doi:10.7289/V5/DR-PIFSC-17-002

Cetacean Monitoring in the Mariana Islands Range Complex, 2016[1]

Marie C. Hill[2,3], Andrea R. Bendlin[4], Adam C. Ü[4,5], Kymberly M. Yano[2,3], Amanda L. Bradford[3], Allan D. Ligon[6], and Erin M. Oleson[3]

[2] Joint Institute for Marine and Atmospheric Research
Research Corporation of the University of Hawai‘i
1000 Pope Road, Honolulu, Hawai‘i 96822, U.S.A.

[3]NOAA Fisheries
Pacific Islands Fisheries Science Center
1845 Wasp Blvd. Building 176, Honolulu, Hawai‘i 96818, U.S.A.

[4]Lynker contractor for
Pacific Islands Fisheries Science Center
1845 Wasp Blvd., Building 176, Honolulu, Hawai‘i 96818, U.S.A.

[5]PO Box 1329, Maple Falls, Washington 98266, U.S.A.

[6]3341 N 27th Ave, Unit 27, Bozeman, Montana 59718, U.S.A.

Suggested citation:

Hill M.C., A.R. Bendlin, A.C. Ü, K.M. Yano, A.L. Bradford, A.D. Ligon, and E.M. Oleson. 2017. Cetacean Monitoring in the Mariana Islands Range Complex, 2016. Prepared for the U.S. Pacific Fleet Environmental Readiness Office. PIFSC Data Report DR-17-002. 46 pp. doi:10.7289/V5/DR-PIFSC-17-002.

[1] PIFSC Data Report DR-17-002
Issued 3 February 2017

Mission

The Pacific Islands Fisheries Science Center's (PIFSC) Cetacean Research Program (CRP) has been conducting visual surveys for cetaceans in the waters surrounding Guam and the Commonwealth of the Northern Mariana Islands (CNMI) as part of an ongoing effort to develop a record of cetacean occurrence in the region. Visual surveys have been conducted aboard small boats (7.6–12.2 m) since 2010 off the southernmost islands of the Mariana Archipelago (Guam, Rota, Saipan, Tinian, and Aguijan). These surveys include the collection of photographs for individual identification, tissue samples for genetic analysis of population structure, and the deployment of satellite tags for assessment of individual movements throughout the broader region. These surveys are conducted in partnership with the Commander, U.S. Pacific Fleet Environmental Readiness Division, which is mandated by Letters of Authorization and Biological Opinions issued under the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA) to monitor cetaceans within the Mariana Islands Training and Testing (MITT) study area. Data sets from the small-boat survey efforts are used to evaluate the distribution, stock structure, and movements of cetaceans within the study area. This report includes a summary of the most recent visual surveys that were conducted in the "winter" (March) and "summer" (MayJune) of 2016.

Methods

Field Methods

Winter Visual Surveys

Visual surveys, with a primary focus on humpback whales (*Megaptera novaeangliae*) were conducted aboard a 12.2-m sport-fisher with flying bridge and twin-diesel inboard engines (*Sea Hunter)* and from multiple shore stations during March 2016. Small-boat surveys were focused on shallow reefs offshore of Saipan, particularly Chalan Kanoa (CK) and Marpi, where humpback whales were observed in previous years. The survey vessel traveled at a speed of 15–19 km/h, depending on sea conditions. Four to 5 observers scanned for marine mammals with unaided eye, collectively searching 360 degrees around the vessel. Each cetacean group was approached for species confirmation, group-size estimates and photo-identification. Biopsy sampling was conducted for certain species including humpback whales. The captain allowed the observer team to operate the vessel when approaching cetaceans for photo-identification and biopsy sampling. Photo-identification and biopsy sampling protocols were the same as those described by Hill et al. (2014). During small-boat surveys, the occurrences and locations of turtles were recorded but photos and biological samples were not collected. Shore-based observations were made from elevated stations at locations around Saipan and Tinian as observers scanned the waters with unaided eye or using 10× power binoculars.

Summer Visual Surveys

During May–June 2016 non-systematic visual surveys for cetaceans were conducted from small vessels off Saipan, Tinian, Aguijan, Rota, and Guam. Surveys off Saipan, Tinian, and Aguijan were conducted using *Sea Hunter* and a 7.9-m Regulator with twin 4-stroke outboard engines (*Regulator*). Surveys around Rota were conducted aboard a 7.6-m Yamaha Tackle with twin 2-stroke outboard engines (*Asakaze*), while those off Guam were conducted aboard and 8.3 m Phoenix Marina with flying bridge and twin diesel inboard engines (*Ten27*). Visual survey effort was designed to cover representative habitat within the study area and vessel tracks were spread out from day to day to ensure broad survey coverage over a wide range of depths. Weather and sea conditions also dictated the direction and scope of the survey effort. The survey vessels traveled at a speed of 15–26 km/h, depending on the size of the vessel and sea conditions. Four to 5 observers scanned for marine mammals with unaided eye, collectively searching 360 degrees around the vessel.

All cetacean groups were approached for species confirmation, group size estimates, and photo-identification. Biopsy sampling, satellite tagging, and passive acoustic recording operations were conducted during encounters with priority species. Photo-identification, biopsy and satellite tagging protocols were the same as those described by Hill et al. (2014, 2015). Captains allowed the observer team to operate the vessel when approaching cetaceans for photo-identification, biopsy, and satellite tagging. Passive acoustic recordings were made using a Compact Acoustic Recording Buoy (CARB) that was deployed from the small boat and remained free floating while the survey team conducted photo-ID and biopsy sampling operations. Occurrences and locations of turtles were recorded but photos and biological samples were not collected.

Data Processing and Analyses

Visual Surveys and Encounters

Visual survey and encounter data were analyzed using the same methods and bathymetry data as those described in Hill et al. (2014, 2016b).

Satellite Telemetry

The same methods as those described in Hill et al. (2014, 2015) were used to process and analyze the satellite tag location data. The data included in these analyses were derived from satellite tags deployed during the 2016 summer small-boat effort.

Photo-Identification

Photo processing and analysis was continued to add to existing individual photo-identification catalogs and protocols were identical to those described in Hill et al. (2014).

Results

Visual Surveys and Encounters

Winter

Small-boat visual surveys were conducted off of Saipan, Tinian, and Aguijan during 2–13 March 2016. A total of 868 km of trackline was surveyed during 9 days (Table 1, Fig. 1). Beaufort sea states along most of the on-effort trackline ranged 4-6 (92%, 802 km) and dominant swell heights were 4-8 ft (70%, 607 km) (Fig. 2). Survey efforts were focused on shallow waters (< 200 m) where humpback whales were expected based on known breeding and calving habitat in other locations (Herman and Antinoja, 1977; Frankel et al. 1995). More than half (51%, 30 h) of the on-effort time was spent over water depths 0–200 m (Fig. 3).

During the small-boat visual surveys, 15 encounters occurred with 3 cetacean species including humpback whales, bottlenose dolphins (*Tursiops truncatus*), and spinner dolphins (*Stenella longirostris*) (Table 2, Fig. 1). There were 7 humpback whale encounters with 5 mother-calf pairs including 1 same-day re-sight. Fluke images were collected from one mother and body and dorsal hump photos were used to distinguish the other individuals. Biopsy samples were collected from all 5 mothers. All but 1 of the humpback whale encounters were on Marpi Reef, and all encounters were over water depths < 100 m. Two bottlenose dolphin encounters occurred off the west side of Saipan, one of which was on CK Reef. The best group size estimate for both bottlenose dolphin groups was 5 individuals. A single biopsy sample was collected from a bottlenose dolphin. The individual was in the existing photo-id catalog but had not been previously sampled. Spinner dolphins were encountered off the west side of Saipan, off the east side of Tinian, and on Marpi Reef. All spinner dolphin encounters (n = 15) were over water depths < 100 m and group sizes ranged between 3-124 individuals. A total of 27 sea turtles were observed during the small-boat cetacean surveys; 14 were identified as green sea turtles (*Chelonia mydas*) and 1 was identified as a hawksbill sea turtle (*Eretmochelys imbricata*) (Table 3). The rest were not identified to species. Sea turtle sighting data were provided to the PIFSC Marine Turtle Biology and Assessment Program (MTBAP).

Between 5 and 13 March, shore-based observations were conducted from elevated stations around Saipan (Fig. 4) to look for humpback whales. On some days, shore-based observations were conducted from locations along the northern Saipan coastline when the small boat was on the water, however efforts were not coordinated. Other shore-based observations were conducted from locations around Saipan when the conditions were too rough for small-boat operations. On 8 March, the survey team split into 3 groups to conduct shore-based observations around Saipan and Tinian (Fig. 4). No humpback whales were seen from shore stations during any observation day. One group of spinner dolphins was observed from a shore station on the west side of Saipan overlooking the Smiling Cove boat channel. The dolphins were observed inside of channel marker 2 but outside of the fringing reef.

Summer

Small-boat visual surveys were conducted in the waters surrounding Saipan, Tinian, Aguijan, Rota, and Guam on 24 days during 7 May–5 June 2016 (Table 1). A total of 1,942 km of trackline was surveyed and most was in Beaufort sea states of 2–4 (78%, 1,517 km) and swell heights of 0–4 ft (78%, 1,522 km) (Table 1, Fig. 6). A little more than 16% (22.7 h) of the total time on effort was spent inside of the 100-m depth contour (Fig. 7). Similar survey effort was made across depth bins of 101–500 m (25 h) and 901–1300 m (24.1 h). Just under half of the total effort (40%, 49 h) was spent surveying over water depths of 501–900 m. Effort was lowest and reduced gradually over depths of 1,300–2,700 m (Fig. 7).

A total of 42 cetacean groups were encountered during the small-boat surveys resulting in the collection of approximately 11,000 photos, 43 biopsy samples, 3 acoustic recordings, and the deployment of 9 satellite tags (Table 3, Figs. 5a–c). All but 2 of the cetacean groups were identified to species. The confirmed species include bottlenose dolphins, spinner dolphins, pantropical spotted dolphins (*Stenella attenuata*), rough-toothed dolphins (*Steno bredanensis*), short-finned pilot whales (*Globicephala macrorhynchus*), sperm whales (*Physeter macrocephalus*), and dwarf sperm whales (*Kogia sima*). The two other groups were Mesoplodon beaked whales.

Spinner dolphins were the most frequently encountered species (n = 15) (Tables 3, 5a–c; Fig. 5). All encounters were in depths < 100 m and most (n = 11) were within 2 km from shore (Table 5). Group sizes ranged from 3 to 124 individuals and Young of the Year (YOY) or neonates were present during 50% of the encounters. More than 2,100 photos were collected for photo-id.

Pantropical spotted dolphins were the second most frequently sighted species (n = 9) during the summer surveys and most encounters were off Guam (Tables 3, 5; Figs. 5a–c). The median depth of the encounter locations was 819 m, and the median distance from shore was 6.1 km (Table 5). Group sizes ranged from 5 to 135 individuals and YOY were present during 3 encounters. A single satellite tag was deployed. This was the first satellite tag deployed on a pantropical spotted dolphin in the Marianas. One of the encounters included bottlenose dolphins and short-finned pilot whales.

Bottlenose dolphins were encountered 4 times during the small-boat surveys including 1 group re-sighted on the same day. Three of the four encounters were off Guam and included other species (pantropical spotted dolphins and short-finned pilot whales) (Table 3, Figs. 5a,c). The other encounter was off Saipan during which a single biopsy sample was collected. The median depth of the encounter locations was 712 m, and the median distance from shore was 7.0 km (Table 5). Group sizes ranged from 4 to 10 individuals. More than 300 photos were collected for photo-id.

There were 4 short-finned pilot whale encounters, all of which were off Guam and with other species (bottlenose dolphins, pantropical spotted dolphins, and rough-toothed dolphins) (Table 3, Fig. 5c). The median depth of the encounter locations was 715 m and the median distance from shore was 4.9 km (Table 5). Group sizes ranged from 31 to 48 individuals. Approximately 5,000 photos were collected for photo-id and 31 biopsy samples were collected for genetic analysis. Six satellite tags were deployed to investigate movements, spatial use, and diving behavior.

Dwarf sperm whales were encountered 4 times off the west side of Guam (Table 3, Fig. 5c). The median depth of the encounter locations was 747 m, and the median distance from shore was 2.6 km (Table 5). Two of the encounters were with the same 2 mother-calf (neonate) pairs. A biopsy sample was collected from 1 mother and acoustic recordings were made during both mother-calf encounters. These recordings are 2 of the only 3 recordings of confirmed dwarf sperm whales in the wild (K. Merkens, pers. comm). A spectrogram of the Kogia's narrow-band high-frequency clicks is shown in Figure 8. A third acoustic recording was attempted during the first dwarf sperm whale encounter, with a single individual, but no vocalizations were detected.

Rough-toothed dolphins were encountered 3 times during the May–June small-boat surveys (Table 3, Figs. 5a,c). The median depth of the encounter locations was 732 m, and the median distance from shore was 6.8 km (Table 5). The first encounter was off Saipan with a group of 5 individuals; 4 of which were recognized in the field as members of the existing photo-id catalog that had been photographed off Saipan and Aguijan in previous years. Individual rough-toothed dolphins were encountered off of Guam during 2 separate short-finned pilot whale encounters. Photos were taken of only 1 dolphin and therefore it cannot be determined if it was the same individual during both encounters.

Sperm whales were encountered twice off Saipan and once off Guam (Table 3, Figs. 5a,c). The median depth of the encounter locations was 1,173 m, and the median distance from shore was 12.1 km (Table 5). Group sizes ranged from 9 to 15 individuals, and a neonate was present during the encounter off Guam. A total of 1,715 photos and 8 biopsy samples were collected. Two satellite tags were deployed; one off of Saipan and another off of Guam. These were the first satellite tags deployed on sperm whales in the Marianas.

Mesoplodon beaked whales were encountered off Rota and Guam (Table 3, Figs. 5b,c). No photos were collected during the encounter off Rota and only dorsal portion of the body (without head) photos were collected during the encounter off Guam. As a result, species could not be determined. The median depth of the encounter locations was 1,140 m, and the median distance from shore was 14.9 km (Table 5).

A total of 26 sea turtles were observed during the May–June small-boat surveys; 8 were identified as green sea turtles (Table 4). The rest were not identified to species. Sea turtle sighting data were provided to the PIFSC MTBAP.

Satellite Telemetry

During the summer small-boat surveys, satellite tags were deployed on sperm whales, short-finned pilot whales, and a pantropical spotted dolphin (Table 6). Two satellite tags were deployed on sperm whales. A location-only (SPOT5) satellite tag was deployed on an adult sperm whale off Saipan on 17 May. The tag transmitted for 41.8 d during which the whale traveled north almost as far as Guguan before returning south (Fig. 9). The second satellite tag, deployed on an adult sperm whale encountered off Guam on 31 May, was a location-depth (SPLASH10) tag. The tag transmitted for 9.7 d during which the whale moved offshore to the west of Guam then north (Fig. 9). The whale was 78 km west of Tinian when the tag stopped transmitting. A total of 285 locations from both tags remained after the Douglas Argos filtering (DAF) process. The median depth of the DAF locations was 2,448 m and the median distance from shore was 34.4 km (Table 6). The SPLASH tag recorded a maximum dive depth of 1,040 m and a maximum dive duration of 1 h to a depth of 196 m.

Six satellite tags (2 SPOT5, 4 SPLASH10) were deployed on short-finned pilot whales during 3 encounters off Guam during the May–June small-boat surveys (Table 6). Tag durations ranged 6.8–79.9 d and a total of 1,835 DAF locations were obtained. The median depth for the DAF locations was 786 m and the median distance from shore was 8.6 m. Most of the tag locations (82%; n = 1,511) were closer to Guam than the other islands (Fig. 10). The maximum dive depth recorded on the SPLASH10 tags was 1,168 m and the maximum dive duration was 22 min to a depth of 560 m.

A single SPOT5 satellite tag was deployed on an adult pantropical spotted dolphin during the summer small-boat surveys off of Guam. The tag transmitted for 11.4 d and 133 DAF locations were obtained (Table 6). The dolphin spent most of the time off the west side of Guam (Fig. 11). The median depth of the DAF locations was 1,020 m and the median distance from shore was 5.6 km (Table 6).

Photo-identification

Existing photo-identification catalogs for cetacean species within the Marianas include spinner dolphins, bottlenose dolphins, rough-toothed dolphins, short-finned pilot whales, false killer whales, and pygmy killer whales (Hill et al. 2013, 2014, 2015, 2016b). Photos from several species are currently being analyzed and are in various stages of completion. These species include humpback whales, short-finned pilot whales, bottlenose dolphins, melon-headed

whales, sperm whales, rough-toothed dolphins, spinner dolphins, and false killer whales. In addition to photos collected during small-boat surveys around the southernmost islands of the Marianas (Guam, Rota, Saipan, Tinian, and Aguijan), photos collected during a 2015 (May–June) PIFSC CRP shipboard survey of the entire Mariana Archipelago (Guam to Uracas (a.k.a. Farallón de Pájaros)) are also being analyzed for inclusion in existing and developing catalogs in order to investigate potential movements between the southernmost islands of the Mariana Archipelago and locations north of Saipan.

During the 2015 and 2016 winter (February–March) small-boat surveys, photos were collected during 23 encounters (including same-day re-sights) with humpback whales. Photos were also collected from an encounter with humpback whales during a 2007 shipboard cetacean survey within the Marianas (Fulling et al. 2011). The photos from all efforts were combined to form a Marianas humpback whale photo-identification catalog (Hill et al. 2016a). Of the 22 humpbacks encountered during the PIFSC CRP 2015-2016 effort, right side, left side, and ventral fluke photographs are available for 17, 17, and 3 individuals, respectively. The 3 PIFSC CRP fluke images were compared to 5 fluke photos taken during the 2007 encounter. One of the 2007 flukes was found to match the female photographed with her calf off the west side of Saipan in 2016 (Fig. 12). This information was reported to a subcommittee of the International Whaling Commission (IWC) during the June 2016 meeting (Hill et al. 2016a). The subcommittee recommended "that the data from the Mariana Islands are compared with other North Pacific humpback whale catalogues, especially those from Ogasawara and Okinawa to facilitate their use in an assessment of the North Pacific humpback whales." (International Whaling Commission 2016). There is currently an effort to look for matches between the Marianas cataloged individuals and existing humpback whales catalogs from the Philippines, Okinawa, and Ogasawara.

Short-finned pilot whales were not encountered in 2015, but were encountered 4 times during the 2016 small-boat surveys off Guam. Photos from these encounters have been fully processed and analyzed and new individuals have been added to the photo-id catalog. The catalog contains 191 individuals photographed between 2011 and 2016. Most of the individuals (73%) have been encountered and photographed more than once over multiple years. Data from the photo-id catalog are currently being analyzed to create a social network diagram and to look at movements between the southernmost islands.

Initial processing and matching has been completed for bottlenose dolphin photos collected during 2015–2016 encounters (n = 11). Checking of initial matches and quality rating assignments have been completed for 4 bottlenose dolphin encounters off Rota in 2015. Twenty-four previously cataloged individuals were present during these 4 encounters (with 8 re-sights between the 2015 Rota encounters). Seven new individuals met the quality and

distinctiveness qualifications to be added to the catalog, bringing the total catalog number to 59 individuals.

During 2014–2015 there were 6 melon-headed whale encounters, and the photos from all encounters have undergone initial processing and matching. Checking of initial matches is complete for 4 encounters from the 2015 PIFSC shipboard survey. Checking of initial matches and quality rating assignments is complete for the 2014 encounter off Saipan. Of the 214 distinct individuals present during the encounter, 146 met the criteria for photo quality and will be the first additions to the catalog. Preliminary matching between encounters suggests that some melon-headed whales move between southern and northern portions of the Archipelago.

Photos of sperm whales from 6 encounters between 2010 and 2016 have gone through initial processing and matching, as well as checking of matches. Fifteen individuals have been identified using complete fluke images. Potentially, 6 additional individuals are represented by partial fluke images. Three individuals photographed off Guam in February 2010 were re-sighted off Saipan in May 2016. Two encounters during the 2015 PIFSC shipboard survey, off Uracas and Agrihan in the northern portion of the Archipelago, are in the stages of initial processing and matching.

Rough-toothed dolphins were photographed during 2 encounters in 2016. Photos have undergone all stages of processing and analysis. Five individuals were present during the first encounter off of Saipan. Four of the individuals were part of the existing photo-id catalog. The fifth was added to the catalog, bringing the total to 7 individuals. The second encounter was with a single individual swimming next to short-finned pilot whales off Guam. The dorsal fin of the individual was very distinct and did not match any of those within the existing catalog; however the quality of the photo did not meet the criteria for entry into the catalog. During the 2015 shipboard survey, rough-toothed dolphins were encountered 4 times off the northern islands of Alamagan, Agrihan, and Guguan. Initial photo processing and matching has been completed for the encounter off of Guguan.

All spinner dolphin photos collected during small-boat survey encounters in 2014–2016 (n = 45) have undergone initial processing and matching. Matches have been checked for 8 encounters and quality ratings have been assigned for 3 encounters. Thirty-nine individuals within the existing catalog were re-sighted during the 3 completed encounters. Six new individuals will be added to the catalog, bring the total to 313 individuals.

Three false killer whale encounters occurred in 2015. One occurred during the small-boat surveys off Guam and the other 2 occurred during the shipboard surveys off Alamagan and Asuncion. The initial processing and matching of photos is underway.

Discussion

The 2016 winter and summer small-boat surveys off Saipan, Tinian, Aguijan, Rota and Guam represent a continuation of the collaborative effort between the PIFSC's CRP and the U.S. Navy towards a better understanding of the occurrence and distribution of cetaceans in waters off of the southernmost islands of the Mariana Archipelago.

The NMFS (PIFSC) is responsible for the assessment of marine mammal stocks in the Exclusive Economic Zone (EEZ) waters of Guam and the CNMI. The U.S. Navy is mandated by Letters of Authorization and Biological Opinions issued under the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA) to monitor cetacean presence within the Mariana Islands Training and Testing (MITT) study area. We discuss the preliminary results from the 2016 cetacean surveys in an effort toward answering questions presented within the U.S. Navy's monitoring plan below.

1. What species of beaked whales and other odontocetes occur around Guam and Saipan?
2. Are there locations of greater relative cetacean abundance around Guam and Saipan?

During the 2016 summer (May–June) visual surveys, two beaked whale encounters occurred with Mesoplodon beaked whales off Rota and Guam. The encounter location off Rota (Fig. 5b) was 1.7 km away from the June 2012 Mesoplodon beaked whale encounter location and had a similar water depth (1,202 m) as that of the 2012 encounter (1,020 m) (Hill et al. 2014). The second Mesoplodon beaked whale encounter was 24 km southwest of Guam just off the northeast corner of Galvez Banks (Fig. 5c). The encounter location depth was 1,078 m. This was the PIFSC CRP's first encounter of a beaked whale (or any species) at Galvez Banks during small-boat surveys.

Although questions about specific locations of greater relative cetacean abundance cannot be addressed at this time, habitat use (depth and distance from shore) and encounter rates reveal varying patterns for species occurring around Guam, Rota, Saipan, Tinian, and Aguijan. Patterns of habitat use by some odontocetes (e.g. spinner dolphins, pantropical spotted dolphins, bottlenose dolphins, short-finned whales) evident from the 2016 summer (May–June) visual surveys were similar to those described in previous years by Hill et al. (2014, 2015, 2016b), while new information emerged for other species (e.g. rough-toothed dolphins, dwarf sperm whales, sperm whales).

Spinner dolphins were once again the most frequently encountered species during the May–June 2016 visual surveys (n = 15; 0.77 encounters/100 km effort) and were found in similar locations as previous years (Hill et al. 2014, 2015, 2016b; Table 5, Figs. 5a–c). They were also encountered 7 times during the March 2016 surveys in locations 140–300 m from previous encounter locations (May–September in 2011–2015), which suggests they may use these areas

year-round. All 2016 encounter locations were in water depths < 100 m (Tables 46). Most of the encounters that were not on Marpi Reef were within 2.5 km from shore. Two encounters off the west side of Saipan were 3.8 km and 6.5 km from shore.

Pantropical spotted dolphins were the second most frequently encountered species (n = 9; 0.46 encounters/100 km effort) and were seen in all survey areas, but were encountered more times off Guam than the other islands (Table 5, Figs. 5a–c). As in previous years, pantropical spotted dolphins were encountered in the widest range of depths (581–2,247 m; Table 5). They also ranged broadly from shore and were found in locations 1.9–15.9 km away from the coast. A satellite tag deployment on a pantropical spotted dolphin encountered off Guam in June 2016 revealed movements of the individual that were not evident from visual survey and photo-id data. Hill et al. 2016b concluded that the creation of a photo-id catalog of pantropical spotted dolphins was not feasible given the low numbers of distinctive individuals and high-quality photos. It was therefore not possible to investigate the movements of individuals solely using photo data. The satellite tag data revealed that over a 11.4-d period the dolphin used the entire west side of Guam and traveled north toward Rota Bank, southwest out to 11-Mile Reef and around the southern tip of Guam to the east side of the island (Fig. 10). During this period, the tagged individual used locations that were 0.1–31.6 km from shore and had depths that ranged from 18 to 2,507 m.

Bottlenose dolphins were encountered a total of 5 times during the March and May–June 2016 small-boat surveys. Encounter locations had similar depths (29–799 m) and were at similar distances from shore (4–8.9 km) (Tables 4–6, Figs. 1,5a,b) as those in previous years (Hill et al. 2014, 2015, 2016b). The 2016 bottlenose dolphin encounters occurred off Saipan and Guam, unlike 2015 during which 4 of 5 encounters were off Rota (Hill et al. 2016b).

Short-finned pilot whales were encountered multiple times off the west side of Guam in depths (607–814 m) and distances from shore (2.7–8.5 km) similar to previous encounters (Hill et al. 2014, 2015). Satellite tags deployed on 6 whales indicate a greater use of nearshore areas off of Guam, with 82% of locations closer to Guam than the other islands and an overall median distance from shore of 8.6 km (Table 6, Fig. 9). The depths of the tag locations ranged from 6 to 2,971 m. Locations from the 2016 satellite tags are being combined with those from 2013–2014 to investigate areas of greatest use by short-finned pilot whales during JuneAugust when most of the location data have been recorded. The combined data suggest that the northwest side of Guam is an important area for these whales.

Rough-toothed dolphins were encountered in 2016 off the southeast side of CK Reef (Fig. 5a), west of Saipan, approximately 8 km from a 2013 encounter off the northwest side of the reef. The same four individuals have been encountered multiple times since 2013. The encounter location depth (384 m) and distance from shore (6.8 km) fell within the range of

previous encounters (Hill et al. 2014). 2016 was the first year that rough-toothed dolphins were encountered during the CRP small-boat surveys off Guam. During two separate short-finned pilot whale encounters, a single rough-toothed dolphin was observed. Whether this was the same individual rough-toothed dolphin cannot be determined because photos were collected during only one of these encounters. The Guam encounter locations ranged from 2.9 to 6.9 km from shore and at depths of 732–808 m.

Dwarf sperm whales were also encountered for the first time off Guam and were seen 4 times. Two of the 4 encounters occurred with the same 2 mother-calf pairs. The encounters were separated by a week but were only 2 km apart, indicating potential preference for the area near Agat Bay (Fig. 5c). The depths at the 4 encounter locations ranged from 642 to 870 m, similar to that (673 m) of the 2011 dwarf sperm whale encounter off Marpi Reef, 18 km north of Saipan (Hill et al. 2014). The 2016 Guam encounters ranged from 1.6 to 3.8 km from shore (Table 5).

Sperm whales were encountered 3 times during the May-June small-boat surveys. The encounters occurred off Saipan (n = 2; Fig. 5a) and Guam (n = 1; Fig. 5c) where sperm whales had been encountered in previous years. The encounter locations had similar depths (922–1,647 m) and were at similar distances from shore (9.1–18.3 km) as those in previous years (Hill et al. 2014). Satellite tags were deployed on two sperm whales for the first time in the Marianas, and the DAF locations indicated the use of separate and broad areas during the duration of the tags (Fig. 8). During a 41.8-d period, the first individual tagged off of Saipan went almost as far north as Guguan (approximately 220 km north of Saipan) and offshore 110 km. The second sperm whale, tagged off Guam, traveled up toward Saipan over a 9.7-d period and went 98 km offshore (Fig. 8). The tag location depths of the two sperm whales ranged from 197 to 4,260 m (Table 6).

3. What is the baseline abundance and population structure of odontocetes which may be exposed to sonar and/or explosives in the near shore areas of Guam, Saipan, Tinian, and Rota?

Although the CRP has produced photo-identification catalogs for spinner dolphins, bottlenose dolphins, short-finned pilot whales, pygmy killer whales, false killer whales, rough-toothed dolphins, and humpback whales, the encounter rate and number of distinctive individuals within each catalog may still be too small to conduct robust abundance analyses. The next step will be to evaluate the existing photo data to determine if such analyses are feasible for any of the cataloged species. It is not yet possible to determine how many animals may be impacted by explosive or sonar exercises in the region annually. While the areas of

underwater detonations and explosive ordnance use off Guam are known and we can begin to assess what species may be exposed, the specific areas of sonar exercises are unknown to us and we are unable to make any evaluation of exposure to cetacean species.

Located off Guam are 3 Navy training areas where underwater detonations occur. These include the Piti Mine Neutralization Area, the Agat Bay UNDET Area, and the Outer Apra Harbor UNDET Area (Fig. 13). The locations of cetacean encounters during small-boat surveys and tracks from satellite telemetry suggest that exposure to UNDET events may occur at Piti and Agat Bay sites, however it is unknown whether UNDETS occurred during the same timeframe. During the 2016 May–June surveys, groups of rough-toothed dolphins, short-finned pilot whales, and dwarf sperm whales were encountered in the vicinity of these two sites (Fig. 13a). Two of the dwarf sperm whale encounters were with the same 2 mother-calf pairs. These locations were 3.8 km and 2.7 km from the Agat Bay UNDET Area. Filtered satellite tag locations from short-finned pilot whales, as well the pantropical spotted dolphin were near both the Piti and Agat Bay sites; some within 500 m (Fig. 13b). The depth at the center of the Piti Mine Neutralization Area is 627 m, which falls into the range of the 2016 encounter locations for pantropical spotted dolphins, bottlenose dolphins, short-finned pilot whales, and rough-toothed dolphins (Table 5). The depth at the center of the Agat Bay UNDET Area is 1,862 m, which falls within the range of depths for locations recorded by the satellite tags deployed on the pantropical spotted dolphin, short-finned pilot whales, and sperm whales in 2016.

To date, cetacean groups have not been encountered during CRP small-boat surveys within Apra Harbor where the Outer Apra Harbor UNDET Area is located; however, DAF satellite tag locations from short-finned pilot whales and a pantropical spotted dolphin in 2016 were inside of Apra Harbor (Figs. 13–14). At least one of the short-finned pilot whale tag locations was of high enough quality (location quality (LC) 3) to indicate with certainty that the whale was inside of the harbor (Fig. 14a). There is less certainty for the other tag locations that fell inside of the harbor (Figs. 14a,b). Although the locations met the requirements of the DAF and were retained, there is still error associated with this type of (Doppler shift) satellite tag data. A tag location with a LC 3 has an estimated error of 250 m and a LC 2 has an estimated error of 500 m. Lower quality locations (e.g. LC B and LC 0) have no estimated error values. Therefore, some of the other short-finned pilot whale and the pantropical spotted dolphin tag locations may indicate use of Apra Harbor and close proximity to the Outer Apra Harbor UNDET Area but this cannot be stated with absolute certainty.

4. What is the seasonal occurrence of baleen whales around Guam, Saipan, Tinian, and Rota?

This was the second year that the observer team has encountered any baleen whale

during our small-boat surveys in the Marianas. The team specifically conducted surveys during March 2016 to coincide with the known seasonal occurrence of humpback whales off Saipan and Tinian based on the 2015 small-boat surveys, an encounter during a 2007 shipboard survey (Fulling et al. 2011), acoustic records (Oleson et al. 2015, Hill et al. 2016a, Fulling et al. 2011) and anecdotal reports. Encounter rates with humpback whales during 2015 and 2016 small-boat surveys were low, resulting in the contribution of 17 individuals (including 9 calves) to the photo-identification catalog of 22 total individuals (5 flukes were photographed in 2007). The lack of sightings during the shore-based observations may be a reflection of low numbers of whales using the area during the survey period. Although sea state conditions were rough during shore-based observations, whale blows should have been visible within several km from the elevated stations.

The fact that the observer team encountered 5 mother-calf pairs in which the calves were clearly YOYs (including a neonate) and the fact that 4 mother-calf pairs were observed in 2015 suggests that the Marianas may be a calving area. The re-sight of 1 of the mothers between 2007 and 2016 demonstrates site fidelity for some individuals (Hill et al. 2016a). This could be an important finding if these whales are part of the western North Pacific humpback population, which remains endangered while other North Pacific humpback populations have been delisted under the Endangered Species Act. As mentioned previously, matching with Western Pacific catalogs is ongoing.

No other baleen whales were observed in 2016. Bryde's whales (*Balaenoptera edeni*), encountered in August–September 2015, were the only other baleen whale species observed during the PIFSC small-boat surveys (Hill et al. 2016b). During 2010–2012, High-frequency Acoustic Recording Packages (HARPs) located off Saipan and Tinian detected other baleen whales including blue (*B. musculus*), fin (*B. physalus*) and minke (*B. acutorostrata*), however detection rates were low for these species (Oleson et al. 2015).

Acknowledgements
This project would not have been possible without logistical support and assistance from a great many individuals and organizations. We would like to thank our boat owners, captains and crews: Sam Markos, Ben Sablan, Aesha Sablan, Masao Tembata, Tim Hanley, and Mark and Lynne Michael.

We would like to thank Karlina Merkens for providing the *K. sima* spectrogram. We would like to thank all of the project assistants and volunteers that assisted with the surveys and provided logistical support for this project: Eric Cruz and Vincent Pangelinan (PIFSC-Guam), Mike Trianni (PIFSC-CNMI), Kalani Reyes (PIFSC-Guam), Steve McKagan and Dana Okano (PIRO-CNMI), Robert Brownell, Jr. (Southwest Fisheries Science Center), Sarah Mallette (Virginia Aquarium

and Marine Science Center), Roy Adsit (Saipan Southern High School), Jonathan Ball (Saipan Elementary School), David Calloway (Sumay Cove Marina), Henry Fandel (University of Washington), Caleb Morrison (U.S. Fish and Wildlife Service), Phil Fandel, Aaron Wuroi (University of Washington), Brent Tibbatts (Guam DAWR), and Taryn Mesa (University of Guam).

All operations in 2016 were conducted under NMFS permit 15240 and CNMI-DFW permit, license no. 03292-16.

Funding was provided by the Commander, U.S. Pacific Fleet, Environmental Readiness Division, and PIFSC. We would like to thank the individuals at Pacific Fleet (Julie Rivers, Julie Jervey, and Editha Yago) and PIFSC (Martha Kawai) who processed reams of paperwork to ensure that funds were provided for this work.

References

Frankel, A.S., Clark, C. W., Herman, L. M. and Gabriele, C. M. 1995. Spatial distribution, habitat utilization, and social interactions of humpback whales, Megaptera novaeangliae, off Hawaii, determined using acoustic and visual techniques Canadian Journal of Zoology. 73:1134–1136.

Fulling, G.L., P.H. Thorson, and J. Rivers. 2011. Distribution and abundance estimates for Cetaceans in the waters off Guam and the Commonwealth of the Northern Mariana Islands. Pacific Science 65(3):321-343.

Herman, L. M. and Antinoja, R. C. 1977. Humpback whales in the Hawaiian breeding waters: Population and pod characteristics. Scientific Reports of the Whales Research Institute. 29:59–85.

Hill, M.C., A.D. Ligon, M.H. Deakos, A.C. Ü, A. Milette-Winfree, A.R. Bendlin, and E.M. Oleson. 2014. Cetacean surveys in the waters of the southern Mariana Archipelago (February 2010 – April 2014). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. PIFSC Data Report DR-14-013. 49 pp. + Appendix.

Hill M.C., A.D. Ligon, E.M. Oleson, K.K. Martien, P.A. Morin, F.I. Archer, S. Baumann-Pickering, A.R. Bendlin, L. Dolar, K.P.B. Merkens, A. Milette-Winfree, A. Rice, K.M. Robertson, J.S. Trickey, A.C. Ü., A.M. Van Cise , and S.M. Woodman. 2015. Cetacean Monitoring in the Mariana Islands Range Complex, 2014. Prepared for the U.S. Pacific Fleet Environmental Readiness Office. PIFSC Data Report DR-15-003. 56 pp. + Appendices.

Hill, M.C., A.L. Bradford, A.D. Ligon, A.C. Ü, J. Rivers, R.K. Uyeyama, R.L. Brownell, Jr., and E.M. Oleson. 2016a. Are humpback whales (*Megaptera novaeangliae*) breeding and calving in the Mariana Islands? Prepared for the International Whaling Commission SC/66b/O/02. 9 pp.

Hill M.C., E.M. Oleson, S. Baumann-Pickering, A.M. VanCise, A.D. Ligon, A.R. Bendlin, A.C. Ü, J.S. Trickey, and A.L. Bradford. 2016b. Cetacean Monitoring in the Mariana Islands Range Complex, 2015. Prepared for the U.S. Pacific Fleet Environmental Readiness Office. PIFSC Data Report DR-16-01. 36 pp. + Appendix

International Whaling Commission. 2016. Report of the Scientific Committee. 7-19 June 2016, Bled, Slovenia. IWC/66/Rep01(2016). 138 pp.

Oleson, E.M., S. Baumann-Pickering, A. Sirovic, K.P. Merkens, L.M. Munger, J.S. Trickey, and P. Fisher-Pool. 2015. Analysis of long-term acoustic datasets for baleen and beaked whales within the Mariana Islands Range Complex (MIRC) for 2010-2013. PIFSC Data Report DR-15-002, 19pp.

Tables

Table 1: Effort summaries for 2016 Marianas winter (March) and summer (May–June) surveys.

Local Date (2016)	Location	Vessel	Survey Description	On Effort Time (h:mm)	On Effort Distance
2-Mar	CNMI-Saipan/Marpi Reef	Sea Hunter	Saipan west to Marpi Reef	9:23	118.2
3-Mar	CNMI-Saipan/Tinian	Sea Hunter	Saipan-Tinian-west	5:52	92.3
4-Mar	CNMI-Saipan	Sea Hunter	Saipan-west; north to Wing Beach then south to CK Reef	5:00	78.2
5-Mar	CNMI-Saipan	Sea Hunter	Saipan-west; CK Reef	3:14	49.1
9-Mar	CNMI-Saipan	Sea Hunter	Saipan-west; north to Wing Beach then south to CK Reef	4:47	73.9
10-Mar	CNMI-Saipan/Marpi Reef	Sea Hunter	Saipan west to Marpi Reef	6:38	97.5
11-Mar	CNMI-Saipan/Marpi Reef	Sea Hunter	Saipan west to Marpi Reef then south over CK Reef	6:50	108.7
12-Mar	CNMI-Saipan/Tinian/Aguijan	Sea Hunter	Tinian-Aguijan circumnavigation	8:52	133.0
13-Mar	CNMI-Saipan/Marpi Reef	Sea Hunter	Saipan west to Marpi Reef then south over CK Reef	8:03	116.6
7-May	CNMI-Saipan	Sea Hunter	Saipan SW loop	2:29	40.1
8-May	CNMI-Saipan	Sea Hunter	Saipan SW loop	3:43	49.6
9-May	CNMI-Saipan	Sea Hunter	Saipan SW loop over CK Reef	2:49	39.4
11-May	CNMI-Saipan/Tinian	Sea Hunter	Saipan-Tinian west loop	7:21	111.1
12-May	CNMI-Saipan	Sea Hunter	Saipan SW loop nearshore	2:14	32.4
14-May	CNMI-Saipan/Tinian	Sea Hunter	Saipan-Tinian west loop	6:16	100.1
15-May	CNMI-Saipan	Regulator	Saipan-NW loop	7:15	98.2
16-May	CNMI-Saipan/Tinian/Aguijan	Regulator	Saipan-Tinian west loop-Coke Reef-Aguijan	8:00	160.0
17-May	CNMI-Saipan/Marpi Reef	Regulator	Saipan NW loop to Marpi Reef	8:23	118.7
18-May	CNMI-Saipan/Tinian	Sea Hunter	Saipan-Tinian east side to Saipan west - 300 Reef	7:12	99.8
19-May	CNMI-Saipan	Sea Hunter	Saipan NW loop	3:29	55.2
21-May	CNMI-Rota	Asakaze	Rota (north) west loop then to Sasanhaya Bay	3:45	52.2
22-May	CNMI-Rota	Asakaze	Rota (north) west loop then to Sasanhaya Bay	4:38	61.6
23-May	CNMI-Rota	Asakaze	Rota (north) west loop beyond 3nmi line	4:22	59.5
24-May	CNMI-Rota	Asakaze	Rota southwest loop to Ice Box Reef	3:05	51.4
25-May	CNMI-Rota	Asakaze	Rota (north) west loop with zig-zags	5:36	83.9
28-May	Guam	Ten27	Hagatna - SW loop	7:07	100.2
29-May	Guam	Ten27	Hagatna - NW loop	9:46	109.9

Local Date (2016)	Location	Vessel	Survey Description	On Effort Time (h:mm)	On Effort Distance
30-May	Guam	Ten27	Hagatna - SW to Galvez Bank	9:48	157.3
31-May	Guam	Ten27	Hagatna - NW loop	8:47	121.3
2-Jun	Guam	Ten27	Hagatna - west following pilot whales	8:08	46.9
3-Jun	Guam	Ten27	Hagatna - west loop	3:37	50.6
4-Jun	Guam	Ten27	Hagatna - SW loop	8:20	111.4
5-Jun	Guam	Ten27	Hagatna - NW	4:01	31.7
			Winter Total:	**58:43**	**868**
			Summer Total:	**140:23**	**1,942**

Table 2: Details of the cetacean encounters during the 2016 Marianas winter (March) small-boat surveys.

Local Date (2016)	Sighting	Common Name	Local Time (GMT +10)	Location	Latitude	Longitude	Depth (m)	Shore Distance (km)	Beaufort	Swell Height (ft)	Total Best	YOY Best	Neonate Best	Behavior	Photos	Biopsy Samples
2-Mar	1	Spinner dolphin	9:50	CNMI-Marpi Reef	15.4303	145.8862	77	17.5	4	4 to 6	82	0	0	mill, boat approach, bow ride	0	0
2-Mar	2	Humpback whale	10:46	CNMI-Marpi Reef	15.4090	145.8449	62	13.6	4	4 to 6	2	1	0	mod trav, evasive	426	0
2-Mar	3	Humpback whale	12:23	CNMI-Marpi Reef	15.4316	145.8587	69	16.5	4	4 to 6	2	1	0	mod trav, evasive	330	1
2-Mar	2-resight	Humpback whale	13:28	CNMI-Marpi Reef	15.4241	145.8565	66	15.6	4	4 to 6	2	1	0	mod trav, evasive	222	1

Local Date (2016)	Sighting	Common Name	Local Time (GMT +10)	Location	Latitude	Longitude	Depth (m)	Shore Distance (km)	Beaufort	Swell Height (ft)	Total Best	YOY Best	Neonate Best	Behavior	Photos	Biopsy Samples
2-Mar	4	Spinner dolphin	16:02	CNMI-Saipan	15.2260	145.7035	8	1.6	3	0 to 2	43	1	0	mill, boat approach, bow ride, spin, evasive	169	0
4-Mar	5	Bottlenose dolphin	11:42	CNMI-Saipan	15.2360	145.6822	167	4.1	5	4 to 6	3	0	0	slow travel	52	1
10-Mar	6	Spinner dolphin	7:08	CNMI-Saipan	15.2288	145.7006	12	2.0	3	0 to 2	13	0	0	mill, synch dive/surface	0	0
10-Mar	7	Humpback whale	9:28	CNMI-Marpi Reef	15.4227	145.8656	66	15.8	5	6 to 8	2	0	1	slow travel	316	1
10-Mar	8	Humpback whale	10:26	CNMI-Marpi Reef	15.4187	145.8595	66	15.1	5	6 to 8	2	1	0	mod trav, evasive	234	1
12-Mar	9	Humpback whale	7:12	CNMI-Saipan	15.2101	145.6938	23	2.4	3	0 to 2	2	1	0	slow travel	580	1
12-Mar	10	Spinner dolphin	7:37	CNMI-Saipan	15.2122	145.6803	27	3.8	3	0 to 2	12	0	0	slow travel	3	0
12-Mar	11	Spinner dolphin	8:51	CNMI-Saipan	15.1296	145.6782	41	1.5	4	2 to 4	8	1	0	boat approach, bow ride, mill	32	0
12-Mar	12	Spinner dolphin	9:53	CNMI-Tinian	15.0296	145.6584	58	0.6	5	4 to 6	7	0	0	boat approach bow ride	0	0
13-Mar	13	Spinner dolphin	10:17	CNMI-Marpi Reef	15.4338	145.8866	74	17.8	6	4 to 6	100	0	0	mill, boat approach, bow ride, surfing, spin	0	0
13-Mar	14	Humpback whale	10:36	CNMI-Marpi Reef	15.4427	145.8689	64	18.0	5	4 to 6	2	1	0	slow travel, evasive	336	1

Local Date (2016)	Sighting	Common Name	Local Time (GMT +10)	Location	Latitude	Longitude	Depth (m)	Shore Distance (km)	Beaufort	Swell Height (ft)	Total Best	YOY Best	Neonate Best	Behavior	Photos	Biopsy Samples
13-Mar	15	Bottlenose dolphin	13:36	CNMI-Saipan	15.1764	145.6237	29	8.5	5	4 to 6	10	0	0	boat approach, bow ride, mod trav	12	0

Table 3: Details of the cetacean encounters during the 2016 Marianas summer (May–June) small-boat surveys.

Local Date (2016)	Sighting	Common Name	Local Time (GMT +10)	Location	Latitude	Longitude	Depth (m)	Shore Distance (km)	Beaufort	Swell Height (ft)	Total Best	YOY Best	Neonate Best	Behavior	Photos	Biopsy Samples	Tags	Acoustic Recording?
7-May	1	Spinner dolphin	6:39	CNMI-Saipan	15.2261	145.7213	3	0.5	4	0 to 2	33	1	0	slow travel, synch dive/surface, mill	0	0	0	No
8-May	2	Spinner dolphin	9:15	CNMI-Saipan	15.2204	145.7004	11	1.7	4	0 to 2	114	4	1	slow travel, spin, boat approach, bow ride, social	663	0	0	No
9-May	3	Spinner dolphin	8:35	CNMI-Saipan	15.2282	145.7193	13	0.8	4	0 to 2	124	2	0	slow travel, mill, synch dive/surface, spin, leap, boat approach, bow ride, social	191	0	0	No
9-May	4	Rough-toothed dolphin	10:05	CNMI-Saipan	15.1604	145.6263	384	6.8	5	4 to 6	5	0	0	slow travel, boat approach, bow ride	226	1	0	No
9-May	3-resight	Spinner dolphin	12:05	CNMI-Saipan	15.2279	145.7201	11	0.7	4	0 to 2	84	2	1	mill, boat approach, bow ride, spin	400	0	0	No
11-May	5	Bottlenose dolphin	8:07	CNMI-Saipan	15.3038	145.7274	562	7.3	4	4 to 6	7	0	0	boat approach, bow ride, mod trav	162	1	0	No
12-May	6	Spinner dolphin	8:55	CNMI-Saipan	15.2181	145.6550	35	6.5	5	4 to 6	43	2	0	porpoise, spin, boat approach, bow ride	0	0	0	No

Local Date (2016)	Sighting	Common Name	Local Time (GMT +10)	Location	Latitude	Longitude	Depth (m)	Shore Distance (km)	Beaufort	Swell Height (ft)	Total Best	YOY Best	Neonate Best	Behavior	Photos	Biopsy Samples	Tags	Acoustic Recording?
15-May	7	Sperm whale	8:20	CNMI-Saipan	15.2904	145.6314	922	12.1	2	4 to 6	12	0	0	breach, slow travel, fluke-up dive, evasive	559	3	0	No
17-May	8	Spinner dolphin	8:50	CNMI-Marpi Reef	15.4327	145.8872	87	17.7	3	2 to 4	86	0	0	mill, spin, boat approach, bow ride, synch dive/surface, social	423	0	0	No
17-May	9	Pantropical spotted dolphin	10:48	CNMI-Saipan	15.4155	145.7390	814	15.9	3	4 to 6	27	0	0	fast travel	29	0	0	No
17-May	10	Sperm whale	11:16	CNMI-Saipan	15.4079	145.6904	1,173	18.3	2	2 to 4	15	1	0	slow travel, fluke-up dive	526	4	1	No
18-May	11	Spinner dolphin	7:12	CNMI-Saipan	15.2277	145.6974	12	2.3	2	0 to 2	17	1	0	slow travel	0	0	0	No
18-May	12	Spinner dolphin	7:21	CNMI-Saipan	15.2141	145.6952	16	2.2	2	0 to 2	31	0	0	slow travel	0	0	0	No
19-May	13	Spinner dolphin	9:42	CNMI-Saipan	15.2231	145.7030	8	1.5	4	0 to 2	57	0	0	mill, boat approach, bow ride, spin, leap, social	320	0	0	No
21-May	14	Pantropical spotted dolphin	6:59	CNMI-Rota	14.1254	145.0976	819	2.6	3	2 to 4	50	0	0	boat approach, bow ride, slow travel	26	0	0	No
22-May	15	Spinner dolphin	9:19	CNMI-Rota	14.1316	145.1538	32	0.4	3	0 to 2	24	0	0	synch dive/surface, rest, boat approach, spin	39	0	0	No

Local Date (2016)	Sighting	Common Name	Local Time (GMT +10)	Location	Latitude	Longitude	Depth (m)	Shore Distance (km)	Beaufort	Swell Height (ft)	Total Best	YOY Best	Neonate Best	Behavior	Photos	Biopsy Samples	Tags	Acoustic Recording?
23-May	16	Spinner dolphin	6:44	CNMI-Rota	14.1722	145.1639	33	0.4	2	2 to 4	32	1	0	synch dive/surface, rest	0	0	0	No
23-May	17	Spinner dolphin	7:07	CNMI-Rota	14.1869	145.1971	66	1.2	3	2 to 4	53	4	0	mod trav, porpoise	47	0	0	No
25-May	18	Spinner dolphin	6:30	CNMI-Rota	14.1546	145.1436	42	0.4	2	0 to 2	43	0	0	mod trav, porpoise, synch dive/surface	41	0	0	No
25-May	19	Mesoplodon beaked whale	10:23	CNMI-Rota	14.1502	145.0753	1,202	5.8	4	2 to 4	1	0	0	slow travel, mill	0	0	0	No
28-May	20	Dwarf sperm whale	7:42	Guam	13.4773	144.6302	870	1.6	1	0 to 2	1	0	0	log, low swim, slow travel	17	0	0	Yes
28-May	21	Dwarf sperm whale	9:15	Guam	13.3977	144.6200	642	3.3	0	0 to 2	4	0	2	slow travel, low swim, dive, evasive	413	1	0	Yes
29-May	22	Pantropical spotted dolphin	6:50	Guam	13.5359	144.6715	1,181	7.6	1	0 to 2	80	0	0	leap, mod trav, boat approach, bow ride	12	0	0	No
29-May	23	Pantropical spotted dolphin	10:08	Guam	13.7224	144.7445	1,012	14.2	5	4 to 6	27	2	0	boat approach, bow ride, mod trav	43	0	0	No
29-May	24a	Short-finned pilot whale	10:58	Guam	13.6680	144.7721	737	8.5	4	2 to 4	42	0	0	slow travel, mill	1,143	12	1	No
29-May	24b	Bottlenose dolphin	12:23	Guam	13.6858	144.7788	658	8.9	4	2 to 4	4	0	0	boat approach, bow ride, social	15	0	0	No

Local Date (2016)	Sighting	Common Name	Local Time (GMT +10)	Location	Latitude	Longitude	Depth (m)	Shore Distance (km)	Beaufort	Swell Height (ft)	Total Best	YOY Best	Neonate Best	Behavior	Photos	Biopsy Samples	Tags	Acoustic Recording?
29-May	24c	Pantropical spotted dolphin	13:38	Guam	13.6986	144.7922	581	8.5	5	2 to 4	42	3	0	boat approach, bow ride, porpoise, social	0	0	0	No
30-May	25	Pantropical spotted dolphin	7:11	Guam	13.4796	144.5908	1,678	4.5	2	0 to 2	37	1	0	leap, boat approach, bow ride	51	0	0	No
30-May	26	Pantropical spotted dolphin	7:43	Guam	13.4694	144.5659	2,247	6.1	2	2 to 4	5	0	0	leap, low swim	0	0	0	No
30-May	27	Mesoplodon beaked whale	12:10	Guam	13.1174	144.5051	1,078	24.0	3	4 to 6	2	0	0	log, dive	13	0	0	No
30-May	28	Spinner dolphin	15:49	Guam	13.4836	144.7239	54	0.6	1	0 to 2	13	0	0	slow travel	0	0	0	No
31-May	29	Sperm whale	11:45	Guam	13.5473	144.6335	1,647	9.1	3	0 to 2	9	0	1	slow travel, evasive	630	2	1	No
2-Jun	30a	Short-finned pilot whale	6:22	Guam	13.5045	144.7351	607	2.7	1	0 to 2	45	0	0	slow travel, dive, boat approach, bow ride, spy hop, log, low swim, social	2,567	18	4	No
2-Jun	30b	Rough-toothed dolphin	7:02	Guam	13.5029	144.7062	732	2.9	2	0 to 2	1	0	0	slow travel, social, evasive	30	0	0	No
3-Jun	31	Pantropical spotted dolphin	8:35	Guam	13.5414	144.7579	652	4.3	1	0 to 2	135	0	0	leap, slow travel, boat approach, bow ride	487	0	1	No
4-Jun	32	Spinner dolphin	7:13	Guam	13.4853	144.7483	21	0.4	1	0 to 2	3	0	0	slow travel	52	0	0	No

Local Date (2016)	Sighting	Common Name	Local Time (GMT +10)	Location	Latitude	Longitude	Depth (m)	Shore Distance (km)	Beaufort	Swell Height (ft)	Total Best	YOY Best	Neonate Best	Behavior	Photos	Biopsy Samples	Tags	Acoustic Recording?
4-Jun	33	Dwarf sperm whale	11:39	Guam	13.3238	144.6287	696	2.0	3	0 to 2	3	0	0	slow travel	21	0	0	No
4-Jun	34	Dwarf sperm whale	12:44	Guam	13.3783	144.6149	797	3.8	4	0 to 2	4	0	2	mill, slow travel	472	0	0	Yes
4-Jun	35	Pantropical spotted dolphin	14:02	Guam	13.4294	144.6081	651	1.9	4	0 to 2	31	0	0	leap, boat approach, bow ride, mod trav, social	112	0	0	No
5-Jun	36a	Short-finned pilot whale	7:38	Guam	13.5049	144.7193	693	2.8	4	0 to 2	31	0	0	slow travel, dive	322	1	0	No
5-Jun	36b	Bottlenose dolphin	8:01	Guam	13.5170	144.7293	766	4.0	4	0 to 2	10	0	0	slow travel, boat approach, bow ride, social	71	0	0	No
5-Jun	37a	Short-finned pilot whale	9:55	Guam	13.5811	144.7528	814	6.9	4	2 to 4	48	0	0	slow travel, dive, boat approach	800	0	1	No
5-Jun	37b	Rough-toothed dolphin	9:56	Guam	13.5821	144.7537	808	6.9	4	2 to 4	1	0	0	slow travel	0	0	0	No
5-Jun	36b-resight	Bottlenose dolphin	9:58	Guam	13.5822	144.7555	799	6.7	5	2 to 4	10	0	0	slow travel	60	0	0	No
														Total:	10,983	43	9	

Table 4: Turtle sightings during the 2016 Marianas winter (March) and summer (May–June) small-boat cetacean surveys.

Local Date (2016)	Local Time (GMT +10)	Island	Latitude	Longitude	Description
2-Mar	15:59	Saipan	15.2268	145.6950	Green Turtle-small (< 1.5 ft)
2-Mar	16:42	Saipan	15.2277	145.7178	Green Turtle-small (< 1.5 ft)
3-Mar	13:11	Saipan	15.2269	145.7206	Turtle-small (< 1.5 ft)
4-Mar	7:02	Saipan	15.2254	145.7210	Turtle-med (1.5-2.5 ft)
4-Mar	7:08	Saipan	15.2286	145.7045	Green Turtle-med (1.5-2.5 ft)
4-Mar	7:09	Saipan	15.2285	145.7013	Green Turtle-med (1.5-2.5 ft)
4-Mar	7:11	Saipan	15.2270	145.6966	Green Turtle-large (> 2.5 ft)
4-Mar	12:13	Saipan	15.2278	145.7088	Turtle-large (> 2.5 ft)
4-Mar	12:16	Saipan	15.2279	145.7186	Turtle-med (1.5-2.5 ft)
4-Mar	12:18	Saipan	15.2267	145.7205	Green Turtle-large (> 2.5 ft)- male
5-Mar	10:19	Saipan	15.2170	145.6923	Green Turtle-large (> 2.5 ft)
5-Mar	10:33	Saipan	15.2269	145.7200	Green Turtle-med (1.5-2.5 ft)
9-Mar	11:57	Saipan	15.2278	145.7138	Turtle-large (> 2.5 ft)
11-Mar	7:11	Saipan	15.2263	145.6917	Green Turtle-small (< 1.5 ft)
11-Mar	13:50	Saipan	15.2185	145.6853	Green Turtle-large (> 2.5 ft)
11-Mar	13:56	Saipan	15.2243	145.6976	Turtle-med (1.5-2.5 ft)
11-Mar	13:58	Saipan	15.2268	145.7041	Green Turtle-large (> 2.5 ft)
11-Mar	14:01	Saipan	15.2278	145.7101	Turtle-med (1.5-2.5 ft)
12-Mar	8:09	Saipan	15.2088	145.6952	Turtle-med (1.5-2.5 ft)
12-Mar	8:15	Saipan	15.2101	145.6951	Turtle-med (1.5-2.5 ft) x 5
12-Mar	15:48	Saipan	15.2194	145.6916	Green Turtle-small (< 1.5 ft)
12-Mar	16:00	Saipan	15.2277	145.7178	Green Turtle-med (1.5-2.5 ft)
13-Mar	7:10	Saipan	15.2279	145.6961	Hawksbill-med (1.5-2.5 ft)
13-Mar	15:03	Saipan	15.2096	145.6950	Green Turtle-med (1.5-2.5 ft); Turtle-small (< 1.5 ft)
13-Mar	15:13	Saipan	15.2276	145.7079	Turtle-large (> 2.5 ft)
13-Mar	15:19	Saipan	15.2263	145.7207	Turtle-med (1.5-2.5 ft)
7-May	7:12	Saipan	15.2287	145.7046	Green Turtle-med (1.5-2.5 ft)
7-May	7:17	Saipan	15.2265	145.6903	Turtle-large (> 2.5 ft)
7-May	9:34	Saipan	15.2117	145.6965	Turtle-med (1.5-2.5 ft)
8-May	6:22	Saipan	15.2283	145.6983	Turtle-med (1.5-2.5 ft)
8-May	10:04	Saipan	15.2280	145.7168	Green Turtle-large (> 2.5 ft)
9-May	9:05	Saipan	15.2288	145.7131	Turtle-large (> 2.5 ft)

Local Date (2016)	Local Time (GMT +10)	Island	Latitude	Longitude	Description
9-May	12:05	Saipan	15.2279	145.7185	Green Turtle-med (1.5-2.5 ft)
9-May	12:07	Saipan	15.2260	145.7227	Green Turtle-med (1.5-2.5 ft)
11-May	13:58	Saipan	15.2267	145.7205	Green Turtle-med (1.5-2.5 ft)
11-May	14:00	Saipan	15.2233	145.7239	Turtle-small (< 1.5 ft)
14-May	9:55	Tinain	14.9276	145.6299	Green Turtle-med (1.5-2.5 ft)
14-May	11:17	Tinain	15.0758	145.6145	Turtle-med (1.5-2.5 ft)
14-May	12:28	Saipan	15.2042	145.6942	Green Turtle-med (1.5-2.5 ft)
14-May	12:29	Saipan	15.2073	145.6940	Green Turtle-large (> 2.5 ft)
14-May	12:31	Saipan	15.2116	145.6961	Turtle-med (1.5-2.5 ft)
14-May	12:32	Saipan	15.2134	145.6968	Turtle-med (1.5-2.5 ft)
21-May	9:31	Rota	14.1233	145.1619	Turtle-med (1.5-2.5 ft)
22-May	9:09	Rota	14.1279	145.1357	Turtle-small (< 1.5 ft)
22-May	9:54	Rota	14.1319	145.1508	Turtle-large (> 2.5 ft)
22-May	11:06	Rota	14.1384	145.1314	Turtle-small (< 1.5 ft)
28-May	6:56	Guam	13.4881	144.7471	Turtle-large (> 2.5 ft)
28-May	7:49	Guam	13.4787	144.6304	Turtle-large (> 2.5 ft)
31-May	6:14	Guam	13.4899	144.7517	Turtle-med (1.5-2.5 ft) x2
2-Jun	14:10	Guam	13.5129	144.7578	Turtle-med (1.5-2.5 ft)
4-Jun	11:08	Guam	13.2569	144.6309	Turtle-large (> 2.5 ft)

Table 5: Species encounter summary including encounter rate (No. encounters/100 km effort), depth (m) and distance from shore (km) for 2016 Marianas summer (May–June) small-boat cetacean surveys (1,942 km survey distance). Includes total encounters and overall encounter rates across all survey years (2010–2016) for species encountered during summer 2016 (19,033 km total survey distance).

Species	No. Species Encounters (Total 2010–2016*)	Encounters/ 100km Effort (Overall 2010–2016*)	Best Group Size Estimate range	Median Depth (m) (min-max)	Median Shore Distance (km) (min-max)
Spinner dolphin	15 (129)	0.77 (0.68)	3-124	21 (3-87)	0.8 (0.4-17.7)
Pantropical spotted dolphin	9 (56)	0.46 (0.29)	5-135	819 (581-2,247)	6.1 (1.9-15.9)
Bottlenose dolphin	4 (32)	0.21 (0.17)	4-10	712 (562-799)	7.0 (4.0-8.9)
Short-finned pilot whale	4 (20)	0.21 (0.11)	31-48	715 (607-814)	4.9 (2.7-8.5)
Dwarf sperm whale	4 (5)	0.21 (0.03)	1-4	747 (642-870)	2.6 (1.6-3.8)
Rough-toothed dolphin	3 (6)	0.15 (0.03)	1-5	732 (384-808)	6.8 (2.9-6.9)
Sperm whale	3 (6)	0.15 (0.03)	9-15	1,173 (922-1,647)	12.1 (9.1-18.3)
Mesoplodon beaked whale	2 (5)	0.10 (0.03)	1-2	1,140 (1,078-1,202)	14.9 (5.8-24.0)
Total:	**44**	**2.27**			

*2015 and 2016 winter efforts not included in calculations because the effort targeted humpback whales.

Table 6: Satellite tag deployment information and summary of depth and distance to shore for the Douglas ARGOS filtered (DAF) tag locations by species and tag ID.

Species and Tag ID	Tag Type	Deployment Location	Local Date-Time (GMT +10)	Sighting	Latitude	Longitude	Duration (d)	No. DAF Locations	Median Depth (m) (min-max)	Median Shore Distance (km) (min-max)
Sperm whale								**285**	**2,448 (197-4,260)**	**34.4 (1.1-110.2)**
141712	SPOT5	Saipan	5/17/2016 12:25	10	15.4308	145.6994	41.8	205	1,875 (197-4,121)	29.1 (1.1-110.2)
141723	SPLASH10	Guam	5/31/2016 12:18	29	13.5532	144.6357	9.7	80	3,510 (1,082-4,260)	71.9 (9.7-98.2)
Short-finned pilot whale								**1,835**	**786 (6-2,971)**	**8.6 (0.1-68.3)**
141721	SPLASH10	Guam	5/29/2016 11:40	24a	13.6724	144.7752	24.6	297	808 (51-2,577)	9.7 (0.7-39.5)
141724	SPLASH10	Guam	6/2/2016 7:23	30a	13.5029	144.7062	12.5	169	787 (50-1,860)	8.6 (0.1-32.1)
141713	SPOT5	Guam	6/2/2016 9:21	30a	13.5260	144.7383	79.9	657	768 (7-2,568)	8.2 (0.1-68.3)
141722	SPLASH10	Guam	6/2/2016 9:45	30a	13.5458	144.7359	7.4	90	702 (28-2,613)	10.9 (0.2-24.7)
141714	SPOT5	Guam	6/2/2016 12:06	30a	13.5962	144.7298	58.7	539	796 (6-2,711)	7.4 (0.2-44.5)
141728	SPLASH10	Guam	6/5/2016 11:12	37a	13.6382	144.7785	6.8	83	906 (41-2,971)	11.5 (0.4-30.6)
Pantropical spotted dolphin								**133**	**1,020 (18-2,507)**	**5.6 (0.1-31.6)**
137752	SPOT5	Guam	6/3/2016 9:37	31	13.5626	144.7559	11.4	133	1,020 (18-2,507)	5.6 (0.1-31.6)

Figures

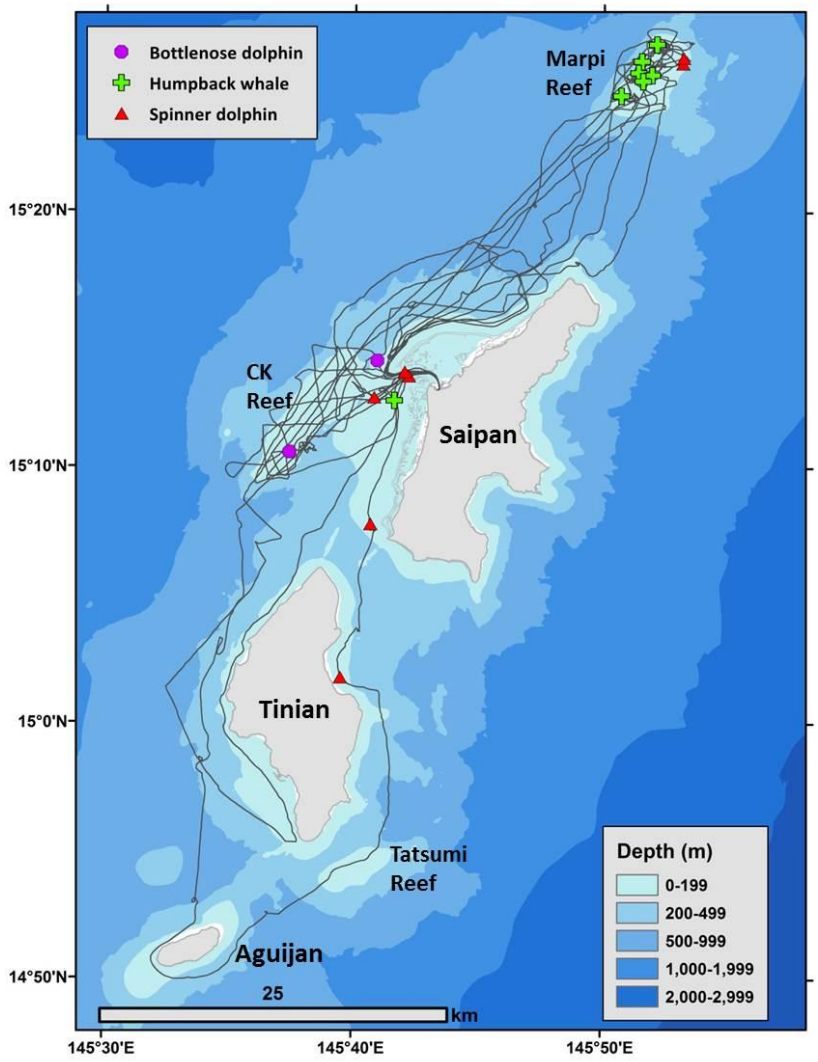

Figure 1: Tracklines and cetacean encounter locations during the 2016 Marianas winter (March) small-boat surveys.

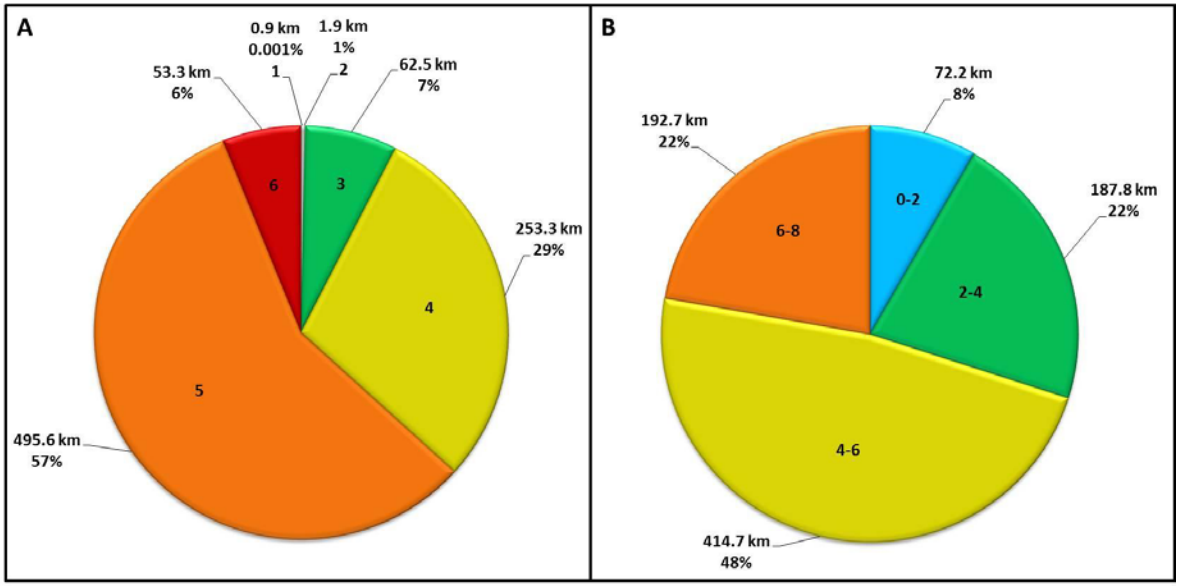

Figure 2: Effort by (A) Beaufort sea state and (B) swell height (ft) during the 2016 Marianas winter (March) small-boat cetacean surveys.

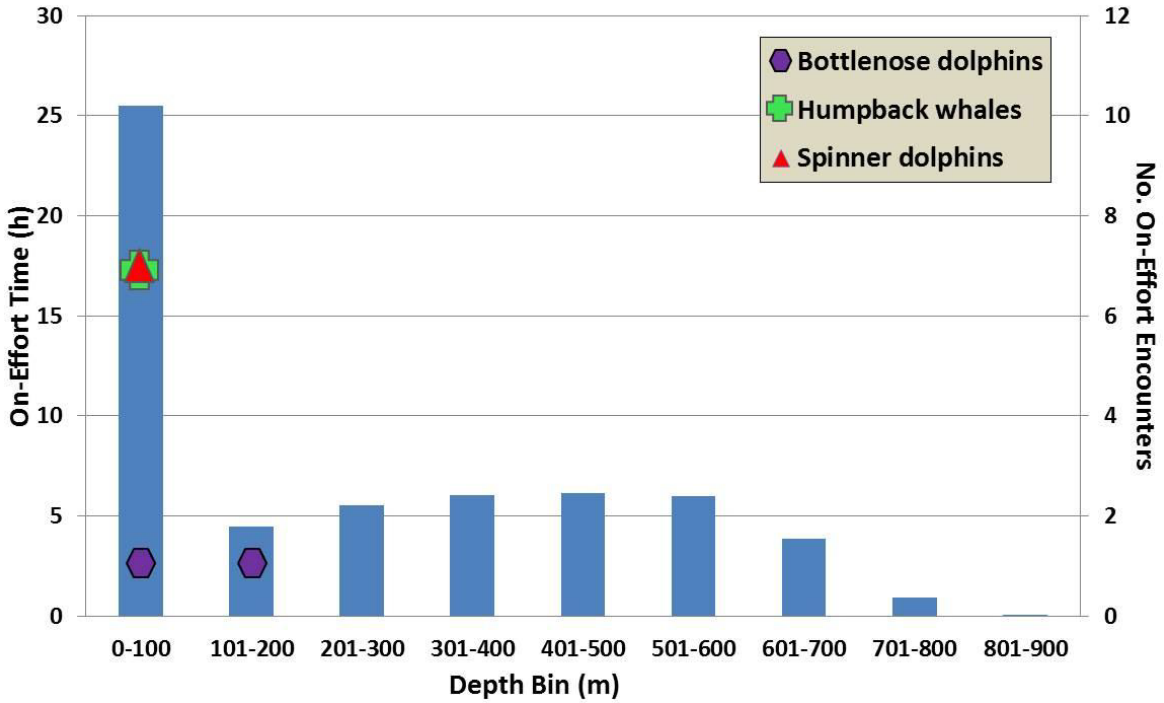

Figure 3: Effort and encounters by depth during the 2016 Marianas winter (March) small-boat cetacean surveys. Survey efforts were focused on shallow waters (< 200 m) where humpback whales were expected based on known breeding and calving habitat in other locations (Herman and Antinoja, 1977; Frankel et al. 1995).

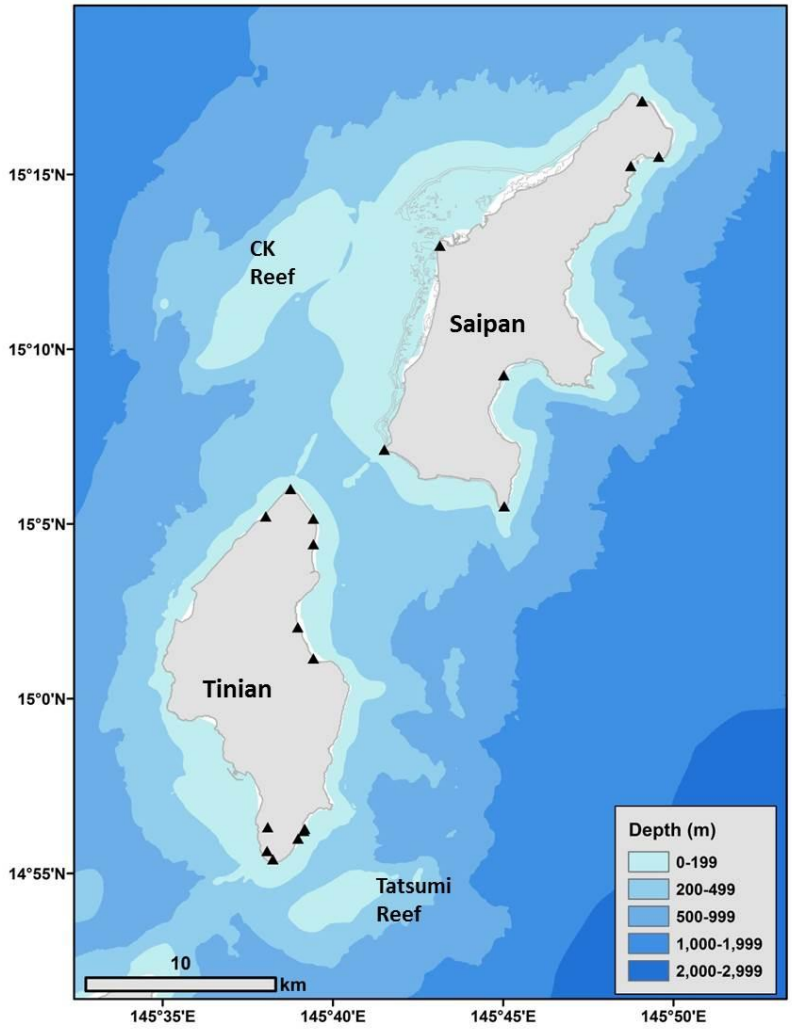

Figure 4: Shore-based observation locations used during 2016 Marianas winter (March) visual surveys for humpback whales.

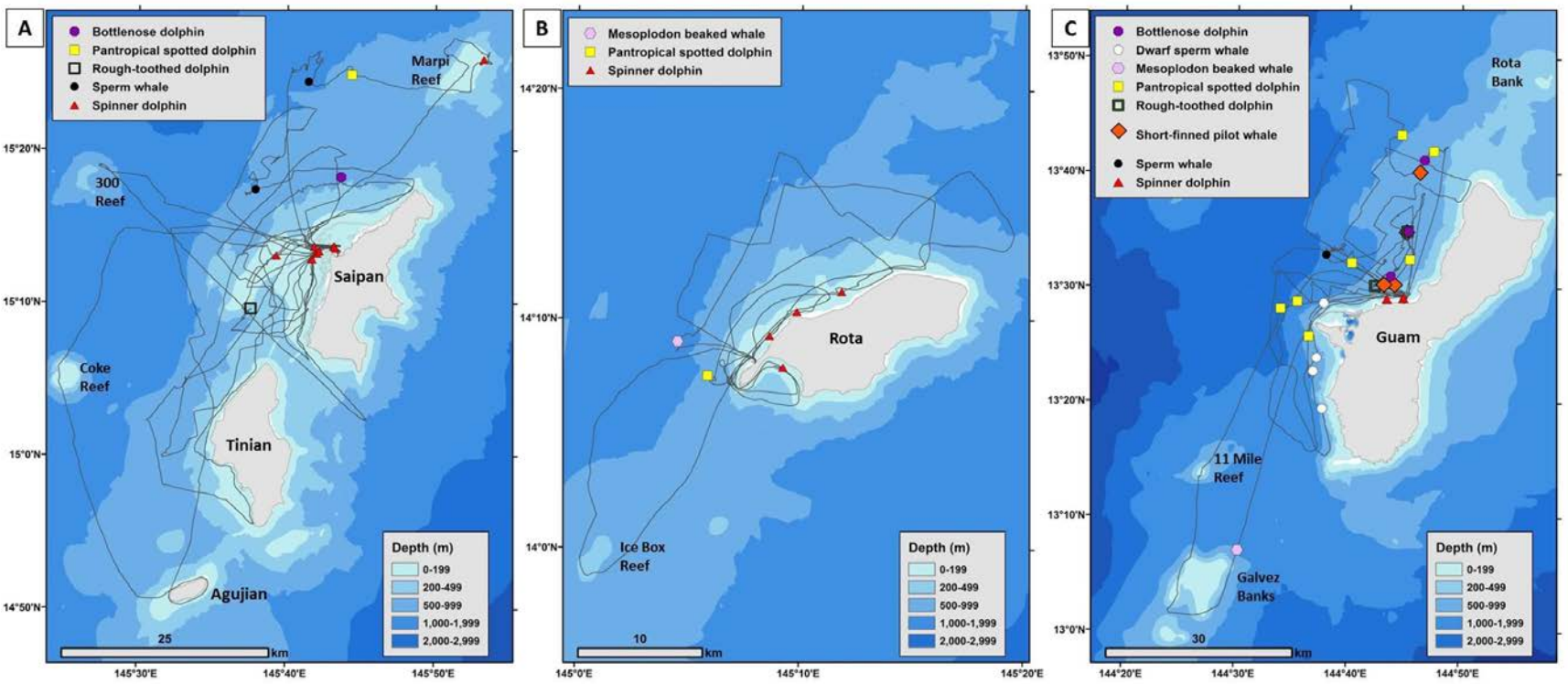

Figure 5: Tracklines and cetacean encounter locations during the 2016 Marianas summer (May–June) small-boat surveys off Saipan, Tinian, and Aguijan (A), Rota(B), and Guam (C).

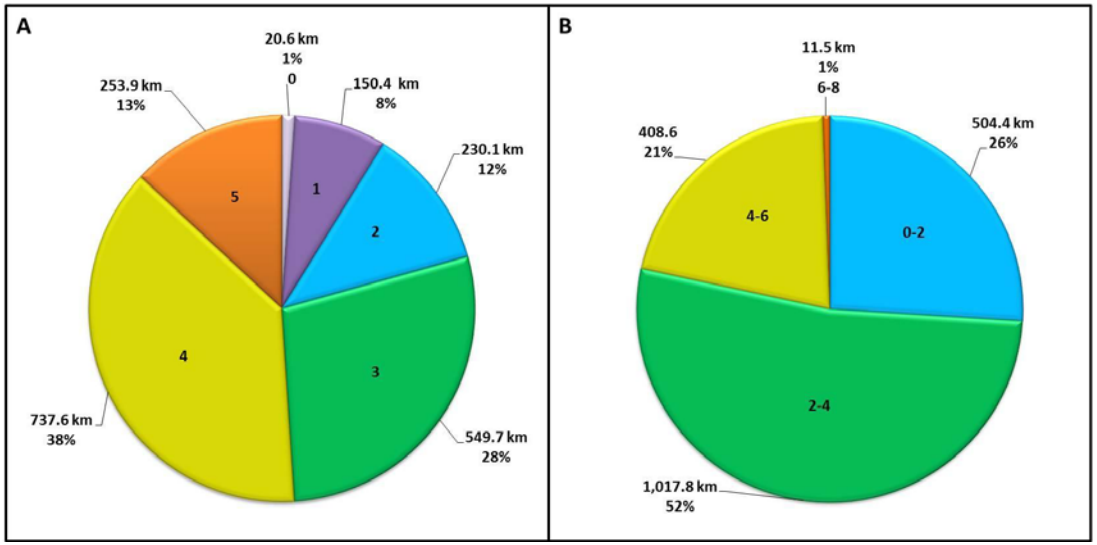

Figure 6: Effort by (A) Beaufort sea state and (B) swell height (ft) during the 2016 Marianas summer (May–June) small-boat cetacean surveys.

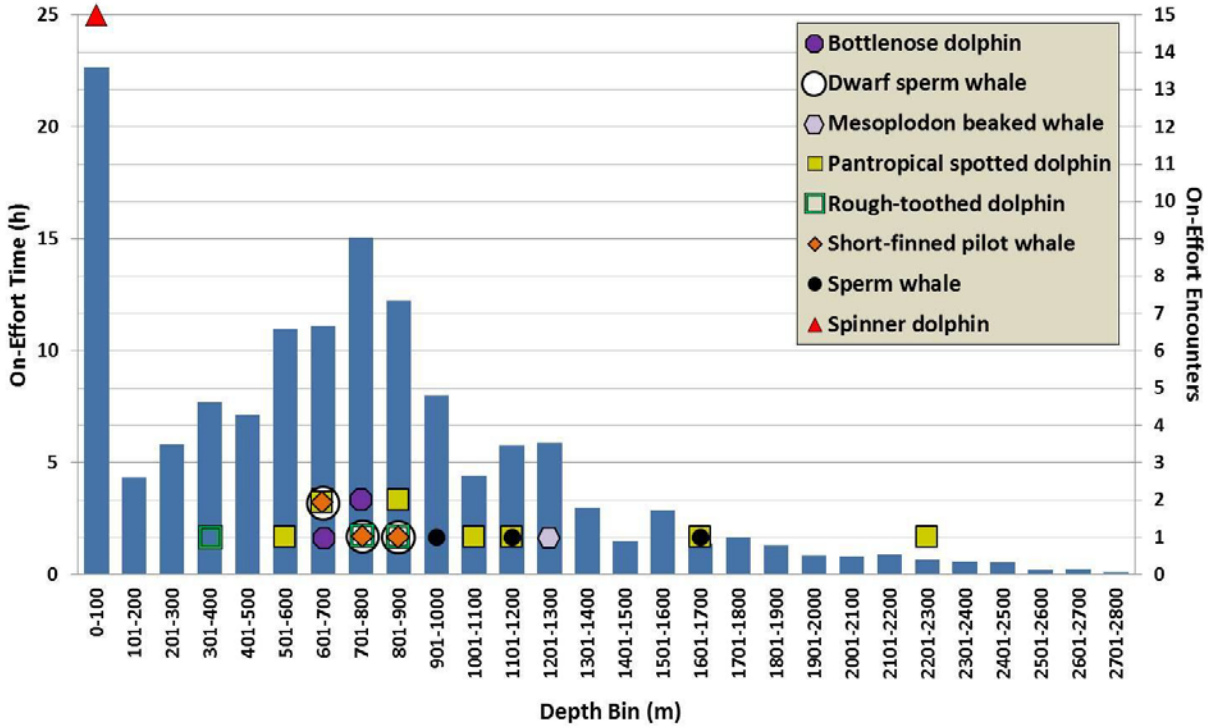

Figure 7: Effort and encounters by depth during the 2016 Marianas summer (May–June) small-boat cetacean surveys.

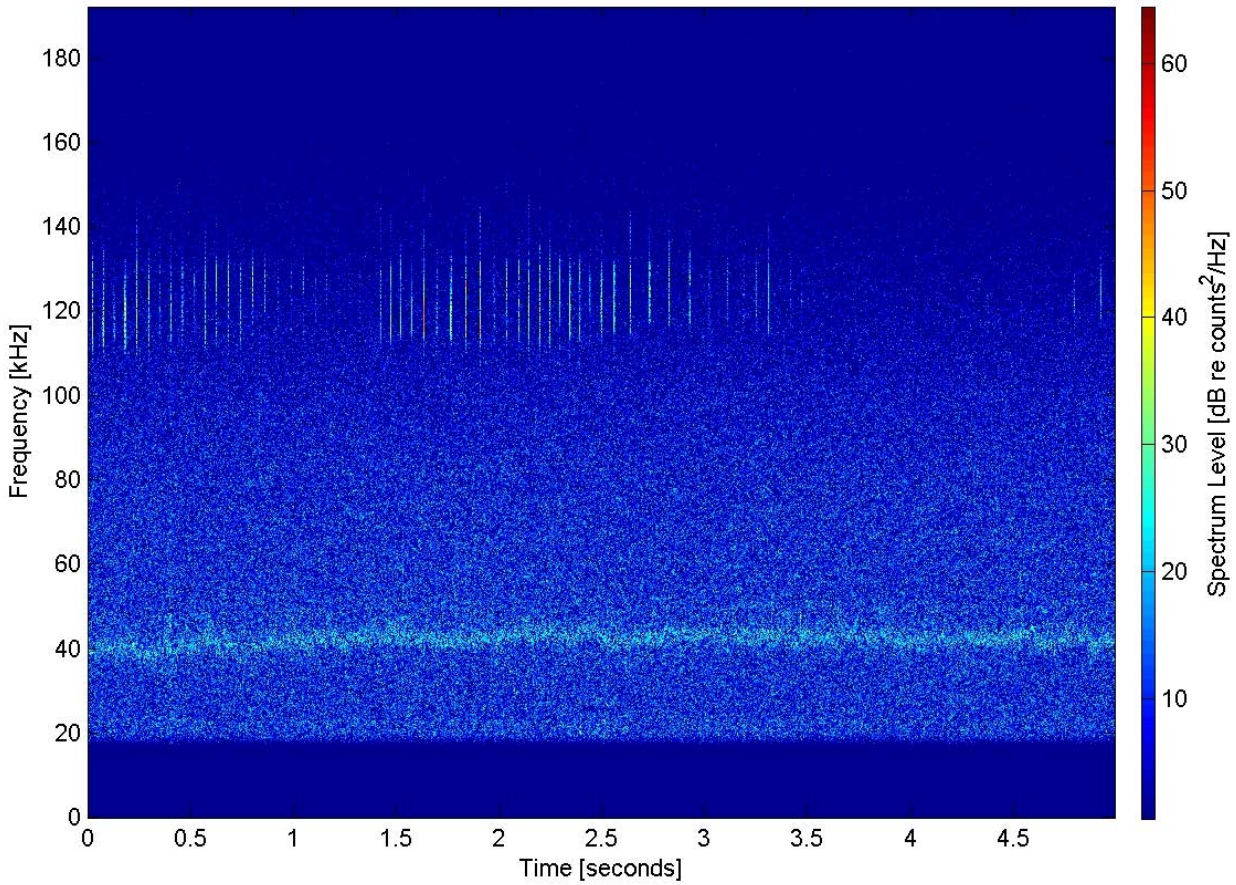

Figure 8: Spectrogram of narrow-band high-frequency clicks made by a dwarf sperm whale encountered off Guam.

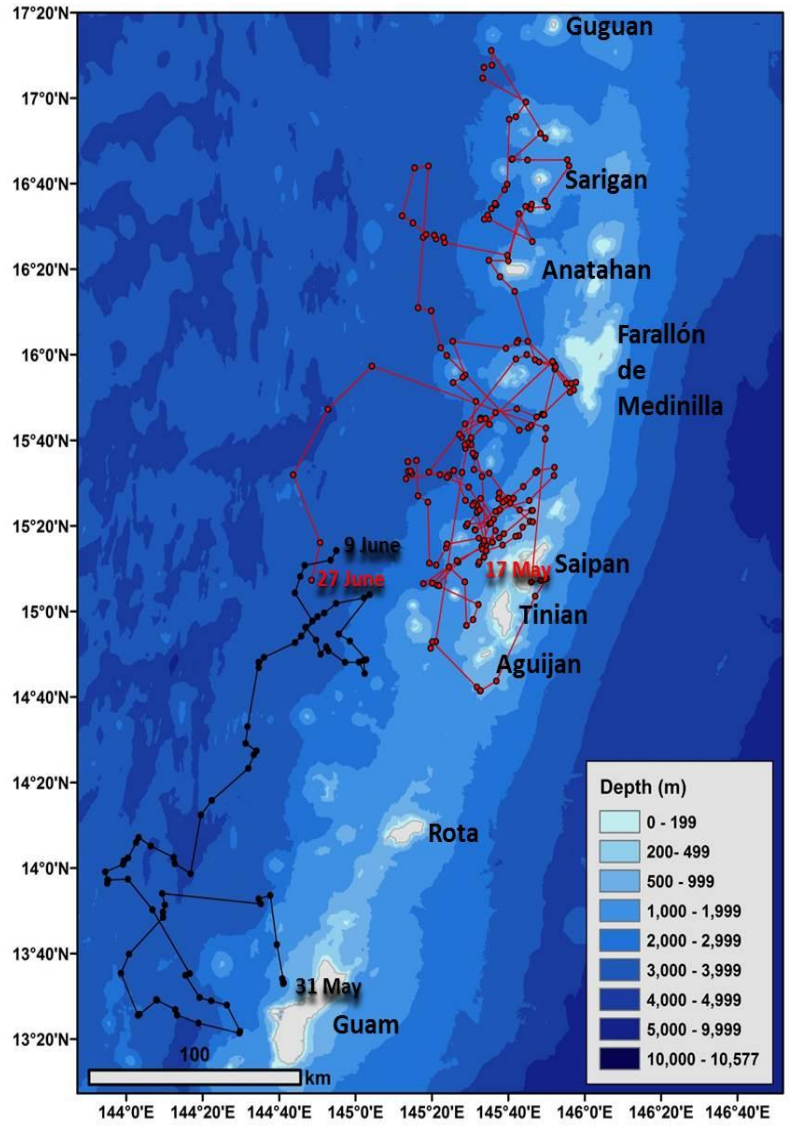

Figure 9: DAF locations and tracks for satellite tags deployed on sperm whales off Saipan (17 May) and Guam (31 May) during small-boat cetacean surveys. Durations of tags were 41.8 d and 9.7 d respectively.

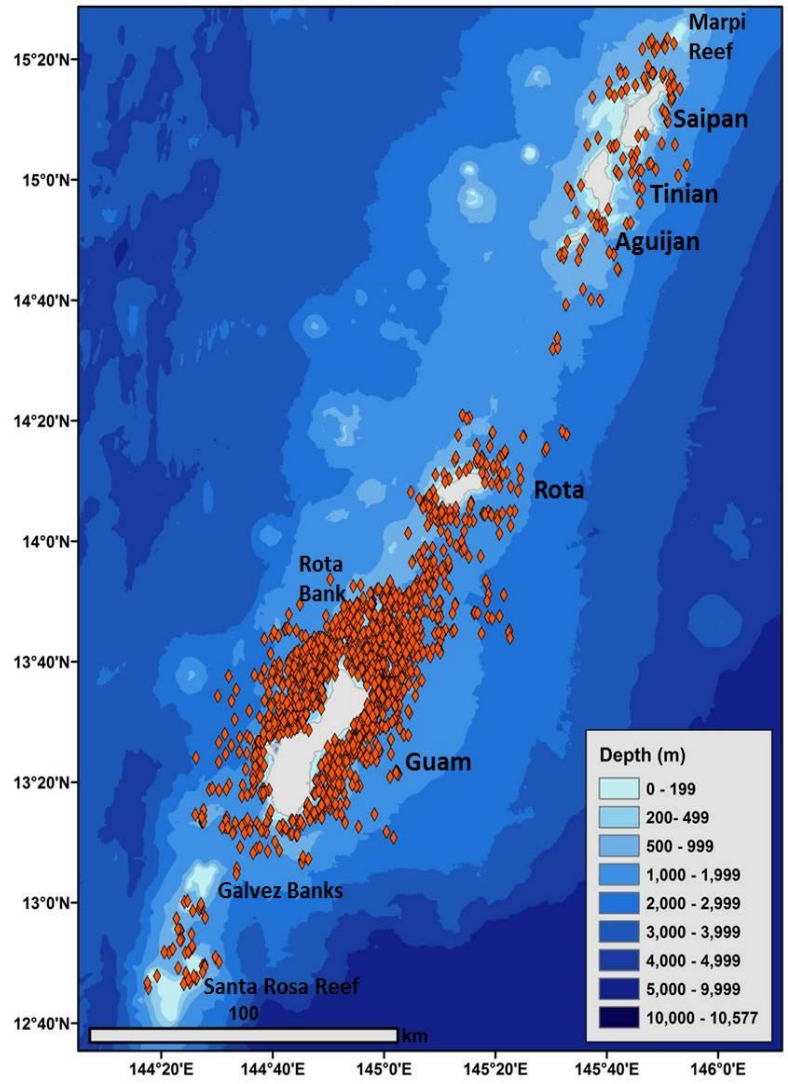

Figure 10: DAF locations for 6 satellite tags deployed on short-finned pilot whales off Guam between 29 May and 5 June during small-boat cetacean surveys. Tag durations ranged from 6.8 to 79.9 d.

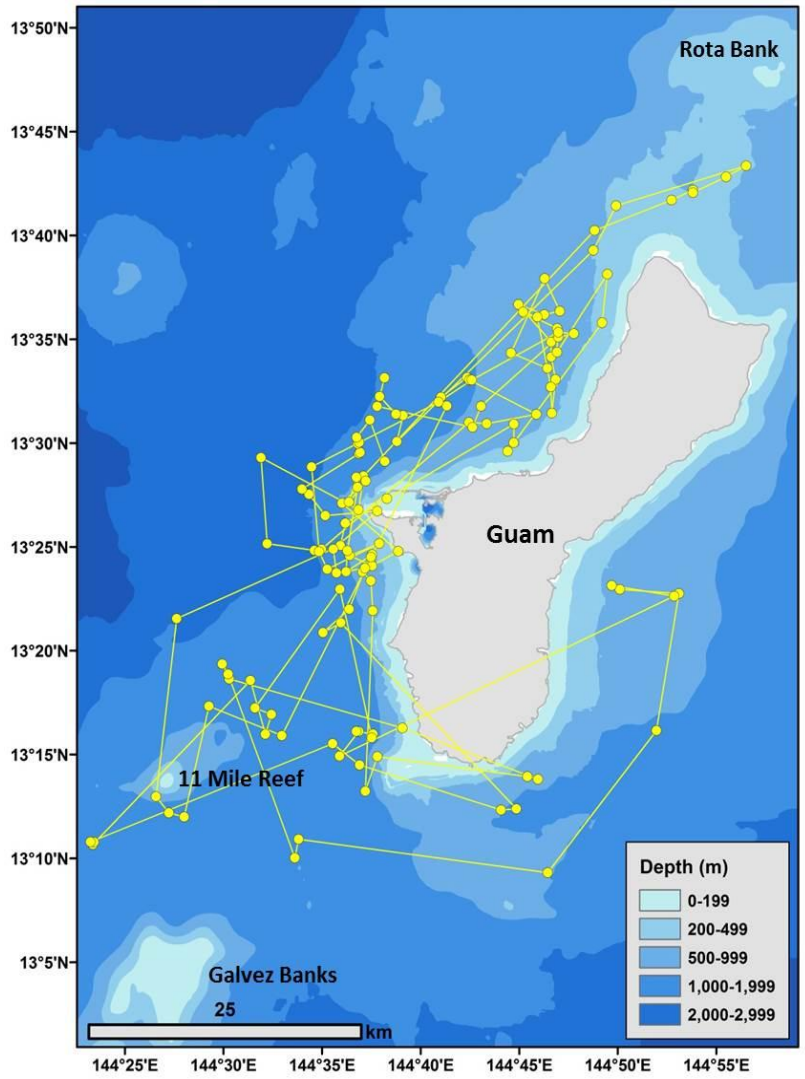

Figure 11: DAF locations and track for a satellite tag deployed on a pantropical spotted dolphin during small-boat cetacean surveys off Guam (3 June). The tag duration was 11.4 d.

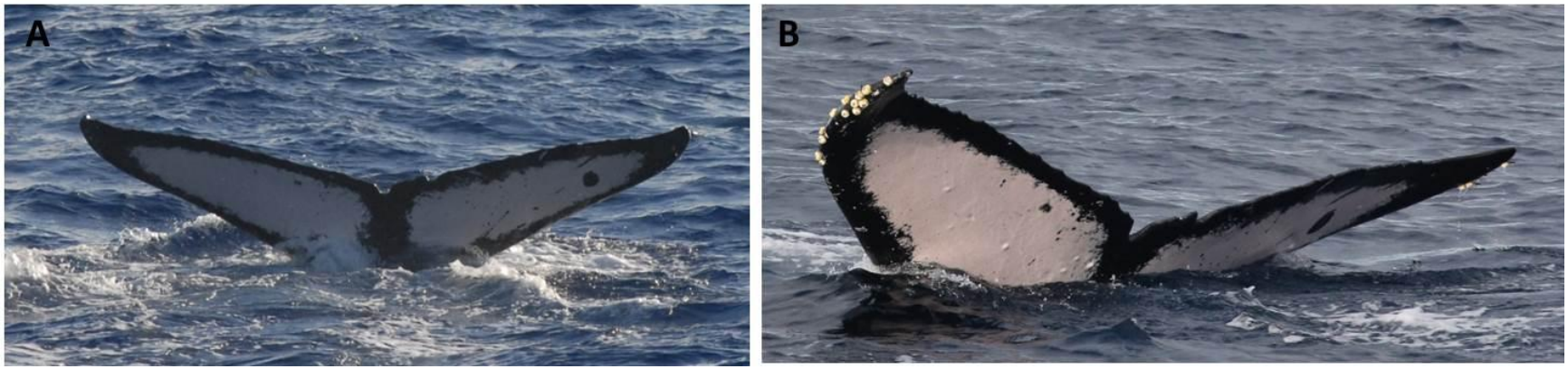

Figure 12: Humpback whale fluke match between the (A) 28 February 2007 sighting (Marpi Reef, Saipan) during a shipboard survey and (B) 12 March 2016 sighting (Saipan - off the west side) during the PIFSC CRP small-boat surveys. The whale was accompanied by a calf in 2016. (photo credit: Adam Ü (A) and Marie Hill (B)).

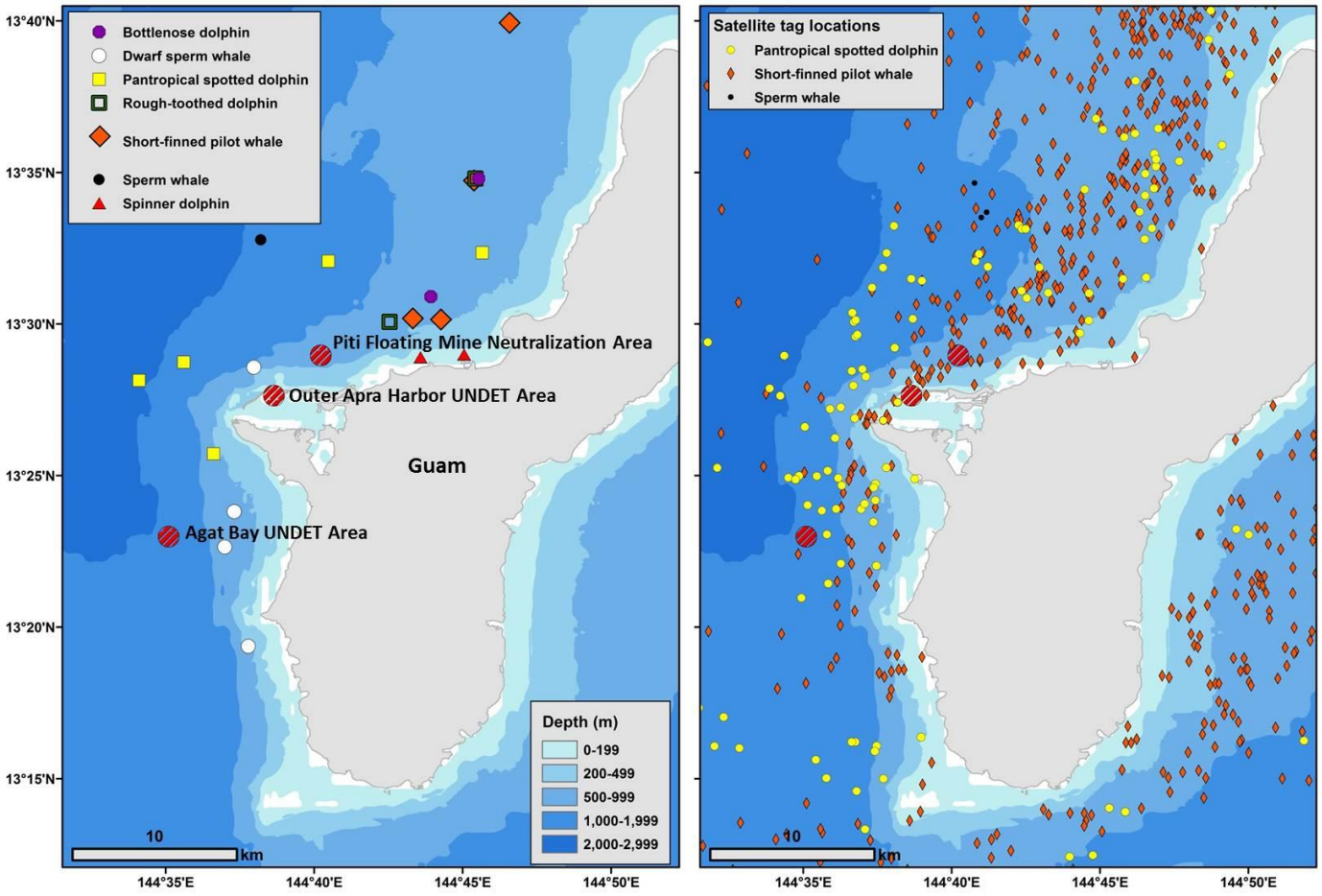

Figure 13: 2016 cetacean encounter and satellite tag locations off Guam and Navy underwater detonation sites.

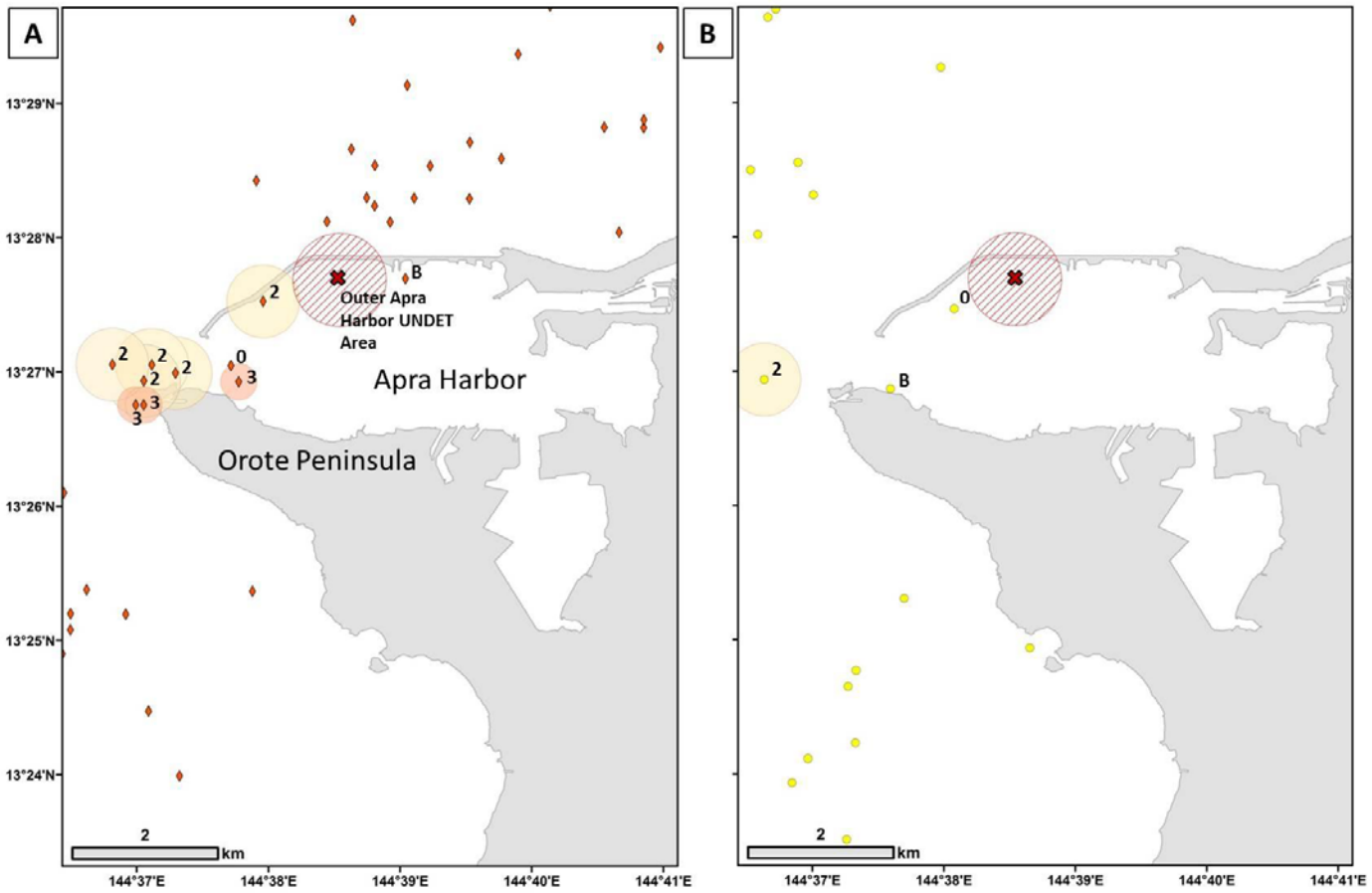

Figure 14: 2016 DAF locations within and around Apra Harbor (Guam) from satellite tags deployed on short-finned pilot whales (A) and a pantropical spotted dolphin (B). Locations within and at the mouth of Apra Harbor are labeled with their Argos-assigned location qualities (LC). A LC 3 has an estimated error of 250 m, shown by the orange circle. A LC 2 has an estimated error of 500 m, shown by the yellow circle. LC B and LC 0 are of lower quality than LC 3 and LC 2 and have no estimated error values. An 'X' marks the location of the Outer Apra Harbor UNDET site and the hashed circle designates the 640 m boundary. There have been no documented cetacean sightings within Apra Harbor. These are the first satellite tag locations to fall within Apra Harbor. The single

LC3 inside the mouth of Apra Harbor indicates that a short-finned pilot whale entered the Harbor. It cannot be stated with certainty that the other tag locations indicate that tagged animals entered the Harbor.