2015 effort two individuals in the group were satellite tagged, and movement data were obtained for 18 days. Based on the tag data those individuals remained

strongly associated with Kaua'i and Ni'ihau and were thus considered to be from an insular population (Baird et al. 2017).

Melon-headed whales had only previously been documented in CRC effort off Kaua'i or Ni'ihau in three different periods, once in June 2003, three times over a 6-day period in June 2008, and four times in August 2017. In August 2018 there were two additional sightings, both of a large group, estimated at 140 individuals in both sightings. During the first sighting (on 7 August 2018) two SPLASH10-F satellite tags were deployed, although transmissions were received from only one tag. The tag transmitted for a 9.4-day period, during which time the tagged individual remained associated with Kaua'i, Ni'ihau, and the area to the south and southwest of Ni'ihau (Figure 8). This tag stopped transmitting prior to the SCC. Two biopsy samples were collected from melon-headed whales from the group encountered 7 August 2018.

The pantropical spotted dolphin sighting, with an estimated group size of 40 individuals, was only the 12th sighting off Kaua'i or Ni'ihau since CRC effort began in 2003. One location-depth satellite tag was deployed on an individual in this group, although only one location was obtained from this tag. Four biopsy samples were obtained from this group, and could be used to assess whether the group is likely part of a pelagic population, as has been evidenced for other groups of spotted dolphins off Kaua'i (Courbis et al. 2014; Baird et al. 2018).

Common bottlenose dolphins were encountered on six occasions in depths ranging from 13 to 670 m (median = 460 m), in groups ranging from 1 to an estimated 40 individuals (median = 17.5 individuals). No tags were deployed on bottlenose dolphins, although photographs (a total of 3,954) are being compared to the CRC photo-identification catalog for this species (Baird et al. 2009). One biopsy sample was collected from a bottlenose dolphin.

Spinner dolphins were seen on eight occasions but only six of the eight groups were approached. Encounter durations ranged from less than one minute to seven minutes (median = three minutes). Depths of the six groups ranged from 15 to 250 m (median = 84.5 m), and group size ranged from 4 to approximately 100 individuals. Photographs (a total of 1,042) were taken for contribution to future spinner dolphin studies.

The sperm whale sighting was cued by an acoustic detection by M3R, although the one individual whale that was closely approached was first found south of PMRF. Based on a combination of sightings and the locations of positions obtained by acoustic monitoring, the sperm whale group was spread over a wide area of at least 10 x 3 km. This was only the third year and fourth sighting of sperm whales during CRC research effort off Kaua'i and Ni'ihau, with the previous sightings in June 2003 and October 2014.

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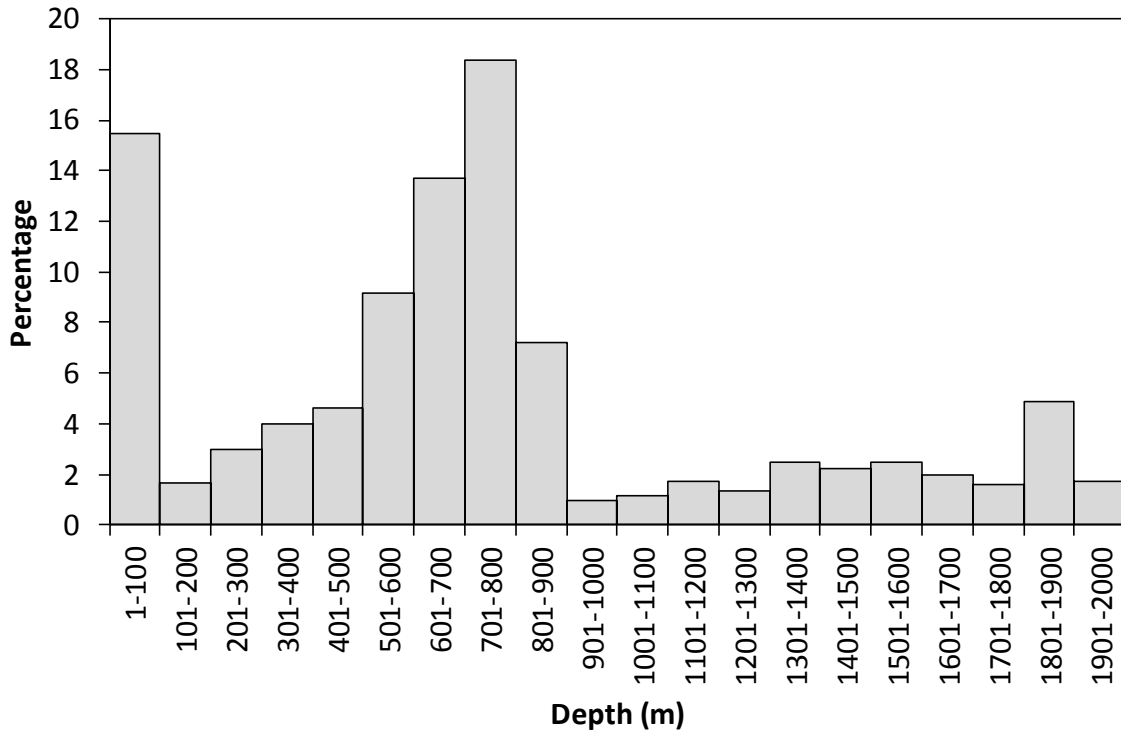


Figure 1. Depth distribution of search effort during 15 days of effort from 6-20 August 2018. Note there was a single effort location recorded at a depth >2,000 m (2,140 m), not shown here as it represents only 0.08% of the total effort.

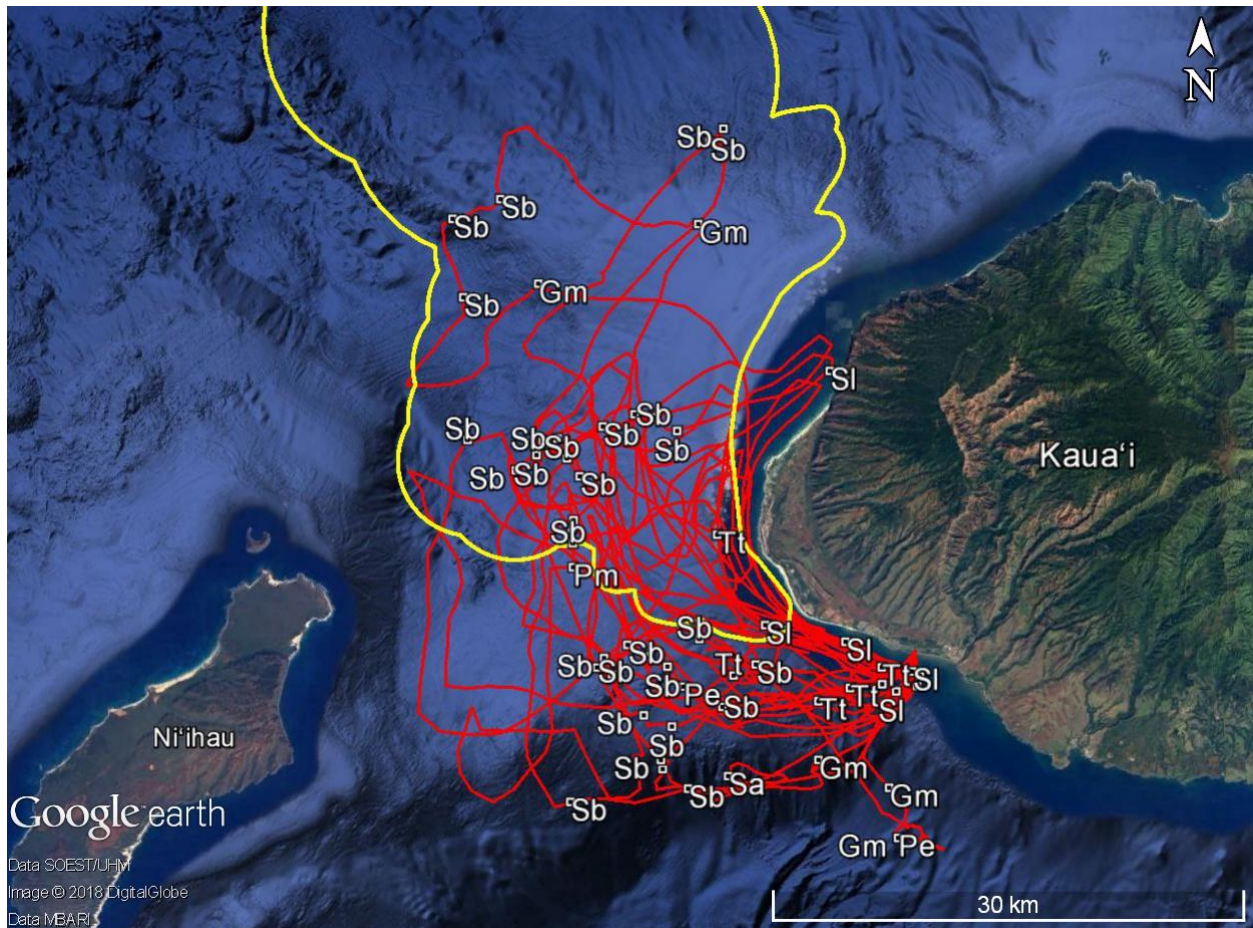


Figure 2. Search effort (red lines) and odontocete sightings (white squares) over 15 days from 6-20 August 2018. Species are indicated by two-letter codes (Sb = *Steno bredanensis*, Tt = *Tursiops truncatus*, Gm = *Globicephala macrorhynchus*, Sl = *Stenella longirostris*, Pe = *Peponocephala electra*, Pm = *Physeter macrocephalus*, Sa = *Stenella attenuata*). The PMRF outer boundary is indicated in yellow.

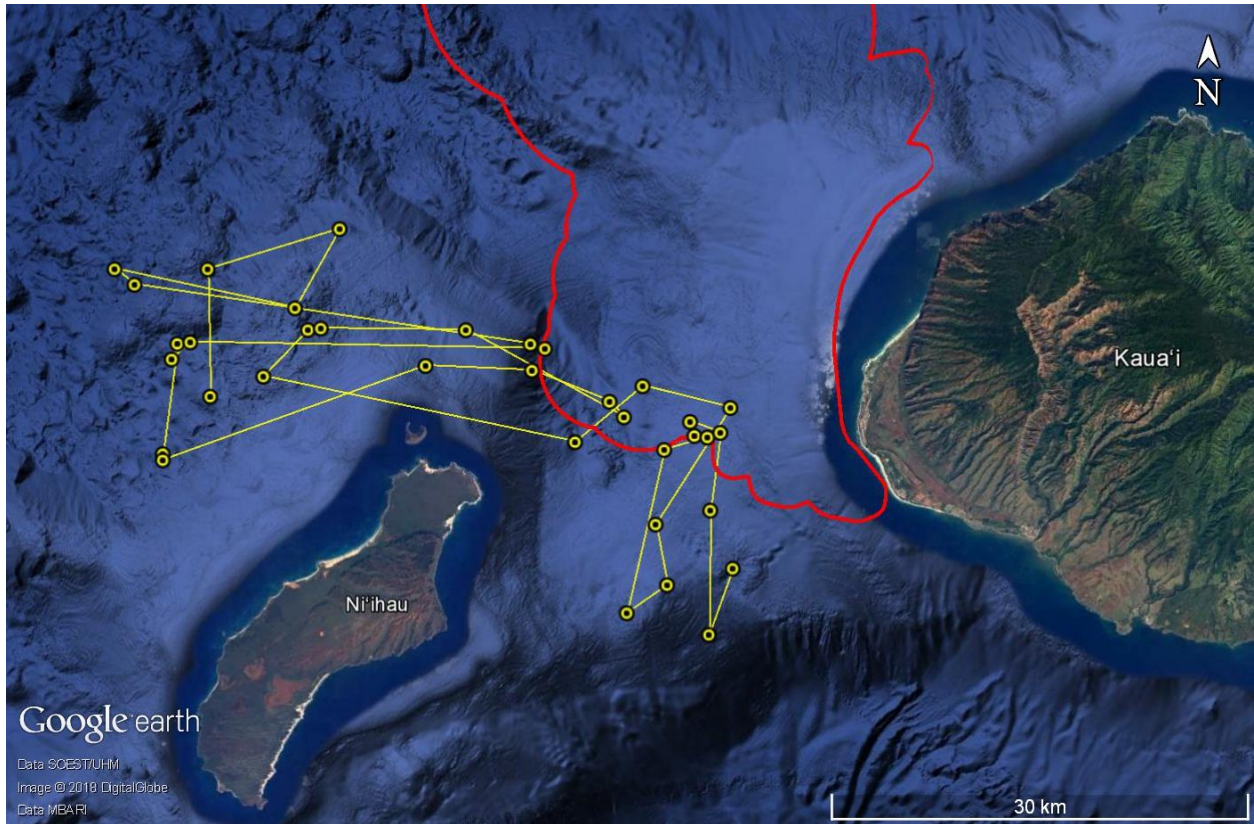


Figure 3. Filtered Argos locations from a satellite-tagged rough-toothed dolphin over a five-day period from 9-14 August 2018. The PMRF boundary is shown in red.

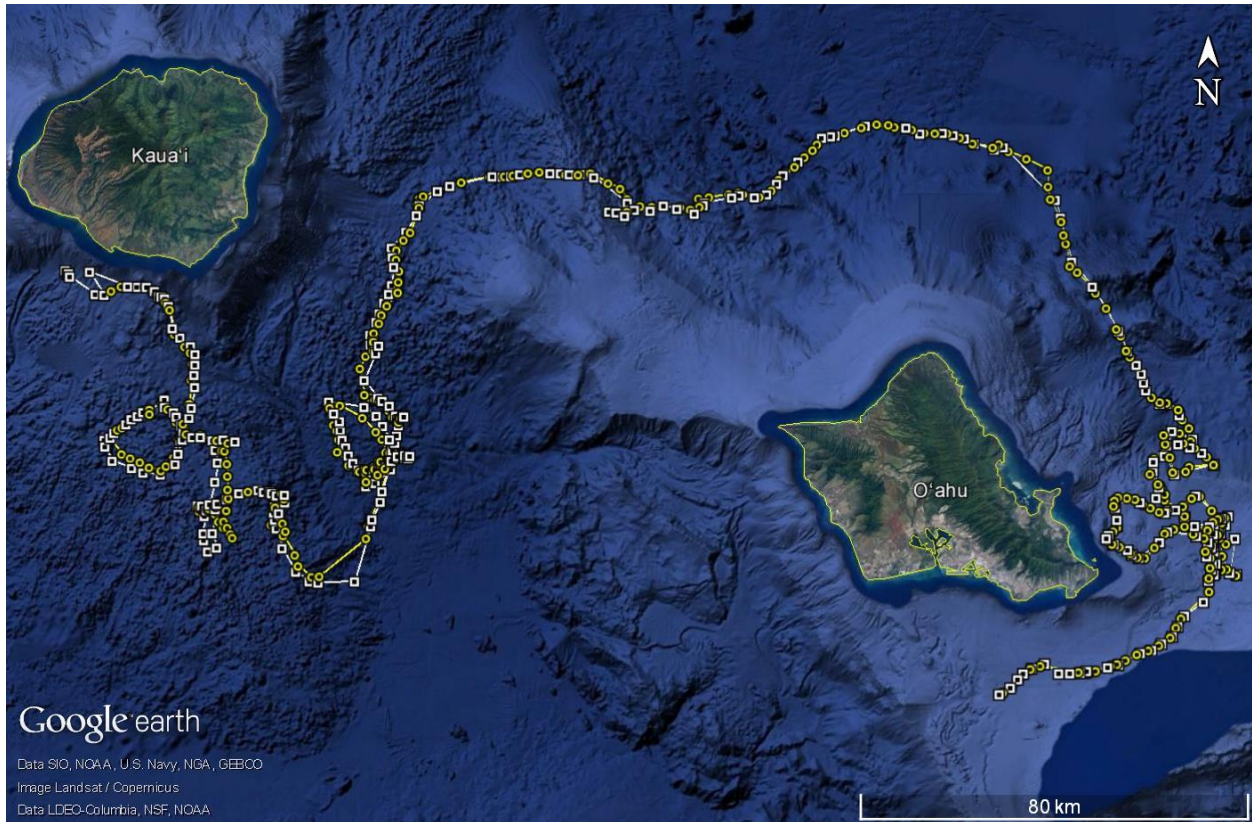


Figure 4. Fastloc-GPS locations from GmTag212 (white squares, $n=278$) and GmTag213 (yellow circles, $n=308$) over an 11-day period from 17-27 August 2018, showing the two individuals remained closely associated during this period.

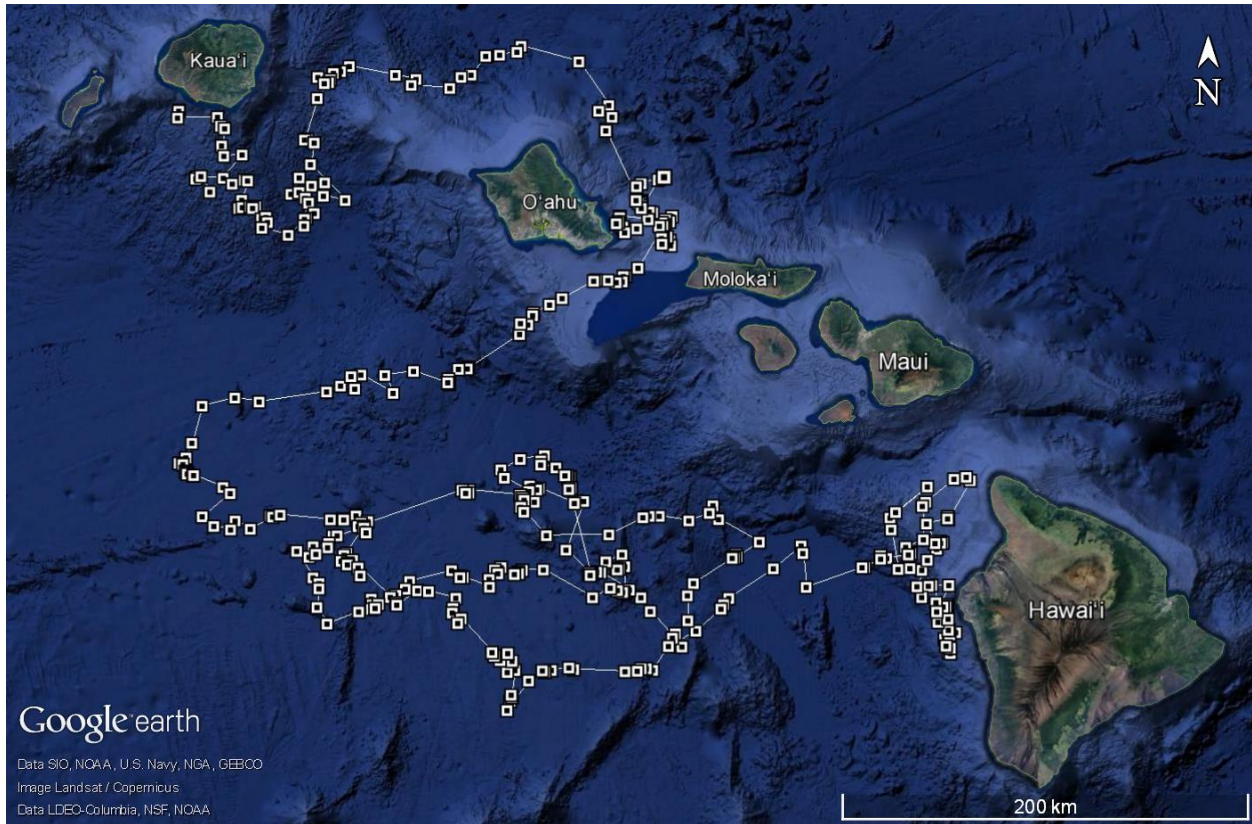


Figure 5. Filtered Argos locations from a satellite-tagged short-finned pilot whale (GmTag213) over a 37-day period from 17 August to 24 September 2018.

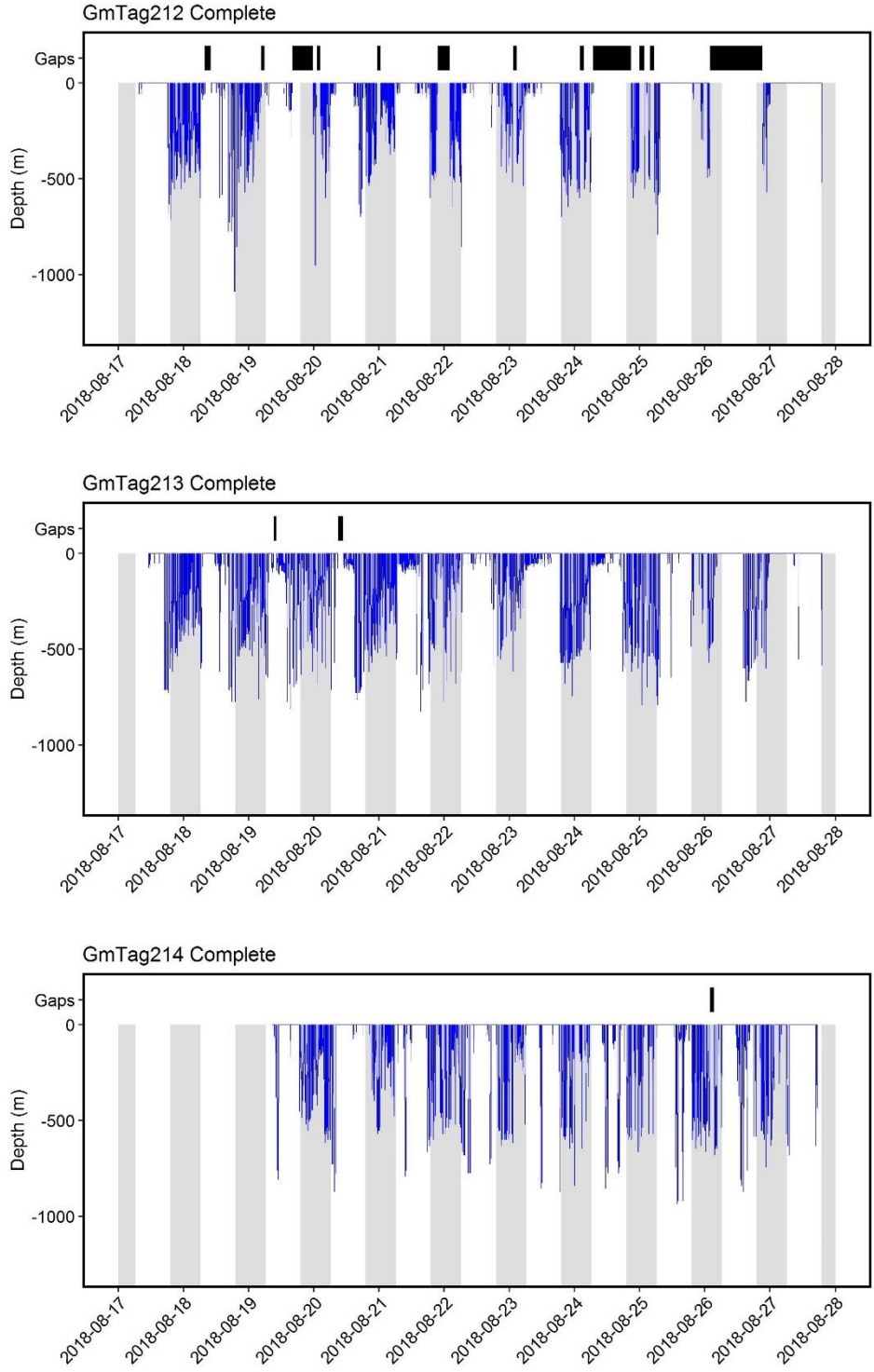


Figure 6. Behavior data from three satellite-tagged short-finned pilot whales: GmTag212 (top), GmTag213 (middle) and GmTag214 (bottom). Dives greater than 50 m are shown; when the whales were <50 m the tag records “surface” periods, indicated by a line at 0-m. The x- and y-axis scales are the same for comparison. The alternating vertical bars represent night (gray) and day (white). Black lines at the top represent gaps in dive and surface data.

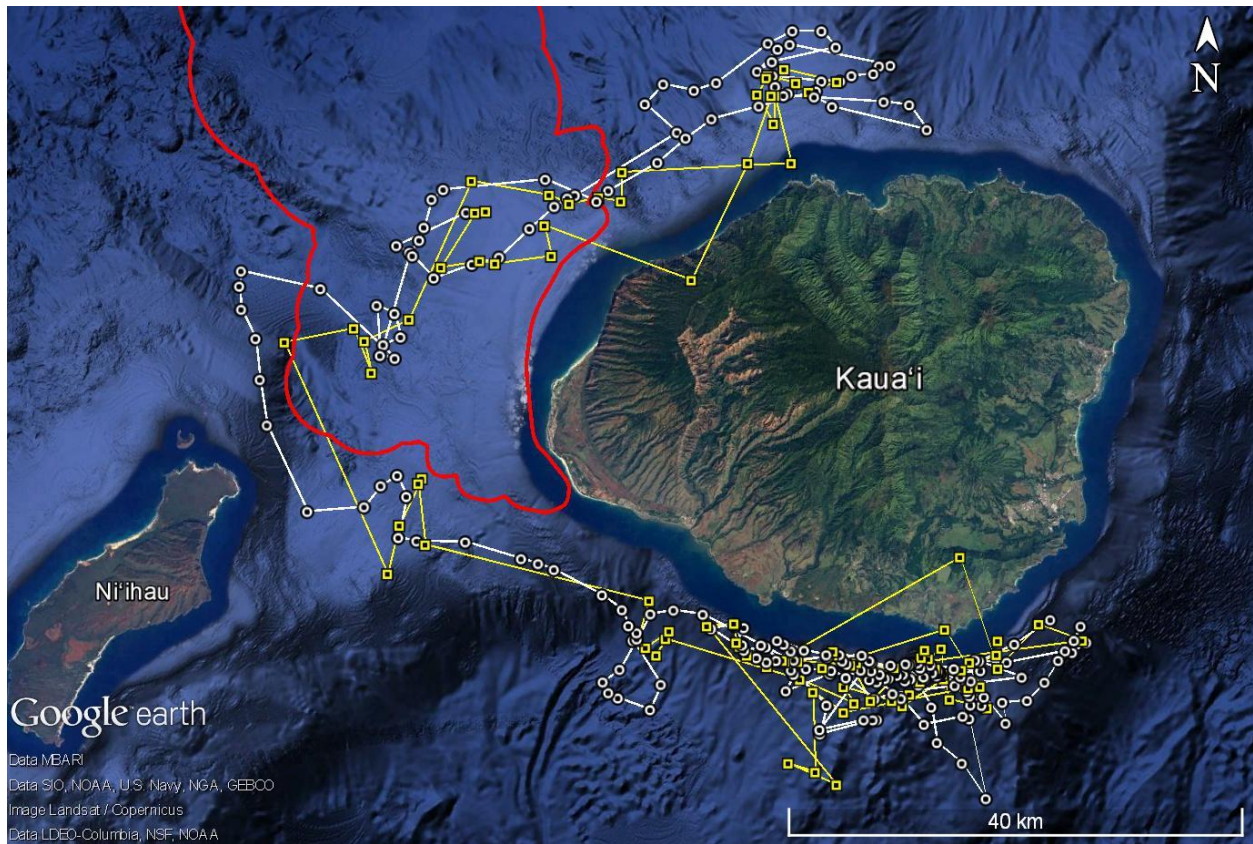


Figure 7. Filtered Argos locations (yellow squares) and Fastloc-GPS locations (white circles) from a satellite tagged short-finned pilot whale (GmTag214) for the period where both location types were received, over a nine-day period from 19-27 August 2018. Consecutive locations are joined by lines. The PMRF boundary is outlined in red.

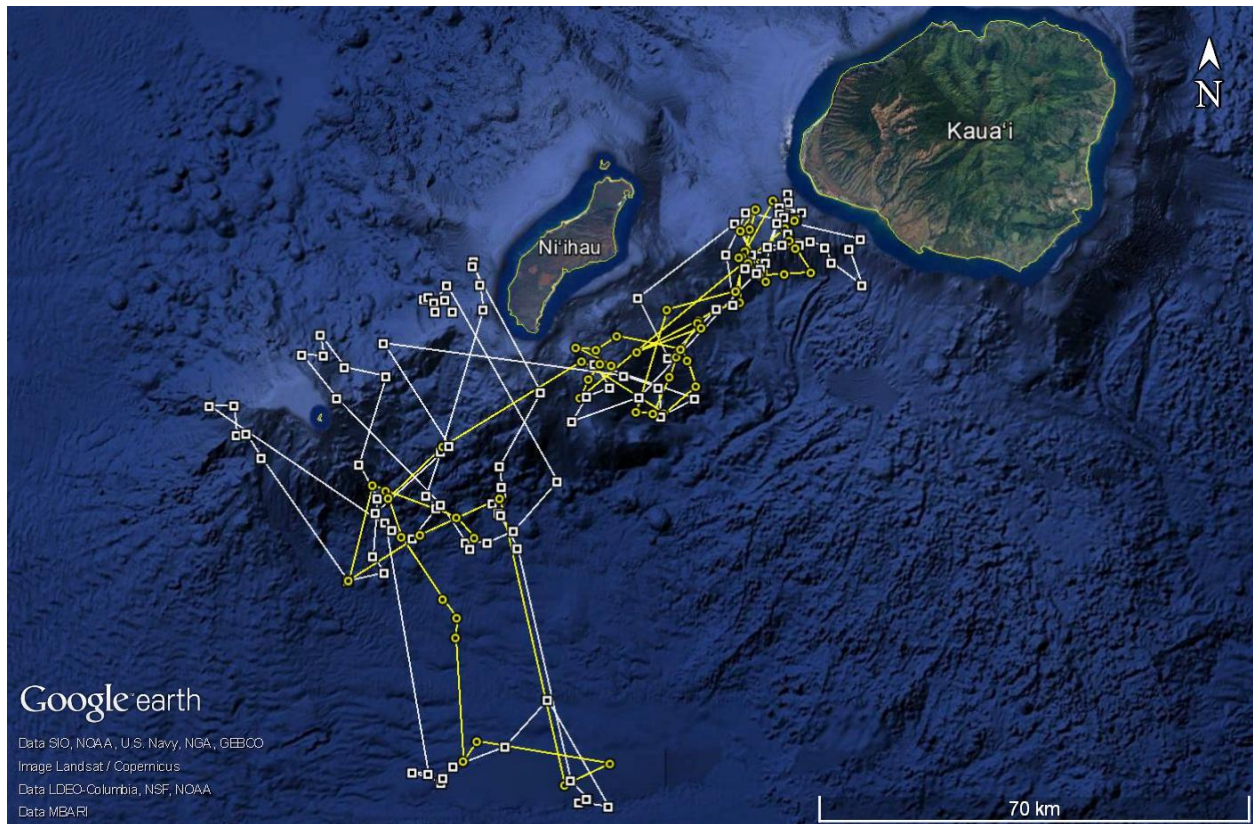


Figure 8. Movements of a satellite-tagged melon-headed whale over a 9.4-day period from 7-17 August 2018. Both filtered Argos locations ($n=105$, white squares) and Fastloc-GPS locations ($n=60$, yellow circles) are shown. The majority of Fastloc-GPS locations (49) were received prior to 12 August, when the whale was to the southwest of Ni'ihau, thus the relative lack of overlap of locations from the two data streams in that area.