

## **Cetacean Surveys in the Waters of the Southern Mariana Archipelago (2010-2012)<sup>1</sup>**

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## Introduction

The Mariana Archipelago is made up of 15 islands stretching approximately 880 km in a north-south arc from the northern-most island of Farallón de Pájaros (also known as Uracas, located at 20° 31'N, 144° 54'E) to Guam (the largest and southern-most island, located at 13° 28' N, 144° 47' E). The southern ("Main") Mariana Islands from Guam to Saipan (Figure 1) are the older (15 - 20 million years) and generally larger islands in the archipelago, with the primary human population residing on Guam, Saipan, Rota, and Tinian. The remote northern islands of the Mariana chain are generally uninhabited and made up of much younger islands (approximately less than 4000 years old) with several islands remaining volcanically active<sup>2</sup>. The region is most notably characterized by the Mariana Trench which parallels the Mariana Islands about 148 km to the east, arcing westward to within 120 km south of Guam. The Trench runs 2500 km long and is the deepest part of the world's oceans, reaching a maximum known depth of 11 km. Another significant oceanographic feature is the West Mariana Ridge which forms a series of seamounts paralleling 145 to 170 km west of the archipelago. The Mariana Islands are composed of two U.S. jurisdictions: the territory of Guam, and the Commonwealth of the Northern Mariana Islands (CNMI). The CNMI includes all islands within the Archipelago with the exception of Guam.

Due to U.S. territorial status, management of marine mammal stocks around Guam and the CNMI is the responsibility of the U.S. National Marine Fisheries Service. Currently, little information exists on cetaceans in the region. Most of what is known comes from stranding records (Kami and Lujan 1976, Kami and Hosmer 1982, Donaldson 1983, Trianni and Kessler 2002, Trianni and Tenorio 2012), whaling records (Townsend 1935, Camba 1965, Masaki 1972), and publications of previously undocumented strandings and anecdotal sighting reports (Eldredge 1991, Eldredge 2003, Wiles 2005, Jefferson *et al.* 2006). A handful of scientific surveys, primarily focused on large whale distribution, were conducted throughout the lower latitude areas of the western North Pacific in the 1990's (Darling and Mori 1993, Yamaguchi 1995, Yamaguchi 1996, Shimada and Miyashita 2001, Ohizumi *et al.* 2002). These met with low sighting rates in the vicinity of the Mariana Islands; however each of these projects only spent a small amount of time in Mariana waters<sup>3</sup>. Only three scientific cetacean surveys dedicated to

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<sup>2</sup> The island of Farallon de Medinilla (83 km northeast of Saipan) is geologically more similar to the southern main islands in terms of age and composition, but grouped here with the remote northern islands for convenience in distinguishing between the larger populated islands to the south and the harder to access, mostly uninhabited islands in the north.

<sup>3</sup> Darling and Mori (1993) spent just one week on Saipan in February 1990; Shimada and Miyashita (2001) conducted "no effort within 12 nm [of] territorial waters" and only just a few days in the region across three survey years; and Ohizumi *et al.* (2002) spent just one day conducting a survey "about 5km off the coast of Pagan and Agrihan Islands in the Northern Mariana Islands." Yamaguchi (1995) spent 10 days surveying nearshore Mariana waters in March-April, 1995, but reported only 5 sightings (of any species). Although no information was given

the Mariana region have been conducted in recent years: a large-ship line-transect survey (the 2007 MISTCS cruise: U.S. Navy 2007, Fulling *et al.* 2011), a 5-day aerial survey conducted in August 2007 (Mobley 2007), and a set of NOAA ship surveys in 2010 (Oleson and Hill 2010, PIFSC 2010-a, -b, and -c)<sup>4</sup>.

In an effort to further develop a record of cetacean occurrence in the region and to gather photos and biopsy samples for population studies, the Pacific Islands Fisheries Science Center's (PIFSC) Cetacean Research Program (CRP) conducted surveys for cetaceans in the waters surrounding Guam and the Commonwealth of the Northern Mariana Islands (CNMI) (Figure 1) during 2010-2012. This research was carried out in partnership with the U.S. Navy and is expected to continue through 2015. Detailed reports for each survey year were submitted to the Navy (Oleson and Hill 2010, Ligon *et al.* 2011, Hill *et al.* 2012, Hill *et al.* 2013). The summary of the combined surveys is reported here.

A long-term goal of this research is the evaluation of the population status of each species. This includes the genetic analysis for stock structure, as well as, producing population abundance estimates using mark-recapture techniques. The first step in the mark-recapture process is the creation of species photo-identification catalogs, which began during the summer of 2012.

## Methods

### Surveys

Small boat surveys were conducted around the southernmost of the Mariana Islands (Guam, Saipan, Tinian, Aguijan, and Rota) during various times of year between 2010 and 2012, and for logistical reasons efforts were divided into three separate locations (Table 1). During the first year of effort, surveys were conducted in February-March, 2010 and included 10 survey days off Guam and 6 off Saipan and Tinian (Oleson and Hill 2010, Ligon *et al.* 2011). The second effort was conducted in August-September, 2011 and included 9 survey days off Guam, 6 survey days off Rota, and 15 survey days in the waters surrounding Saipan, Tinian, and Aguijan (Hill *et al.* 2012). The most recent effort was conducted in May-July, 2012 and included 11 survey days off Guam, 6 survey days off Rota, and 14 survey days in the waters surrounding Saipan, Tinian, and Aguijan (Hill *et al.* 2013).

Survey effort was designed to cover representative habitat within the study area and did not conform to systematic (e.g. line-transect) design. Vessel tracks were spread out from day to day to ensure broad survey coverage over a wide range of depths and were also dictated by weather and sea conditions. The survey vessels traveled at a speed of 8-12 knots, depending on

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regarding weather, such a low sighting rate implies that poor sea conditions were likely a factor (No sighting data was reported from Yamaguchi 1996.).

<sup>4</sup> The NOAA ship surveys were mammal-specific line-transect surveys conducted while in transit between Hawaii and Guam (PIFSC 2010-a and -c), so little effort was actually spent surveying within Mariana waters. Mammal observations were also conducted opportunistically during an NOAA offshore oceanographic survey within the EEZ's of the Marianas and Federal States of Micronesia (PIFSC 2010-b).

the size of the vessel and sea conditions. A number of vessels were chartered for these surveys ranging from 5.8 to 12.2 m length, some of which had a flying bridge. The vessels were operated by locally experienced captains, with knowledge of cetacean sighting locations. In 2011 and 2012 during surveys off Saipan, Tinian, Aguijan, and Rota the captains allowed the research team to operate the vessel during search effort and when approaching cetaceans for photo-identification and biopsy. Between four and six observers scanned for marine mammals with unaided eye or occasional use of 10x binoculars, collectively searching 360-degrees around the vessel.

All cetacean groups encountered were approached for species confirmation, group size estimates, photo-identification, biopsy sampling (for assessment of genetic population structure), and acoustic recording when possible. A GPS waypoint was recorded at the group. Digital SLR cameras with telephoto zoom lenses were used for taking photographs. Photographic efforts were focused on dorsal fin images (for individual identification purposes) and images of the body and head (for assessments of health and scarring). Additional data collected during each sighting included the location, behavior, estimate of calf (neonates and young of the year) numbers (when possible), Beaufort sea state, and swell height. Environmental data (e.g., Beaufort sea state, swell height) and effort status were recorded regularly as conditions changed. Global Positioning System (GPS) readings of the vessel's track were automatically recorded once per minute.

Biopsy sampling was conducted using a Barnett RX-150 crossbow and Ceta-Dart bolts with sterilized, stainless steel biopsy tips (25 mm long x 8 mm diameter). Tissue samples were preserved in a cooler on ice while on the boat. Samples were split in half longitudinally at the end of each field day (with each subsample stored in a different vial) and transferred to a standard refrigerator freezer until the end of the project. Samples were transported, in a cooler with dry ice, on board a commercial airline to Honolulu, HI. One vial of each sample was stored in an -80°C freezer at the PIFSC and the other was submitted to the Southwest Fisheries Science Center (SWFSC) for tissue archiving. Samples are archived until adequate numbers are available to assess stock structure or until funding is provided to address other specific questions.

#### *Bathymetry Data and ArcGIS*

Bathymetric datasets used in displaying and analyzing the depth profiles of the survey effort and sightings were obtained from two different sources. First, the Pacific Islands Benthic Habitat Mapping Center (PIBHMC)<sup>5</sup> has available high-resolution multibeam color-shaded bathymetry datasets for nearshore waters. For this project, 5 m grids were used for waters inside the 400 m isobath surrounding Guam, Rota, Saipan, Tinian, Aguijan and Marpi Reef. Sixty meter resolution grids were used for portions of the waters out to the 3,500 m isobath surrounding Guam; the 2,700 m isobath surrounding Saipan, Tinian, and Aguijan; and the 1,900 m isobath surrounding Rota. In addition, a 114 m resolution synthesis grid of multibeam

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[http://www.soest.hawaii.edu/pibhmc/pibhmc\\_cnmi.htm](http://www.soest.hawaii.edu/pibhmc/pibhmc_cnmi.htm)

datasets of primarily offshore locations to depths of 10,650 m was used<sup>6</sup> (Weiss *et al.* 2007). The second source of bathymetric data was the SRTM30\_plus (“Smith and Sandwell”) dataset<sup>7</sup> (Smith and Sandwell 1997, Becker *et al.* 2009). The dataset uses satellite altimetry and ship depth soundings and covers 0 to 360 in longitude and -90 to 90 in latitude. A portion of this data was used for this report, to fill in the gaps that the other datasets did not cover, which is a 560 m resolution grid that contains the entire CNMI Exclusive Economic Zone (EEZ).

All bathymetry datasets were processed using ArcCatalog 10.0 (ESRI, Redlands, CA). The ASCII files were first converted into raster grids, projected in the WGS 1984 UTM Zone 55N coordinate system and imported into ArcMap 10.0 (ESRI, Redlands, CA). Vessel GPS tracks and sighting locations were also projected in the WGS 1984 UTM Zone 55N coordinate system and then overlaid onto the bathymetric datasets. Depths of sighting locations were determined by using the Spatial Analyst Extraction tool within the ArcToolbox to extract the depth values from each relevant bathymetric raster dataset. If the high-resolution PIBHMC multibeam data were not available for a particular sighting location, then the depth value was obtained from synthesis data set or the Smith and Sandwell (SRTM30) dataset. To analyze the amount of search effort by depth, on-effort times were calculated for depth bins from 0 to 3,100 m in 100 m intervals. As with the sighting locations, depths were extracted from the appropriate bathymetric raster datasets for the points (each representing 1 minute) within the on-effort tracklines.

### *Photo-Identification*

Photo analysis began in June 2012 to create species-specific individual photo-identification catalogs. Photos taken by PIFSC in 2010-2012 and those taken by Geo-Marine (Navy contractor) in 2007 (U.S. Navy 2007, Fulling *et al.* 2011)<sup>8</sup> and HDR (Navy contractor) 2011-2012 (HDR 2011, 2012)<sup>9</sup> are being included in the photo analysis. Initial matches of individuals were made within each sighting by one photo-identification analyst and were then checked by another. Marks along the leading and trailing edges of the dorsal fins were used as the primary identifiers. Marks or scars on the body, dorsal fin surface, and peduncle; and coloration patterns on the body and dorsal fin were used as secondary identifiers. Each individual fin in each photo was rated for quality based on 4 categories (focus/clarity, contrast/lighting, angle, extent visible) and was assigned an overall quality rating (1 = high, 2 = moderate, 3 = poor). Distinctiveness ratings were assigned to each individual based on the number, size, and shape of the features located on the leading and trailing edges of the dorsal fin (D-1 = high, D-2 = moderate, D-3 = low, D-4 = clean fin and no marks on the peduncle within 12 inches of the dorsal fin). After the completion of matching and rating within sightings, identified individuals

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<sup>6</sup> Multibeam datasets from Hawaii MR-1 (COOK06MV & COOK07MV), HS-DS2 (EW0202 & EW0203), SEABEAM (NOAA Vents Program), and EM300 (NOAA OE Ring of Fire 2003 & 2004).

<sup>7</sup> David T. Sandwell, Walter H. F. Smith, and Joseph J. Becker. Copyright 2008. The Regents of the University of California. All Rights Reserved. [http://topex.ucsd.edu/WWW\\_html/srtm30\\_plus.html](http://topex.ucsd.edu/WWW_html/srtm30_plus.html)

<sup>8</sup> Geo-Marine conducted shipboard surveys within the CNMI EEZ during 1 January – 14 April, 2007. All photos were contributed to PIFSC for photo-identification analysis. To date, no photos have been analyzed.

<sup>9</sup> HDR conducted small boat surveys in the waters surrounding Guam and Saipan during 17 February – 3 March, 2011 and 15-29 March, 2012. All photos were contributed to PIFSC for photo-identification analysis.

were compared between sightings. Only those fins with a distinctiveness of D-1 or D-2 and a quality rating of Q-1 or Q-2 were initially entered into the catalog.

## Results

### Surveys

The PIFSC Cetacean Research Program completed a total of 7,729 km of on-effort survey trackline over 519.5 hours during the 2010-2012 surveys of the southern Mariana Islands (Table 2). Nearly half (46%, 3525 km) of the on-effort trackline was surveyed in Beaufort sea state conditions of 0-3 (Figure 2). Most (74%, 5689 km) of the on-effort trackline was surveyed in swells heights of 0-4 ft (Figure 3). Approximately one-quarter (26%, 138 hours) of the total time on-effort was surveyed inside of the 100 m depth contour (Figure 4). Effort was distributed fairly evenly over 101 – 1000 m depth bins and was reduced gradually over depths of 1001 – 3100 m (Figure 4).

The survey team encountered a total of 95 cetacean groups (Table 3, Figures 5-9). Eighty-seven of these groups were identified to species and included spinner dolphins (*Stenella longirostris*), bottlenose dolphins (*Tursiops truncatus*), pantropical spotted dolphins (*Stenella attenuata*), short-finned pilot whales (*Globicephala macrorhynchus*), pygmy killer whales (*Feresa attenuata*), sperm whales (*Physeter macrocephalus*), and a dwarf sperm whale (*Kogia sima*). The overall sighting rate for all cetacean groups (including those unidentified) was 1.23 sightings/100 km of effort (Table 4), or 1.16 sightings/100 km of effort excluding directed effort toward known spinner dolphin locations (n = 6; 45 km of trackline).

Spinner dolphins were the most frequently encountered species. Even after adjusting for directed effort, spinner dolphins made up 55% (n = 49) of the total number of encounters (Table 4). All of the sighting locations were in depths less than 200 m. The vast majority (n = 48) of the locations were in depths less than 100 m. Spinner dolphins were encountered at offshore reefs (Marpi Reef and Rota Bank; 17-18 km from shore) on 8 occasions over the 3-year period (Table 3, Figure 5). All other spinner dolphin encounters were within 1 km of shore (Table 3, Figure 5). A total of 75 biopsy samples were collected across all locations.

Pantropical spotted dolphins were the second most frequently encountered species (0.17/100 km of effort, n = 13) (Tables 3 and 4, Figure 5). The groups were encountered in the widest range of depths, as well as the deepest depths (505 m to 3012 m) (Table 3, Figure 4). In addition, one sighting of spotted dolphins (offshore of Saipan near Malakis Reef) was the farthest from shore (52.8 km) of all cetacean encounters (Table 3). A total of 34 biopsy samples were collected across all locations.

Short-finned pilot whales ranked third highest in sighting rates (0.10/100 km of effort, n = 8) (Table 4). They were encountered in depths that ranged from 215 m to 825 m (Table 3). One sighting location was near Esmeralda Bank, approximately 36 km west of Tinian (Table 3, Figure 6). One group of pilot whales, encountered south of Aguijan, was associated with a

group of bottlenose dolphins (Figure 6). A total of 37 biopsy samples were collected across all locations.

Bottlenose dolphins were also encountered within a few hundred meters of spinner dolphins on two occasions at Rota Bank (Figure 6). Bottlenose dolphins were ranked fourth in frequency of encounters (0.09/100 km of effort,  $n = 7$ ). Their sighting locations ranged 43-734 m in depth and 0.5-18.7 km distance from shore. A total of 9 biopsy samples were collected across all locations.

Sperm whales were encountered twice (Figure 7); both occurrences were in 2010. The first sighting location was off of Guam (374 m depth and 1.1 km from shore). The second location was off Saipan (1971 m depth and 22.0 km from shore). A total of 5 biopsy samples were collected across both locations.

Beaked whales were also encountered twice (Figure 8); both occurrences were in 2012. The first encounter was off of Rota when 2-3 animals were seen approximately 5 km off the southwest tip of the island in 1,032 m deep water. Photographs were obtained but no biopsy sample could be collected due to high winds (Beaufort 5) and moderate swell (4-6 feet). The whales disappeared quickly and were not resighted. Initially, the observer team thought that they were Blainville's beaked whales. After further analysis of the photos and consultation with other experts the species identification could not be agreed upon and was therefore classified as unidentified Mesoplodon. The second encounter occurred off of Saipan when an unidentified beaked whale was spotted in the distance before it dove. The survey vessel went to the estimated location (~12 km off the north tip of Tinian; 1,352 m depth) and the observer team scanned the area for 1.5 hours, but the whale was not resighted.

The final two identified species (pygmy killer whale and dwarf sperm whale) were encountered only once each and no biopsy samples were collected (Table 4, Figure 6 and 7).

#### *Photo-Identification*

To date, photo-identification catalogs for three cetacean species (short-finned pilot whales, spinner dolphins, and bottlenose dolphins) have been created. Photos taken during each of the PIFSC survey years (2010-2012) as well as photos taken by HDR during their winter/spring (February-March) surveys of Guam and Saipan (2011-2012) and Geo-Marine<sup>10</sup> during the winter/spring (January-April) surveys of the Marianas are being used for the creation of the catalogs (U.S. Navy 2007, Oleson and Hill 2010, Fulling *et al.* 2011, Ligon *et al.* 2011, HDR 2011, HDR 2012, Hill *et al.* 2012).

A total of 5,636 photos were analyzed from 10 sightings of short-finned pilot whales between 22 February, 2011 and 10 June, 2012 (Table 5), including photos contributed from two sightings made by HDR. The catalog includes 129 individuals across all islands. Several individuals seen off Guam were also seen at least off one other island, including matches

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<sup>10</sup> Of the three cataloged species, pilot whales were the only species photographed by Geo-Marine. To date, those photos have not been processed.

between Saipan, Tinian, and Rota (Table 6). Bottlenose dolphins were present and photographed during two of the pilot whale sightings.

A total of 1,793 photos were analyzed from 9 sightings of bottlenose dolphins between 22 February, 2011 and 29 June, 2012, including photos contributed from two sightings made by HDR (Table 7). There are a total of 34 cataloged individuals across all locations and years. Although the catalog is still small, matches have been found between all islands (Table 8).

A total of 8,047 photos from 29 sightings of spinner dolphins in CNMI between 22 February, 2010 and 16 June, 2012 were analyzed (Table 9). A total of 89 individuals were cataloged across CNMI locations and years. Resightings of individuals have occurred between Saipan, Tinian, Rota, and Marpi Reef - a shallow bank northwest of Saipan (Table 10). Photos of spinner dolphins taken off of Guam during all three years are currently being analyzed, but a catalog has not been created.

#### *Tissue Sample Analysis*

Fifty-three samples from spinner dolphins were analyzed by the genetics lab at SWFSC to determine sex of the sampled individuals. Those samples from males were then submitted to the Environmental Assessment Lab at Northwest Fisheries Science Center for evaluation of stable isotopes and contaminants. Evaluation of mtDNA haplotypes, as well as stable isotopes and contaminants is still underway.

## **Discussion**

### *Surveys*

The PIFSC CRP completed 75 days of survey effort over a three year period (2010-2012). These surveys were some of the first small boat surveys for cetaceans within the Marianas<sup>11</sup>. The surveys represent three years of collaborative effort between the PIFSC's CRP and the U.S. Navy Pacific Fleet towards a better understanding of the occurrence and distribution of cetaceans in waters off of Guam and the southernmost islands of CNMI (Saipan, Tinian, Aguijan, and Rota). The NMFS is responsible for the assessment of marine mammal stocks in the Exclusive Economic Zone (EEZ) waters of Guam and CNMI. The U.S. Navy is mandated by the Marine Mammal Protection Act (MMPA) and the Endangered Species Act (ESA) to monitor cetacean presence within the Mariana Island Range Complex (MIRC).

Beaked whales are a species of particular interest for both the Navy and NMFS. From studies in the main Hawaiian Islands, the two most commonly sighted beaked whale species are Blainville's (*Mesoplodon densirostris*) and Cuvier's beaked whales (*Ziphius cavirostris*), though encounter rates are low (Baird *et al.* 2003, 2006; McSweeney *et al.* 2007). Baird *et al.* (2006) found that Blainville's beaked whales sightings occur in a median water depth of 922 m while Cuvier's beaked whales occur in deeper waters with a median depth of 2,079 m. Two unidentified beaked whale sightings were in water depths of 3,373 and 4,224 m (Baird *et al.*

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<sup>11</sup> HDR conducted small-boat surveys in the waters off of Guam and Saipan in the winter of 2011 and 2012 (HDR 2011, 2012).

2006). During the 2010-2012 Marianas surveys, 34% of the effort was spent in water depths of 800-2,200 m and two encounters with beaked whales occurred.

### *Photo-Identification*

The creation of photo-ID catalogs represents the first effort in cetacean photo-identification within the Marianas. It is clear from the initial photo-identification analysis that individuals of the three cataloged species are moving between the southern Mariana Islands, in contrast to some of the same species within the main Hawaiian Islands. Both pilot whales and bottlenose dolphins moved between Guam and CNMI waters and bottlenose dolphins moved between islands within the CNMI waters. Spinner dolphins moved between the islands and Marpi Reef (~18 km north of Saipan) within the CNMI waters. Analysis of photos from spinner dolphin sightings off of Guam and at Rota Bank is underway. When complete, individuals will be compared with those from the CNMI to examine movements throughout the main Mariana Islands.

With only 2-3 years of photo data, it is unlikely that all of the distinct (D-1 or D-2) individuals have been cataloged for any of the three species for which catalogs have been created so far. Given the range of movements between the lower Mariana Islands, it is possible that individuals are moving farther up the chain of islands and that there is a larger population of individuals contributing to the groups encountered during these surveys. This underscores the importance of conducting surveys throughout the Mariana archipelago.

### *Future Work*

Surveys are planned for the spring (April-May) and summer (July-August) of 2013. The springtime effort will be primarily land-based surveys with a focus on the northern and eastern shores of Guam and Saipan scanning with 10x binoculars. The purpose will be to evaluate the effectiveness of land-based surveys. If successful, theodolite surveys may be implemented in the following year. Small boat surveys will be conducted on days when the weather permits. The summertime effort will be all boat-based surveys and will follow a similar pattern as the 2011 and 2012 surveys. Effort will be divided between the three separate locations of Guam, Rota, and Saipan, Tinian, Aguijan. A satellite tagging effort will also be implemented during the upcoming surveys. Beaked whales, humpback whales (*Megaptera novaeangliae*), and pilot whales will take the highest priority. Other species, including sperm whales, false killer whales, and melon-headed whales would also be tagging candidates if they are sighted.

The analysis of photos and the creation of new photo-identification catalogs will be ongoing. Photos collected during the 2010-2012 surveys of pantropical spotted dolphins from all locations, spinner dolphins from Guam, sperm whales from Guam and Saipan, and 1 sighting of melon-headed whales off Guam (by HDR) need to be processed. In addition, all photos from the 2007 MISTICS cruise need to be processed. Photos collected during the upcoming surveys will also be added to the catalogs.

Currently there are no designated marine mammal stocks within the CNMI EEZ. Molecular analyses of the biopsy samples collected from pilot whales, sperm whales, and bottlenose dolphins are planned for the summer of 2013. The results will likely inform questions around stock structure for the Marianas region.

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## Tables

Table 1: Dates and locations of the PIFSC cetacean surveys in southern Mariana waters.

Location	2010	2011	2012
Guam	9-18 February	26 August - 5 September	25-28 May, 26 June -3 July
Saipan-Tinian-Aguijan	22 February - 3 March	7-12, 20-29 September	7 - 24 June
Rota	----	14-19 September	28 May - 4 June

Table 2: On-effort survey distance and time by location and year.

Location	2010		2011		2012		Location Total	
	Distance (km)	Time (hr)	Distance (km)	Time (hr)	Distance (km)	Time (hr)	Distance (km)	Time (hr)
Guam	693	58.0	968	66.2	1323	90.8	2984	214.0
Saipan-Tinian-Aguijan*	571	39.1	1460	96.0	1580	102.6	3612	237.7
Rota	0	0.0	623	38.0	510	29.5	1133	67.8
<b>Year Total</b>	1265	96.1	3051	200.2	3413	223.2	<b>7729</b>	<b>519.5</b>

\*The on-effort totals reported here differ slightly from the previous reports (Oleson and Hill 2010, Ligon *et al.* 2011, Hill *et al.* 2012, Hill *et al.* 2013). On-effort minutes and trackline points were eliminated within the lagoon channel off of Saipan between the Smiling Cove Marina seawall and an outside channel marker (“green can no. 3”). This was done to reduce shallow water bias introduced from transiting through the lagoon.

Table 3: Summary of on-effort sightings by location and species across all years (2010-2012). Some of the locations listed are submerged reefs located offshore of the main Islands.

Location/Species	No. Sightings	No. Sightings for Photo-ID	No. Biopsy Samples	Mean Group Size (std dev)	Mean Depth-m (std dev)	Mean Distance to Shore-km (std dev)
<b>Marpi Reef</b>						
Dwarf sperm whale	1	0	0	1	673	16.7
Spinner dolphin	6	5	8	42 (28)	68.7 (5.1)	16.6 (1.2)
<b>Malakis Reef</b>						
Pantropical spotted dolphin	1	1	0	45	3012	52.8
<b>Saipan</b>						
Bottlenose dolphin	1	1	2	10	35.5	0.4
Pantropical spotted dolphin	1	1	6	40	562	6.1
Short-finned pilot whale	1	1	7	34	570	8.2
Sperm whale	1	1	2	6	1971	22
Spinner dolphin	14	10	27	29 (19)	61.2 (26.5)	1.0 (1.1)
Pygmy killer whale	1	0	0	6	563	10

Location/Species	No. Sightings	No. Sightings for Photo-ID	No. Biopsy Samples	Mean Group Size (std dev)	Mean Depth-m (std dev)	Mean Distance to Shore-km (std dev)
Unid. medium dolphin	1	0	0	1	464	6.2
Unid. small dolphin	2	0	0	2 (1)	770 (1053)	14.9 (17.4)
Unid. Ziphiid whale	1	0	0	2	1352	11.8
<b>Tinian</b>						
Bottlenose dolphin	1	1	1	10	62.1	0.4
Short-finned pilot whale	1	1	6	33	724	4.4
Spinner dolphin	3	2	2	25 (17)	43.5 (13.0)	0.3 (0.1)
<b>Esmeralda Bank</b>						
Short-finned pilot whale	1	1	2	23	720	36.3
<b>Aguijan</b>						
Bottlenose dolphin	1	1	1	5	734	7.3
Short-finned pilot whale	2	2	3	20 (2)	615 (87.0)	6.7 (2.3)
Spinner dolphin	3	2	7	26 (25)	147 (98.3)	0.4 (0.1)
<b>Rota</b>						
Bottlenose dolphin	1	1	2	12	43	0.5
Pantropical spotted dolphin	3	3	7	31 (24)	946 (221)	6.0 (2.8)
Short-finned pilot whale	1	1	9	38	215	0.5
Spinner dolphin	9	7	8	22 (10)	98.4 (32.6)	0.4 (0.1)
Unid. medium dolphin	1	0	0	5	631	12.6
Unid. Mesoplodon whale	1	0	0	2	1032	5.1
<b>Rota Bank</b>						
Bottlenose dolphin	2	2	1	10 (6)	113 (18.4)	18.6 (0.2)
Spinner dolphin	2	2	6	45 (0)	126 (0.0)	18.4 (0.2)
Unid. small whale*	1	0	0	1	343	21.3
<b>Guam</b>						
Bottlenose dolphin	1	1	2	7	559	1.1
Pantropical spotted dolphin	8	6	21	27 (15)	838 (521)	7.8 (3.2)
Short-finned pilot whale	2	2	10	22 (11)	647 (252)	7.0 (0.1)
Sperm whale	1	1	3	9	374	1.1
Spinner dolphin	18	18	17	40 (22)	31.9 (9.7)	0.4 (0.2)
Unid. medium dolphin	1	0	0	1	702	2.8
<b>Total</b>	<b>95</b>	<b>75</b>	<b>160</b>			

\*The position of the unidentified small whale was estimated. It was seen in the distance during an encounter with bottlenose dolphins.

Table 4: Sighting rate by species. The adjusted numbers for spinner dolphins and for the overall total are within parentheses.

<b>Species</b>	<b>No. Sightings</b>	<b>Sighting Rate (No./100km)</b>
Bottlenose dolphin	7	0.09
Dwarf sperm whale	1	0.01
Pantropical spotted dolphin	13	0.17
Pygmy killer whale	1	0.01
Short-finned pilot whale	8	0.10
Sperm whale	2	0.03
Spinner dolphin	55 (49)	0.71 (0.64)
Unid. medium delphinid	3	0.04
Unid. small delphinid	2	0.03
Unid. small whale	1	0.01
Unid. Ziphiid whale	1	0.01
Unid. Mesoplodon whale	1	0.01
<b>Grand Total</b>	<b>95 (89)</b>	<b>1.23 (1.16)</b>

Table 5: Number of pilot whale encounters and cataloged individuals by location and year, including within-year matches.

Year	Esmeralda Bank		Saipan		Tinian		Aguijan		Rota		Guam	
	No. Encounters	No. Cataloged Individuals										
2010	0	0	0	0	0	0	0	0	n/a	n/a	0	0
2011	0	0	1	19	1	30	0	0	1	32	2*	23
2012	1	9	0	0	0	0	2	25	0	0	2*	39

\*One encounter during this year was made by HDR.

Table 6: Number of cataloged pilot whale individuals matched between locations across all years (2010-2012). The numbers on the diagonal represent the number of cataloged individuals seen more than once at that location and in parentheses (the number of cataloged individuals encountered only once at that location).

	Esmeralda Bank	Saipan	Tinian	Aguijan	Rota	Guam
Esmeralda Bank	0 (9)	0	0	0	0	0
Saipan		0 (11)	0	0	0	8
Tinian			0 (10)	0	0	20
Aguijan				0 (25)	0	0
Rota					0 (13)	19
Guam						0(15)

Table 7: Number of bottlenose dolphin encounters and cataloged individuals by location and year, including within-year resights.

Year	Saipan		Tinian		Aguijan		Rota		Rota Bank		Guam	
	No. Encounters	No. Cataloged Individuals										
2010	0	0	0	0	0	0	n/a	n/a	n/a	n/a	0	0
2011	1	7	1	6	0	0	0	0	1	8	1*	3
2012	1*	1	0	0	1	4	1	12	1	6	1	5

\*HDR encounters

Table 8: Number of cataloged bottlenose dolphin individuals matched between locations across all years (2010-2012). The numbers on the diagonal represent the number of cataloged individuals seen more than once at that location and in parentheses (the number of cataloged individuals encountered only once at that location).

	Saipan	Tinian	Aguijan	Rota	Rota Bank	Guam
Saipan	0	6	0	4	0	4
Tinian		0	0	3	0	2
Aguijan			0(4)	0	0	0
Rota				0(8)	0	3
Rota Bank					4(6)	0
Guam						0(3)

Table 9: Number of spinner dolphin encounters and cataloged individuals by location and year, including within-year resights. TBD = To Be Determined

Year	Marpi Reef		Saipan		Tinian		Aguijan		Rota		Rota Bank		Guam	
	No. Encounters	No. Cataloged Individuals												
2010	1	7	3	8	0	0	0	0	n/a	n/a	n/a	n/a	8	TBD
2011	2	24	4	18	2	2	1	18	7	57	1	TBD	3	TBD
2012	2	22	6	14	0	0	2	3	1	1	1	TBD	6	TBD

Table 10: Number of cataloged spinner dolphin individuals matched between locations across all years (2010-2012). The numbers on the diagonal represent the number of cataloged individuals seen more than once at that location and in parentheses (the number of cataloged individuals encountered only once at that location). TBD = To Be Determined

	Marpi Reef	Saipan	Tinian	Aguijan	Rota	Rota Bank	Guam
Marpi Reef	6(14)	7	0	7	1	TBD	TBD
Saipan		5(14)	1	3	0	TBD	TBD
Tinian			0(1)	0	0	TBD	TBD
Aguijan				0(9)	1	TBD	TBD
Rota					16(4)	TBD	TBD
Rota Bank						TBD	TBD
Guam							TBD

## Figures

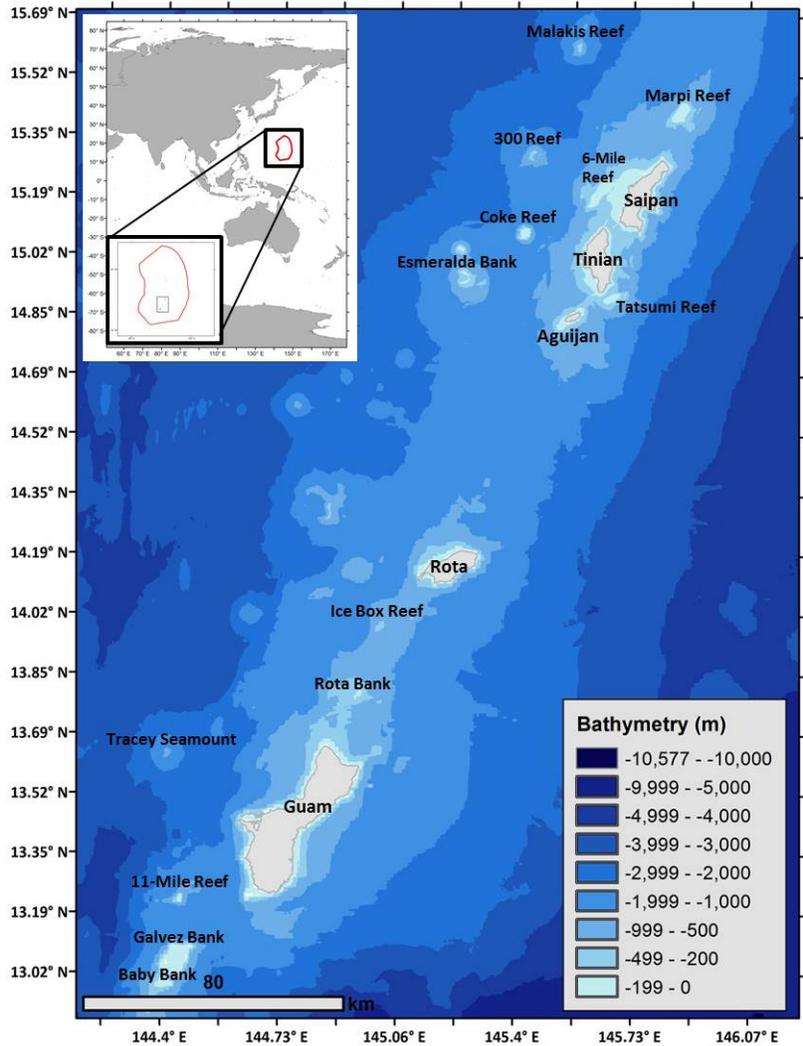


Figure 1: Survey locations of southern Marianas displaying bathymetry from all datasets combined in depth bins between 0 and 10,500 m. The inset shows the location of the Commonwealth of the Northern Mariana Islands (CNMI) Exclusive Economic Zone (EEZ) and the location of the study area within the CNMI EEZ.

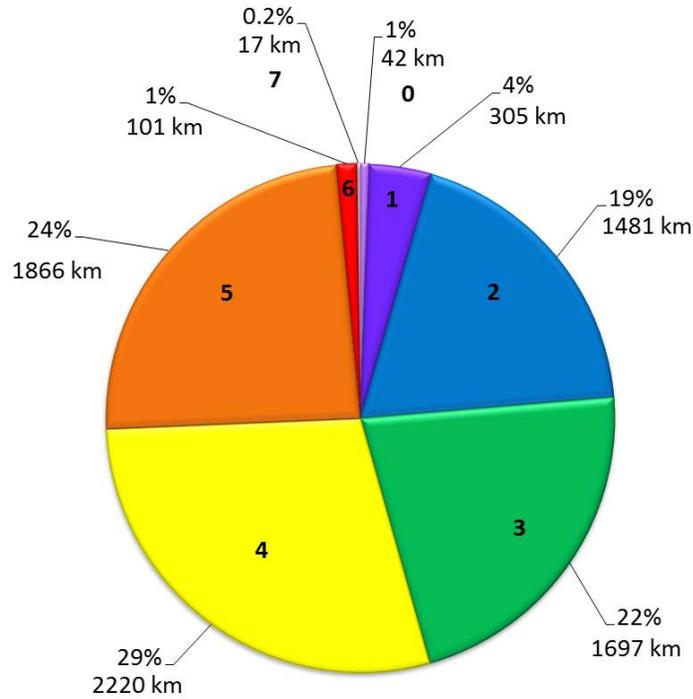


Figure 2: Beaufort sea state as a percentage of the total on-effort trackline distance (7,729 km) during the 2010-2012 surveys of the southern Mariana Islands.

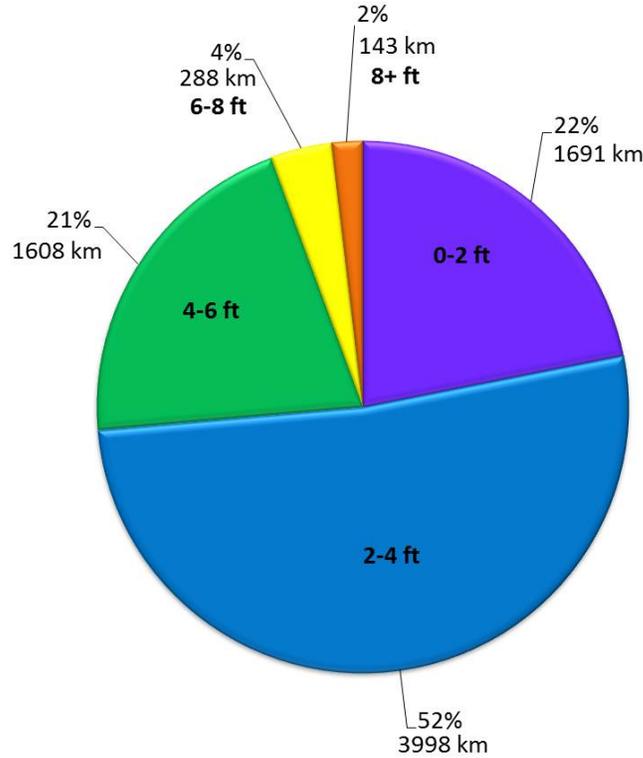


Figure 3: Swell height (ft) as a percentage of the total on-effort trackline distance (7,729 km) during the 2010-2012 surveys of the southern Mariana Islands.

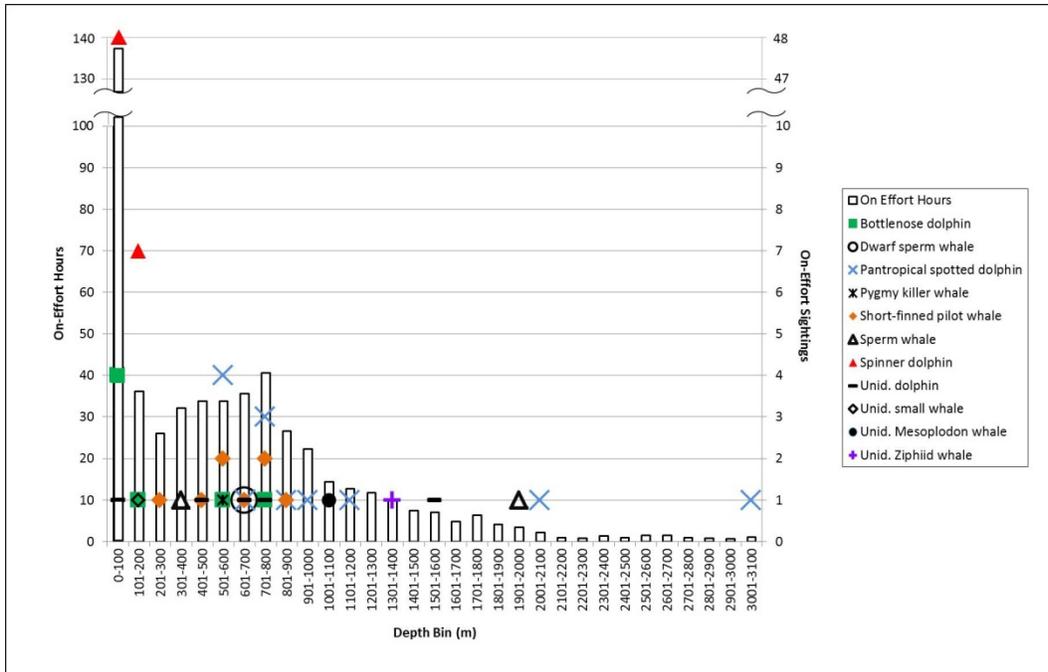


Figure 4: Distribution of sightings and search effort across depth profiles divided into 100 m interval depth bins for all locations combined. Total on-effort hours = 519.5.

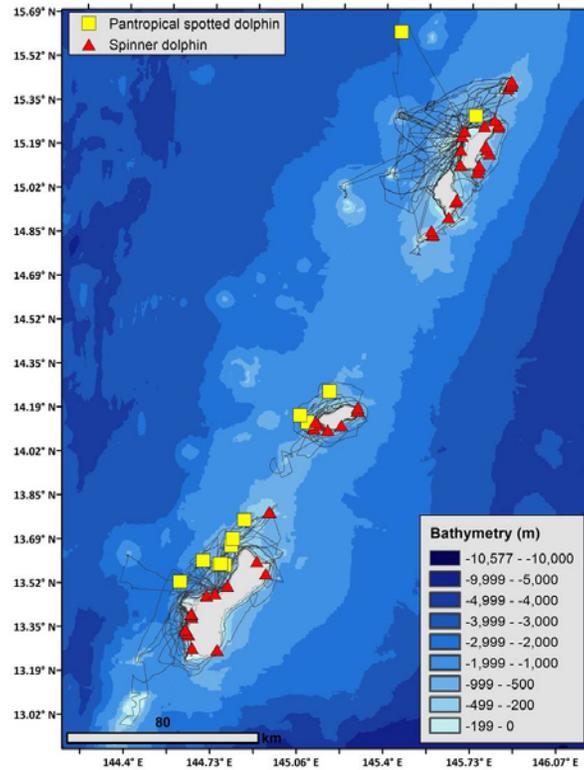


Figure 5: Spinner and pantropical spotted dolphin sightings and survey tracklines 2010-2012.

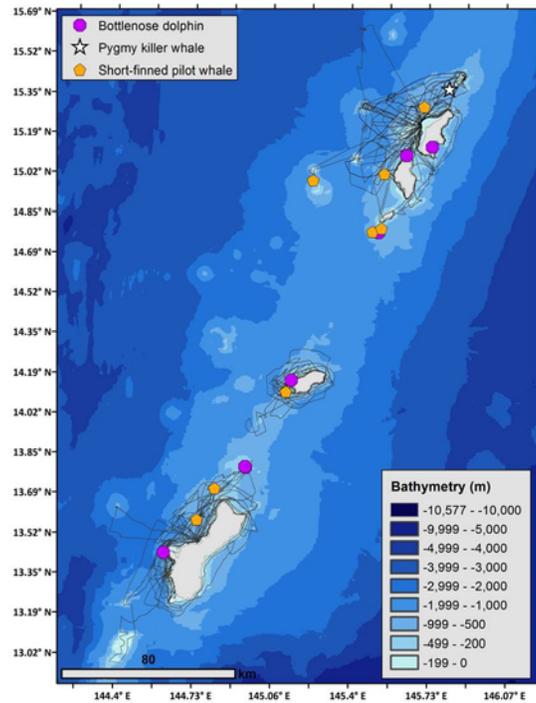


Figure 6: Bottlenose dolphin, pygmy killer whale, and short-finned pilot whale sightings and survey tracklines 2010-2012.

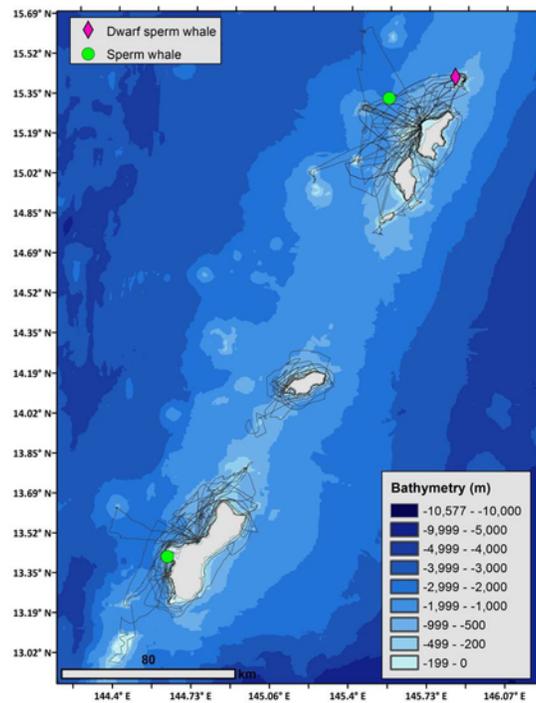


Figure 7: Sperm and dwarf sperm whale sightings and survey tracklines 2010-2012.

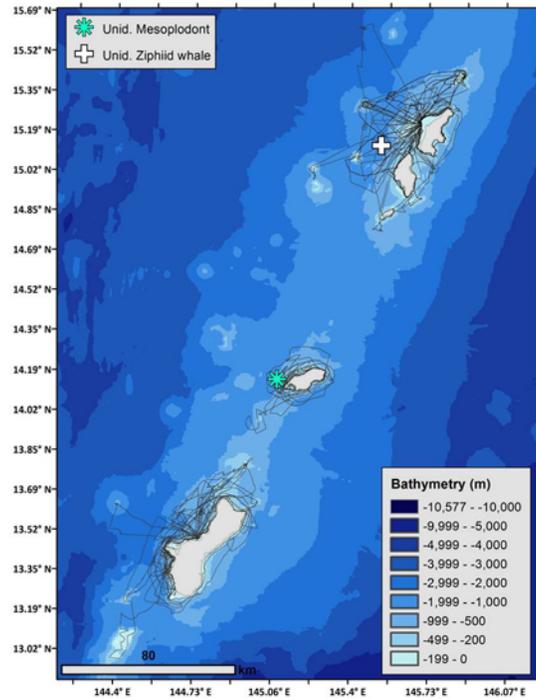


Figure 8: Beaked whale sightings and survey tracklines 2010-2012.

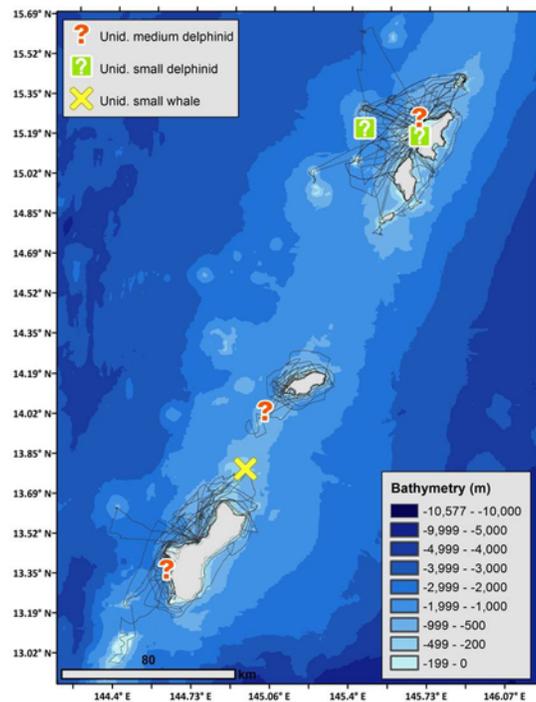


Figure 9: Unidentified dolphins and whales and survey tracklines 2010-2012.