SMALL-BOAT CETACEAN SURVEYS OFF GUAM AND SAIPAN, MARIANA ISLANDS, FEBRUARY – MARCH 2010

Allan D. Ligon[1], Mark H. Deakos[2], Adam C. Ü[3]

[1] 3-3359 Kuhio Highway, Lihue, HI 96766 (e-mail: aligon@aol.com)

[2] Hawaii Association for Marine Education and Research, Inc., PMB# 175, 5095 Napilihau Street 109B, Lahaina, HI 96761

[3] Southwest Fisheries Science Center, National Marine Fisheries Service, 3333 North Torrey Pines Court, La Jolla CA 92037

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Summary

Little information is available for cetaceans around the Mariana Islands in the western North Pacific. Small-boat surveys were conducted around the islands of Guam and Saipan from February 9 to March 3, 2010 in order to document cetaceans that occur in the region. The primary objectives were to locate cetacean species, assess group sizes, obtain photos, and collect genetic samples to determine sightings rates and assess the structure, abundance, and movement habits of these populations. Surveys were conducted on 16 days: 10 off the island of Guam, and 6 off the island of Saipan, consisting of 98.3 hrs of effort and 1,296.7 km of trackline. Strong trade winds persisted during most of the survey period with 72% of overall effort occurring in Beaufort 4 conditions or greater. Despite the strong winds, we had 18 sightings consisting of 4 species. These included spinner dolphins (14 sightings: 8 off Guam, 6 off Saipan), sperm whales (2 sightings, 1 each off Guam and Saipan), 1 group of pantropical spotted dolphins off Guam, and 1 unidentified, medium-sized dolphin off Guam. A total of 3,470 photos were collected with the majority (81%) from spinner dolphins (2,334 off Guam, 692 off Saipan). All photographic data was submitted to the Pacific Island Fisheries Science Center for analysis and development of species ID catalogs. Fifteen tissue samples were obtained for genetic analysis: 10 from spinner dolphins (5 each off Guam and Saipan), and 5 from sperm whales (3 off Guam, 2 off Saipan). All samples contained skin and blubber except for 1 sloughed skin sample from a sperm whale off Guam. The overall sighting rate for the project was 1.39 sightings/100km of effort, however many of the sightings off Guam were from directed approaches of a spinner dolphin group known to recur regularly in the same location, positively biasing the sighting rate. Adjusting for the directed approach bias, the sighting rate was reduced to 0.96 sightings/100 km.

Introduction

The Mariana Archipelago is made up of 15 islands stretching approximately 880 km in a north-south arc from Guam (the largest and southern-most island, located at 13 28’ N, 144 47’ E) to the northern-most island of Farallon de Pajaros (also known as Uracas, located at 20 31’N, 144 54’E), (see Figure 1 for a map of the Mariana Archipelago). The southern (“Main”) Mariana Islands from Guam to Saipan 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 (in decreasing order). 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[1]. In regards to ocean topography, 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. Geopolitically, the Mariana Islands are composed of two US jurisdictions: the territory of Guam, and the Commonwealth of the Northern Mariana Islands (CNMI). The CNMI covers all of the Mariana Islands (except for Guam) with Saipan being the second-largest island in the archipelago, and the center of CNMI government.

[1] 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.

Due to US territorial status, management of marine mammal stocks around Guam and CNMI is the responsibility of the US National Marine Fisheries Service (PIFSC, 2006). Currently, little information exists on cetaceans in the region. Most of what we know comes from stranding records (Kami & Lujan, 1976; Kami & Hosmer, 1982; Donaldson, 1983; Trianni & Kessler, 2002; Jefferson et al, 2006), whaling records (Townsend, 1935; Camba, 1965; Masaki, 1972), and publications of previously undocumented strandings and anecdotal sighting reports (Eldredge, 1991; Eldredge, 2003; Wiles, 2005). 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 & Mori, 1993; Yamaguchi, 1995; Yamaguchi, 1996; Shimada & Miyashita, 2001; Ohizumi et al, 2002). These met with little sighting success in the vicinity of the Mariana Islands; however each of these projects only spent a small amount of time in Mariana waters[2]. Only three scientific cetacean surveys dedicated to the Mariana region have been conducted in recent years: a large-ship line-transect survey (the 2007 MISTCS cruise: US Navy, 2007; Fulling et al. *In press*.), a 5-day aerial survey conducted in August 2007 (Mobley, 2007), and a set of NOAA ship surveys in 2010 (PIFSC, 2010-a, -b, & -c)[3].

In order to obtain data on species occurrence and to assess logistical issues for future cetacean research projects, the Pacific Islands Fisheries Science Center contracted us to conduct small-boat surveys off the islands of Guam and Saipan. These surveys were carried out opportunistically during the interim between two NOAA-ship marine mammal surveys (PIFSC, 2010-a, January-February, 2010; and PIFSC, 2010-b & -c, March-May, 2010).

Besides the transportation convenience for timing our field effort between the interim of the NOAA-ship surveys, scheduling the surveys during winter months was desired to investigate the presence of migrating humpback whales (*Megaptera novaeangliae*) around the Mariana Islands. According to whaling data, many humpbacks were historically observed (and taken) in the vicinity of the Marianas (Townsend, 1935; Camba, 1965) to the extent that the region was once identified as one of eleven "prime world population" areas for humpbacks (Eldredge, 1991). Even recent descriptions and stock assessments of Asian (western North Pacific) humpbacks listed the Marianas as part of the regular winter range (Rice, 1998; Angliss & Outlaw, 2007; Calambokidis et al, 2008). However, Leatherwood et al. (1982) described that "the Asian stock [of humpback whales] were overexploited by commercial whalers … and [were] seriously depleted." Indeed, only a few anecdotal reports of humpback sightings around the Marianas are available during the last 3 decades of the 20th century (Eldredge, 1991; Eldredge 2003), and the few dedicated attempts that were made in the 1990's to investigate the presence of humpbacks around the Marianas had no success (Darling & Mori, 1993; Yamaguchi, 1995; and Yamaguchi, 1996; Shimada & Miyashita, 2001; and Ohizumi et al, 2002). Yet, anecdotal humpback reports continued to occur during that timeframe (Darling & Mori, 1993; Eldredge, 1991; Yamaguchi, 1995, Eldredge, 2003).

[2] Darling & Mori (1993) spent just one week on Saipan in February 1990; Shimada & 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 regarding weather, such a low sighting rate implies that poor sea conditions were likely a factor. (No sighting data was reported from Yamaguchi, 1996.)

[3] The NOAA ship surveys were mammal-specific line-transect surveys conducted while in transit between Hawaii and Guam (PIFSC, 2010-a & -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).

Methods

During February and March 2010, we chartered small-boats on the islands of Guam and Saipan to conduct cetacean surveys with the following primary goals: 1) locate cetacean species, 2) document group sizes, 3) collect photo-identification data, and 4) collect tissue samples. The effort put forth in locating cetaceans will provide documentation on species presence and distribution and will be used to calculate sighting rates to compare with other regions. Group size data and sighting rate calculations together can be used to assess abundance. As data accumulates with future projects, the photographic data can be used to investigate population structure and abundance, movements of individuals and residency, and to help identify potential health issues that can be assessed through visual cues (such as the presence of skin lesions or scarring from fisheries interactions). Genetic analysis of the tissue samples will provide additional information on population structure such as the identification of independent stocks. Tissue samples could also be used to examine diet, hormone levels, and toxin loads.

We planned 10 field days each off Guam and Saipan, hoping to be able to conduct at least seven surveys off each island, depending on weather conditions and any potential vessel mechanical/availability issues. The surveys were planned between February 9th through 18th, 2010 off Guam and February 22nd through March 3rd, 2010 off of Saipan (Figure 2 shows a bathymetric map of the study area). Vessels used included a 5.8 m Boston Whaler, a 9.4 m Bertram Sport Fisher with flying bridge, a 11.6 m Walk-Around Sport Fisher with flying bridge, and a 12.2 m Sport Fisher with flying bridge (Table 1). All but two days of the Guam surveys were conducted aboard the 5.8 m Boston Whaler, and one day each was afforded for the 9.4 m Bertram and the 11.6 m Walk-Around. All survey days off Saipan were aboard the 12.2 m Sport Fisher.

Between four and seven observers were used for each survey. Three of the observers were highly experienced, NOAA-trained, marine mammal observers serving as the project's primary research staff[4]. The fourth crewperson aboard for every survey was a locally experienced vessel captain[5] with insight on cetacean sighting locations. Additionally, one to three others assisted on most of the Saipan surveys. These consisted of either additional vessel crew or local government resource management personnel. Each supported the field work by providing additional eyes for the search effort, as well as assisting with data recording or other tasks as needed.

During active search effort (termed "On-Effort"), all observers were designated overlapping quadrants around the vessel to scan for marine mammals, collectively searching the full 360-degree area around the boat. Depending on vessel size and sea conditions, an 8 to 12 knot search speed was generally maintained. Occasional stops were made for brief 360-degree binocular scans to search for distant or cryptic animals.

Surveys were non-random and non-systematic, and although weather conditions greatly restricted the coverage area, attempts were made to spread vessel tracks out from day to day to increase coverage area and distribution over a wide range of depths. However, some particular areas identified by local captains as having a high probability for cetaceans were targeted daily (these were locally-known spinner dolphin resting areas). Preferences for coverage area were given to calmer water conditions when available. For small-boat surveys, sea states of Beaufort 4 and higher are typically avoided due to

[4] Only two of the three primary research staff were available for the last two Saipan survey days (March 2nd and 3rd).
[5] The captain varied depending upon the vessel used, but the description fits all captains we worked with during the project.

significantly decreased likelihood of spotting cetaceans amongst high seas and white caps (Barlow et al, 2001; Beavers & Ramsey, 1998). However, due to small wind-lee protection and consistently strong east/northeast trade winds, Beaufort 5 (and occasionally higher) conditions were regularly surveyed. Winds tended to strengthen each day around 09:00 – 10:00 in the mid-morning, remaining strong through the rest of the afternoon. Therefore surveys began around 06:30 – 07:00 to take advantage of generally calmer conditions just after first light. To further enhance our detection potential in relation to sea conditions, we employed search strategies which dictated whether surveys would initiate offshore or inshore based upon the area we intended to cover. If we planned to survey areas southwest (down-weather) of our launch point, we would direct our pattern to survey offshore in the morning heading south in the down-weather direction, and make the return circuit surveying close to shore in the up-weather direction, where the small lee could provide some protection from swell and white-caps. If we planned to search areas north/northeast (up-weather) from our launch point, we would run the opposite pattern: up-weather nearshore in the morning, down-weather offshore for the return. This strategy provided better viewing conditions and smoother vessel ride for the overall intended coverage area across the survey-day.

Data regarding effort status, sea-state, and swell height were recorded as condition changes dictated. GPS readings of the vessel's track were automatically recorded once per minute. All cetaceans encountered were approached for species confirmation, group size estimates, photo ID and biopsy sampling, when possible. The photographic equipment used included a Nikon D200 digital SLR camera body with f/2.8 70-200m telephoto zoom lens, and Canon EOS 50D digital SLR camera body with Canon EF f/4.5 100-400mm IS USM telephoto zoom lens. Photography efforts focused on dorsal fin (dolphin) and fluke (large whale) images for individual identification purposes, but also emphasized body and head shots when possible to assist with health and scarring assessments. All photographs were submitted to the Pacific Island Fisheries Science Center's (PIFSC) Cetacean Research Program for analysis and to develop species catalogs for distinctively marked individuals.

Biopsy sampling was conducted using Barnett crossbows and Ceta-Dart bolts with sterilized, stainless steel biopsy tips (25 mm long x 8 mm diameter biopsy tips for dolphins, and 40 mm x 8mm diameter biopsy tips for large whales). Tissue samples were preserved in a cooler on ice while on the boat, and transferred to liquid nitrogen at the end of each day while on Guam. Since liquid nitrogen was not available on Saipan, samples were stored in a standard refrigerator freezer for up to three weeks before being transferred to liquid nitrogen upon return to Guam. In both cases, samples were split in half longitudinally at the end of each field day with each subsample stored in a different vial. One vial of each sample was submitted to the PIFSC (Honolulu, HI, USA), and the other was submitted (via PIFSC) to Southwest Fisheries Science Center (La Jolla, CA, USA) for tissue archiving.

Two bathymetry datasets were used in analyzing the depth profiles of our survey effort. A high resolution (5m, 10m & 60m grids) multibeam color-shaded bathymetry dataset was available for use for nearshore waters inside the 400m isobath surrounding the islands. This dataset was downloaded from the Pacific Islands Benthic Habitat Mapping Center[6] (PIBHMC, 2007). This high resolution data was not available outside of the 400m isobath, therefore another bathymetry dataset was downloaded from the National Geophysical Data Center's GEODAS Grid Translator (www.ngdc.noaa.gov/mgg/gdas/gd_designagrid.html) using the ETOPO1 1 arc-minute global relief

[6] The Pacific Island Benthic Habitat Mapping Center is in association with NOAA-PIFSC-CRED (Coral Reef Ecosystem Division), Honolulu, HI, USA.

model (Amante and Eakins, 2009). This dataset lacked the resolution and accuracy needed to analyze shallow depth profiles and thus was used only for bathymetry beyond the 400m isobath.

For both bathymetry datasets, binary ASCII data files (.ASC) were downloaded from each dataset's respective website and then processed into depth contour shape-files (.SHP) using SAGA (free, open source shareware GIS software, www.saga-gis.org). The shape-files were then imported into ExpertGPS v4.25 (www.expertgps.com). Vessel GPS tracks and sighting locations were then overlaid onto the bathymetric dataset to conduct depth profile analysis of survey effort.

Depths of sighting locations were determined manually by plotting the location over the PIBHMC's multibeam bathymetry raster map using SAGA GIS and zooming in to reveal the nearest depth pixel underlying the position. If multibeam data was not available for a particular sighting location, then the depth value was interpolated using the two nearest nautical chart depth soundings. To analyze the amount of search effort by depth, 'On-Effort' times were calculated for depth bins from 0 to 2,100 m in 100 m intervals.

Results

Survey Effort & Weather Conditions:

Field work was conducted between February 9 to March 3, 2010. Overall, 16 surveys were completed (10 days off Guam, 6 days off Saipan) covering 1,297 km with 98 hours of survey effort. (Figure 3, Table 1).

Off Guam, we experienced quite strong and consistent northeast trade winds during the entirety of the 10-day field effort. According to data recorded by the Agana National Weather Service Office, the daily maximum sustained winds onshore at Hagatna, Guam during our surveys ranged from 14 to 22 knots (mean = 18.8, SD = 2.35 knots) with daily maximum gusts ranging from 19 to 28 knots (Table 2). Fortunately, Guam does have a small, but narrow lee on its southwestern flank. The lee only extends about 1 to 2 km from the coast, but does provide protection very close to the shoreline in the area of some locally known spinner dolphin resting areas. (Figure 4 shows a map of "On-Effort" vessel tracks color-coded by recorded swell height and gives a visual example of the protective effect provided by island lees.) Thus, we were able to conduct surveys on all 10 days off Guam, covering 693.1 km with 56.9 hrs of survey effort (Tables 1 & 3).

Because of the narrow lee, we had good search coverage close to shore along the southwest side of Guam between Agat Bay and Merizo (Figure 5). We covered this circuit and shoreline five of the ten survey days (Table 1). After achieving good multi-day coverage tight in shore within the lee, we made efforts to expand our surveys into new areas and deeper waters. However, the high winds made this unproductive. In the end, our average (km) sea conditions was Beaufort 4.3, with 560.7 km (80.9%) and 43.2 hrs conducted in Beaufort 4+ sea conditions (Tables 3, 4 & 5, Figure 6). If we limit our analysis to conditions less than Beaufort 4 (generally the preferred norm for small-boat surveys), we would have only achieved 13.7 hrs and 132.4 km (19.1%) of effort (in Beaufort 0 – 3) across 10 days. From personal experience, this is roughly $1/7^{th}$ of the effort values we typically would expect during the same number of survey days in Hawaii (where more extensive lees exist and where we generally would have a greater timeframe available, thus more flexibility to select survey dates based on favorable weather forecasts).

Off Saipan, we were quite fortunate to begin our surveys with an unseasonably calm weather system. Across the first 3 survey days, the daily maximum sustained wind speeds only ranged from 8 to 9.9 knots (Table 2). Day 4 started off with calm conditions, but quickly deteriorated to Beaufort 5 and later Beaufort 7. These high winds did not abate until March 2. We were unable to work the coastline along the leeward side of Saipan during the windier days, as we did off Guam. About three quarters of the western coastline of Saipan is bordered by a shallow lagoon that ranges from 1 km to 3.5 km wide with an average depth of less than 3 m (Trianni and Kessler, 2002). Therefore, virtually no protected areas were available to work during windy days[7]. We were able to resume surveys again on March 2nd & 3rd, our last 2 days available for the project. With the size of the vessel, and the fortunate calmness of the first few days, we were able to circumnavigate Saipan once and Tinian once, head to Marpi Reef 18km north of Saipan on 2 occasions, and surveyed some offshore shallow reefs 25 km northwest/southwest off Saipan on 2 occasions ("300" Reef & Coke Reef, respectively), thus providing broad coverage around the Saipan/Tinian area (Figure 8). In the end, we were able to conduct 6 days of surveys off Saipan with 41.4 hrs and 603.6 km of effort (Tables 1 & 3). Our average (km) sea-state was Beaufort 3.9 (Table 5) with daily maximum sustained winds ranging from 8 to 16.9 knots (mean = 12.3, SD = 3.97 knots; Table 2). A total of 230.4 km (38.2%) and 16.4 hrs of effort were completed in conditions between Beaufort 0 – 3 (Tables 3 & 5, Figure 7), a significant improvement over the conditions experienced off Guam.

Sightings, Samples and Photographs:

Despite the consistently strong trade winds and poor sea conditions, we had 11 cetacean sightings off Guam (Tables 6 & 7). The most commonly encountered species were spinner dolphins (*Stenella longirostris*) with 8 sightings (73%). Depth locations for Guam spinner dolphin sightings ranged from 7 to 13 m (mean = 9.5m, SD = 2.8m), and distance from shore ranged from 0.12 to 0.67 km (mean = 0.36, SD = 0.16 km). All but one of the spinner encounters were located in the same general area tucked deep within Agat Bay (Figure 9), which had dolphins present on all but one of the days the area was searched (6 days out of 7, 86%). This is the primary location utilized by Guam's commercial dolphin-watching industry. We worked with this group early in the morning before other boats arrived, and the animals were generally, but inconsistently, approachable and tolerant of the research vessel. The only other location where we came across spinner dolphins was just south of Facpi Point (Figure 8). These animals were largely unapproachable, even for photographs.

Other species encountered off Guam included: 1 group of pantropical spotted dolphins (*Stenella attenuata*, group size = 17, depth = 1,864 m, distance from shore = 7.6 km); 1 group of sperm whales (*Physeter macrocephalus*, group size = 9, depth = 404 m, distance from shore = 1.3 km); and a single unidentified, medium-sized dolphin (possibly *Tursiops* sp. or *Steno* sp.). Both the spotted dolphin encounter and the unidentified dolphin were sighted in Beaufort 5 seas, and both were quickly lost in the conditions with little data obtained. All other sightings were located in seas between Beaufort 2 and 4. The sperm whales, although initially located resting/logging in relatively shallow water (404 m), moved north around Orote Point and into deeper waters (approx.1200 m) by the end of the encounter.

[7] There is a small area in the northernmost section of Saipan Lagoon that does reach a maximum depth of 14 m and from which occasional spinner dolphin sightings are reported nearly every year (Trianni and Kessler, 2002), however: 1) it was deemed impractical to use the 12.2 m vessel and crew in such shallow waters, 2) we were unable to locate an available smaller vessel on short-notice to survey the lagoon, 3) the winds were visibly quite strong and unworkable even within the lagoon during our weather days.

On February 13 (Day 5), there was a marine radio report of "pilot whales" a few miles NW of Orote Point; however we searched the area described, in Beaufort 5 conditions, without success.

Off the Saipan area, despite some nice weather days, and relatively good coverage in deeper waters, we only had 7 cetacean encounters (Tables 6 & 7). Our most commonly sighted species were spinner dolphins (6 sightings, 86%). Initial sighting depths ranged from 33 to 81 m (mean = 63.5, SD = 20.7m), while distance from shore ranged from 0.42 to 18.3 km (mean = 6.6, SD = 8.51 km). Unlike Guam, these sightings were distributed in different areas around the islands (Figure 10). The most unexpected sighting location was an area of open water over an offshore shallow reef located 18 km north of Saipan known locally as Marpi Reef. This feature is an underwater bank approximately 9 km long by 4 km wide. The surrounding 100 m isobath covers an area of 17.1 km^2, and the bank's shallowest point is at 53 m. Spinner dolphins were encountered at Marpi Reef on both days that we surveyed the area. On both occasions the groups were milling along the northeastern corner of the bank at 74 m, and 71 m depth, respectively.

The only other species sighted off of Saipan was a group of 6 to 8 sperm whales. They were spread out over a large area 21.9 km west of Saipan in approximately 1,900 m of water. We were successful in obtaining complementary fluke identification photographs and biopsy samples from 2 individuals in this group.

Over the whole project, a total of 3,740 photographs were taken (Table 7). Of these, 2,334 (62.4%) were from Guam spinner dolphin sightings (1,978 of these were from the 7 sightings at Agat Bay, 347 from the Facpi Point group). Another 692 photos were taken of spinner dolphins near Saipan. A total of 695 images were taken of sperm whales (416 from the Guam sighting, and 279 from the Saipan sighting). The other two sightings off Guam were quickly lost in Beaufort 5 seas, so only 13 photos were taken of the spotted dolphins, and only 6 images were taken of the unidentified dolphin encounter.

A total of 15 tissue samples were collected. Ten samples were taken from spinner dolphins, 5 each from Guam and Saipan. The other 5 samples were collected from sperm whales, (3 from Guam, including one sloughed skin sample, and 2 from Saipan (Table 6 & 7, Figures 11 & 12).

Sighting Rates and Depth Distribution:

The sighting rate for all sightings on Guam was 1.6 sightings/100 km of effort (Table 8). For Saipan, this rate dropped to 1.2 sightings/100 km. For all sightings and surveys combined from both island areas, the rate comes out to 1.4 sightings/100 km. An adjusted sighting rate was also calculated to correct for a positive bias from directed Agat Bay spinner dolphin approaches (refer to Discussion section below). The adjusted sighting rate for Guam is 0.8 sightings/100 km; for Saipan, the sighting rate remains the same; and overall the adjusted sighting rate for both islands reduces to 1.0 sightings/100 km (Table 8).

In regards to sighting rates relating to sea conditions, as expected, sighting success was significantly higher for calmer Beaufort levels (Table 9). These sighting rates (sightings/100 km) were: Beaufort 2 = 4.0, Beaufort 3 = 2.3, Beaufort 4 = 1.1, and Beaufort 5+ = 0.5. (We had little effort, and no sightings in Beaufort 0 and Beaufort 1 conditions). After applying the Agat Bay bias adjustment,

sighting rates per sea state drop to: Beaufort 2 = 2.0, Beaufort 3 = 2.5, Beaufort 4 = 0.8, and Beaufort 5+ = 0.5 (Table 9).

When looking at depth distribution of all sightings, we find that all 14 spinner dolphin groups were located in 0 – 100m depth (Figure 12), and no sightings of any species occurred in depths greater than 2,000 m. Distribution of effort across depth profiles is shown in Figure 12 with 32.3% of overall effort in waters less than 100 m depth, and 59.5% in less than 500 m.

Discussion

Sighting Rates:

On the days when we departed from Agat Marina on Guam, we routinely began each survey by heading directly into the corner of Agat Bay to work with a group of spinner dolphins known to regularly occur there, before beginning the search for other sightings. This directed pattern applies a positive bias to the standard sighting rate calculations. If we include only the first sighting occurrence of the Agat Bay spinner group, but exclude each subsequent sighting of that group, as well as the effort values (km) accumulated for the period spent on subsequent Agat Bay spinner sightings, then we should be able to provide a more representative value for the actual "search" part of the project's effort. In doing so, the number of Guam spinner dolphin sightings was reduced from 8 to 2 (including only the initial Agat Bay sighting, and the one spinner group sighted near Facpi Point). This would also eliminate approximately 45.0 km of effort which accumulated during subsequent targeted approaches to the Agat Bay spinners. Therefore, the overall adjusted sighting rate is calculated with just 12 project sightings over 1,252 km giving a rate of 0.96 sightings/100 km. This rate is only slightly smaller than what other vessel surveys have seen in the Marianas and other island areas of the Central North Pacific (Table 10). However, most of the data available come from large-ship surveys where observer eye height is typically about 15 m above the water versus small-boat surveys where eye level is usually between 2 to 4 m high. Additionally, due to greater platform stability, large-ship surveys are often able to utilize magnified lenses continuously during their search effort. Both of these features provide significant sighting advantages to large ships in being able to spot animals over a much greater area and at distances indiscernible from a small-boat platform. The only data we located that would be comparable with small-boat sighting rates for Central North Pacific island areas comes from cetacean surveys conducted around the Hawaiian Islands. Baird et al (2003) reported an overall sighting rate of 1.62 sightings/100 km during a 6-week survey across the Main Hawaiian Islands, and a rate of 2.55 sightings/100 km during a survey focusing around the islands of Kaua'i and Ni'ihau (Baird et al, 2006). These sighting rates are significantly higher than that experienced during our project, however, both Hawaii surveys reported much calmer sea conditions with 91.1% and 73.7% (respectively) of all search effort conducted in sea states of Beaufort 3 or less, whereas we experienced only 28% of our effort conducted under Beaufort 4 levels. Therefore, for all comparable projects listed in Table 10, contrasts in platform height and/or weather conditions should easily account for the slightly lower sighting rate observed during our 16-day Mariana project.

Weather:

Clearly the weather conditions greatly affected the productivity of this project. With over 80% of the survey effort off Guam in sea conditions of Beaufort 4 or higher (despite working off the protected

leeward side), the probability of observing marine mammals was greatly reduced. Mariana residents describe the winter months as the "windy season" or "Sailing Season", with strong trade winds blowing consistently from November to April. Calm weather systems can occur during this time of year but they are usually brief and can be quickly replaced by longer periods of strong winds, much like we experienced off Saipan. The winter winds are consistently strong with few disturbances thus winter is considered to be the more stable, reliable time of year in regards to weather. The summer months are generally more volatile with some strong, wet storm systems and occasional typhoons, but with extended periods of calm weather often occurring between the stronger weather systems, unto which local residents often apply the term 'doldrums'. Despite the risk of a severe storm, accurately timing a future project within a summer period of "doldrums" should provide ideal sighting conditions and much greater opportunities to collect data on the many species that likely occur around the Marianas, particularly odontocetes.

Odontocetes:

Knowledgeable fishing captains report seeing numerous odontocetes throughout the year, including spinner, spotted and common bottlenose dolphins (*Tursiops truncatus*), short-finned pilot whales (*Globicephala macrorhynchus*), melon-headed whales (*Peponocephala electra*), sperm whales, false killer whales (*Pseudorca crassidens*) and beaked whales (family *Ziphiidae*). Spinner dolphins, spotted dolphins, common bottlenose dolphins, short-finned pilot whales and sperm whales were described as being the species most likely to be seen year-round. One captain noted that although false killer whales could be seen at any time of the year, he felt they were more commonly encountered around September, although still somewhat infrequently. With September being one of the calmer months of the year (in regards to wind speed and sea state), and false killer whales being a high-priority species in other Central Pacific island regions (PIFSC, 2006), it may be of interest to conduct additional small-boat surveys during this time of year to compare sea conditions, sighting rates, and species diversity.

Spinner dolphins:

Off Guam, almost all of our spinner dolphin sightings occurred in a central area known as Agat Bay. This location is the "bread and butter" of the Guam dolphin watching industry. It is in very well protected waters, and by boat, is only 5 km north of Agat Marina, 12 km south of Apra Harbor, and 24 km south of Hagatna Boat Basin. We are uncertain how many boats may interact with the dolphins in Agat Bay, but while heading back to port around mid-day, we occasionally observed 2 to 3 boats grouped together in the area where the dolphins are regularly observed. Some of the commercial operators are known to make multiple dolphin viewing trips per day. The only other location where we observed spinners was just south of Facpi Point. Although we never spotted animals elsewhere, local residents described regularly seeing spinner dolphins occurring in the following locations around Guam: a) the Merizo channel, b) tucked into the several small, remote bays between Merizo and Facpi Point, c) Piti Bay, d) Hagatna, e) Tumon Bay and f) Pugua Point ("Double Reef", described in Eldredge, 1991 & 2003). Refer to Figure 9 for a map of these additionally reported sighting areas.

Off Saipan, we encountered spinner dolphins twice at Marpi Point and once each off "The Grotto", Tank Beach, Naftan Cliff, and just outside Saipan Lagoon adjacent to Managaha Island. Additionally, residents described seeing spinner dolphins occasionally in the northern part of Saipan Lagoon (Trianni and Kessler, 2002), Laulau Bay on the southeast coast of Saipan, and all along the west coast

of Tinian in the bays between Hilo Point and Diapblo Point, and particularly just north of the Tinian Harbor boat channel from which Saipan/Tinian ferry passengers often see spinners as they arrive/depart Tinian. Refer to Figure 10 for a map of these anecdotally reported sighting areas.

The Humpback Question:

During our February/March 2010 surveys, a number of Mariana residents conveyed seeing humpbacks earlier in the season just prior to our arrival, but unfortunately no known sightings were reported during our on-island (Guam or Saipan) research presence from February 7 to March 8. However, during the first week of March, the NOAA ship *Oscar Elton Sette* (which was involved in mapping surveys in the region during our small-boat field effort), reported seeing numerous humpback whales close to shore off the island of Farallon de Medinilla (Figure 1), 83 km NE of Saipan (pers. comm. with A. Lopez, CO of the *Oscar Elton Sette*). The "*Sette*" also reported observing a single baleen whale breaching nearshore off the west side of the island of Rota on February 20, 2010 (A. Lopez, *Sette* CO, pers. comm.).

Additionally, during the 2007 MISTCS line-transect cetacean survey (US Navy, 2007; Fulling et al, *in press.*), seven unique acoustic detections were made of singing humpback whales separated across a 54-day period, indicating extended occupation of the study area (Morse et al, 2008). Also, in daylight hours following a nighttime acoustic humpback localization, the MSTCS cruise observed a "surface active group of 6-9 [humpbacks]". As postulated by Morse et al, 2008, the presence of "singers" and multiple animals in a surface-active group indicates the Marianas as an active breeding site.

During our field project, we received consistent reports from local commercial sport fishing captains who describe general humpback sightings as passing through Guam and Saipan around January, heading north. They describe these sightings as animals that are "traveling" and do not seem to linger around the main islands for very long. These captains go on to describe that humpback sightings are less common in February and March, but begin to pick up again sometime in April, this time with animals generally traveling south. There is speculation amongst various long-time local fishing captains that the humpbacks hang out during the winter at the more northern islands of the Mariana archipelago, such as Pagan. These islands are uninhabited and quite remote (Pagan is approximately 320 km due north of Saipan, whereas Farallon De Pajaros, the most northern-island of the archipelago, is 598 km north-northeast of Saipan; refer to map on Figure 1). The captains that provided these speculations are long-term Mariana residents that have been working on local waters for more than 30 years and likely have a highly acute sense of the behavior and movements of the animals that occur in the region.

Recent humpback expansion into new North Pacific wintering areas has been described for the Northern Philippines (Yaptinchay, 1999; Acebes et al, 2007; SPLASH, 2009) and the Northwest Hawaiian Islands (Johnston et al, 2007; Lammers et al, 2011). Furthermore, results from the SPLASH[8] project indicate a North Pacific humpback whale population growth rate as high as 6.8% over the 39 year period since the end of international whaling in 1966 (SPLASH, 2009). This along with the 2010

[8] SPLASH was a 3-year intensive, internationally collaborative study of the structure, population, and abundance of humpback whales across all known wintering and summering grounds of the North Pacific (2004-2006).

reports of multiple humpback observations from the NOAA ship *Oscar Elton Sette*, the 2007 MISTCS cruise acoustic detections and surface-active visual observation, and the ostensibly increasing anecdotal humpback reports from Mariana residents, fisherman and boat captains all lend support to the idea that humpback whales could be in the process of expanding or re-occupying their historic winter range into the Marianas. Significant humpback whale preferred wintering habitat (shallow waters less than 200 m depth; Rice, 1978) exists throughout the Mariana Islands. A brief analysis of the bathymetric data used in this study indicates that the archipelago contains about 1,460 km^2 of water area less than 200 m depth (after subtracting island surface areas). The remote northern islands themselves provide 44% (643 km^2) of this habitat; with the area around Farallon De Medinilla being the single largest contributor in the archipelago at approximately 411 km^2 (28%) [9]. If expansion/re-occupation is taking place, and if the fishing captains are correct in their speculation that humpbacks generally pass through the Main Mariana Islands to the more remote northern reaches of the archipelago, then identifying the expansion from Guam and Saipan might prove to be a slow and difficult process to pursue with vessel surveys alone.

Although few people venture to the remote northern end of the Mariana archipelago, finding ways to survey these places during winter months could be quite informative. Vessel surveys, whether they be large-ship line-transect surveys, smaller live-aboard charter vessel surveys, or remote small-boat field camps, have the advantage of obtaining photo-ID and tissue samples of any animals encountered (humpbacks or other species), providing a better understanding of stock structures and usage of the Guam/CNMI region. Some worthy questions that vessel surveys could address include:

1) Are the humpback whales passing through the Guam/CNMI area arriving from the Philippines to the west, or from Ogasawara and the Volcano Islands to the north, or possibly from a different area altogether?
2) Are the same individuals returning to the Marianas each year, as is documented for humpbacks in other wintering areas?
3) Do individuals reside in the region for a period of time or are they just passing through?
4) What is the sex and age class of individuals utilizing the area?

However, without extensive time and effort, success with vessel surveys focusing on a sparse population can be quite elusive, particularly when considering the poor sea conditions that prevail during winter months. This disadvantage was a likely factor in the lack of success of the 1990's surveys (Darling & Mori, 1993; Yamaguchi, 1995; and Yamaguchi, 1996; Shimada & Miyashita, 2001; and Ohizumi et al, 2002), considering that these projects (with exception to Yamaguchi 1995 & 1996) spent little to no effort (in the Marianas) surveying shallow waters (< 200 m depth) where humpbacks are more likely to be found.

Multiple year vessel surveys may be necessary to adequately address the questions proposed, but may prove costly. However, cost-effective alternatives could be pursued to address baser questions regarding distribution, duration and relative abundance of humpbacks across the Marianas, and across the winter season. One such option could be to deploy acoustic recorders along multiple islands of the Mariana Archipelago to investigate the temporal occurrence and abundance of humpback song. This approach was just recently investigated by Lammers et al (2011) successfully providing strong, novel

[9] High-resolution bathymetry data is available for most of the Mariana Islands, but is not yet available (from PIBHMC) for Zealandia, Anatahan, Farallon De Medinilla (FDM) and a number of submerged shallow reef areas. Therefore, the 200m area around FDM is based on ETOPO1 bathymetry which is known to be inaccurate for shallow depths, and thus should be considered as a rough estimate.

evidence that humpback whales are common throughout the winter season in the remote, difficult to access Northwest Hawaiian Islands. Another alternative would be to set up shored-based theodolite tracking stations on both Guam and Saipan with full winter-season coverage. Data collected from extended survey effort throughout the winter season would be able to identify seasonal timing, numbers, direction-of-travel, duration, group composition, the type and frequency of surface-exhibited behaviors, as well as serve to validate the observations of humpback whales as described by Mariana residents and seasoned vessel captains. Developing a coordinated system of theodolite-based, shore-tracking with periodic, small-vessel surveys (perhaps through collaboration with local resource management agencies) would likely provide the most productive, cost-efficient means of deciphering humpback whale activity, and that of other species, in the Mariana region.

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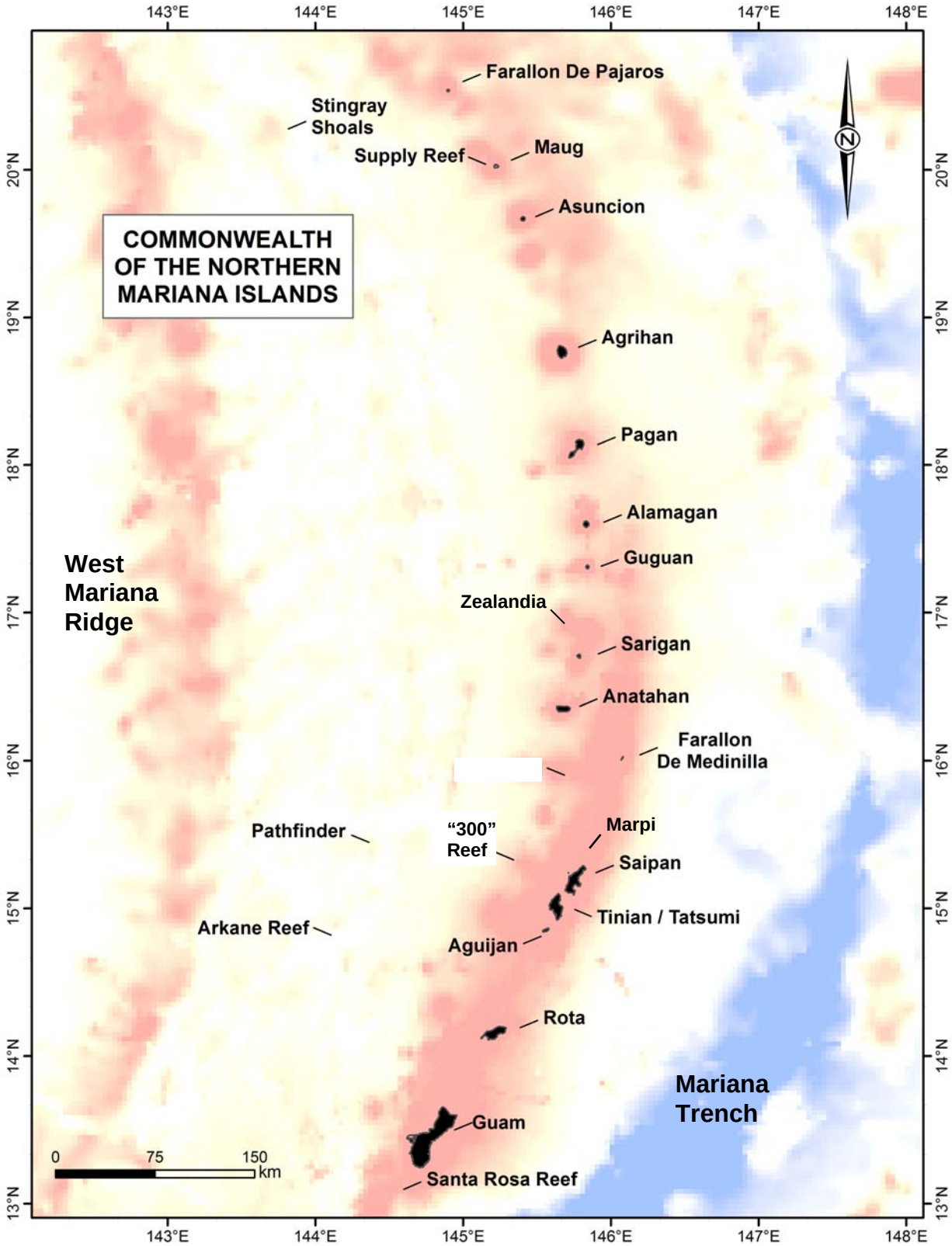

Figure 1: Map of the Mariana Archipelago showing all 15 islands as well as a number of shallow banks. (Image source: PIBHMC, 2007; slightly modified.)

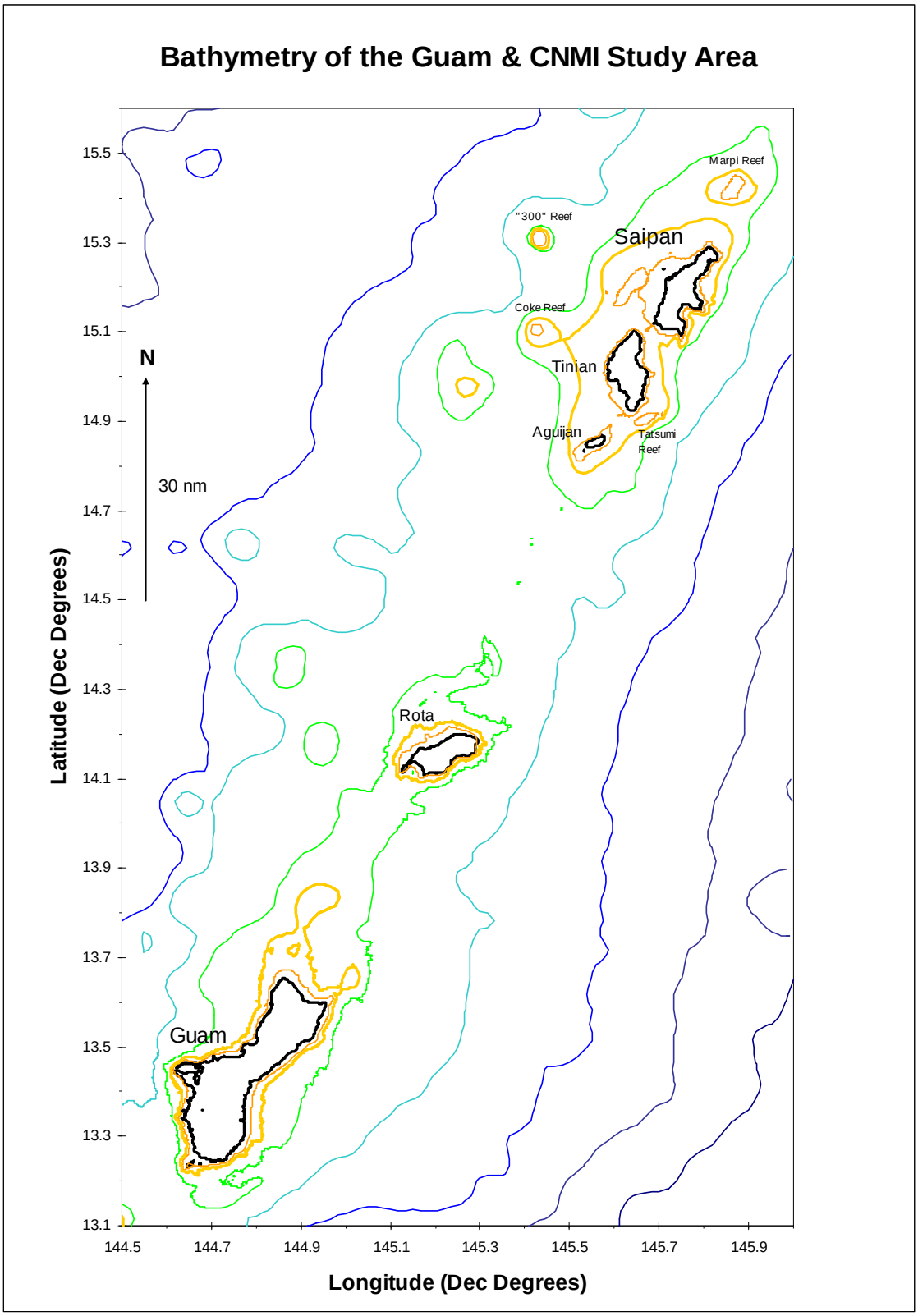

Figure 2: Map of the Mariana study area showing bathymetry, islands and relevant offshore shallow reefs. Depth contour lines are as follows: orange = 200m, yellow = 500m, green = 1000m, aqua = 2000m, blue = 3000m, indigo = 4000m, dark blue = 5000m.

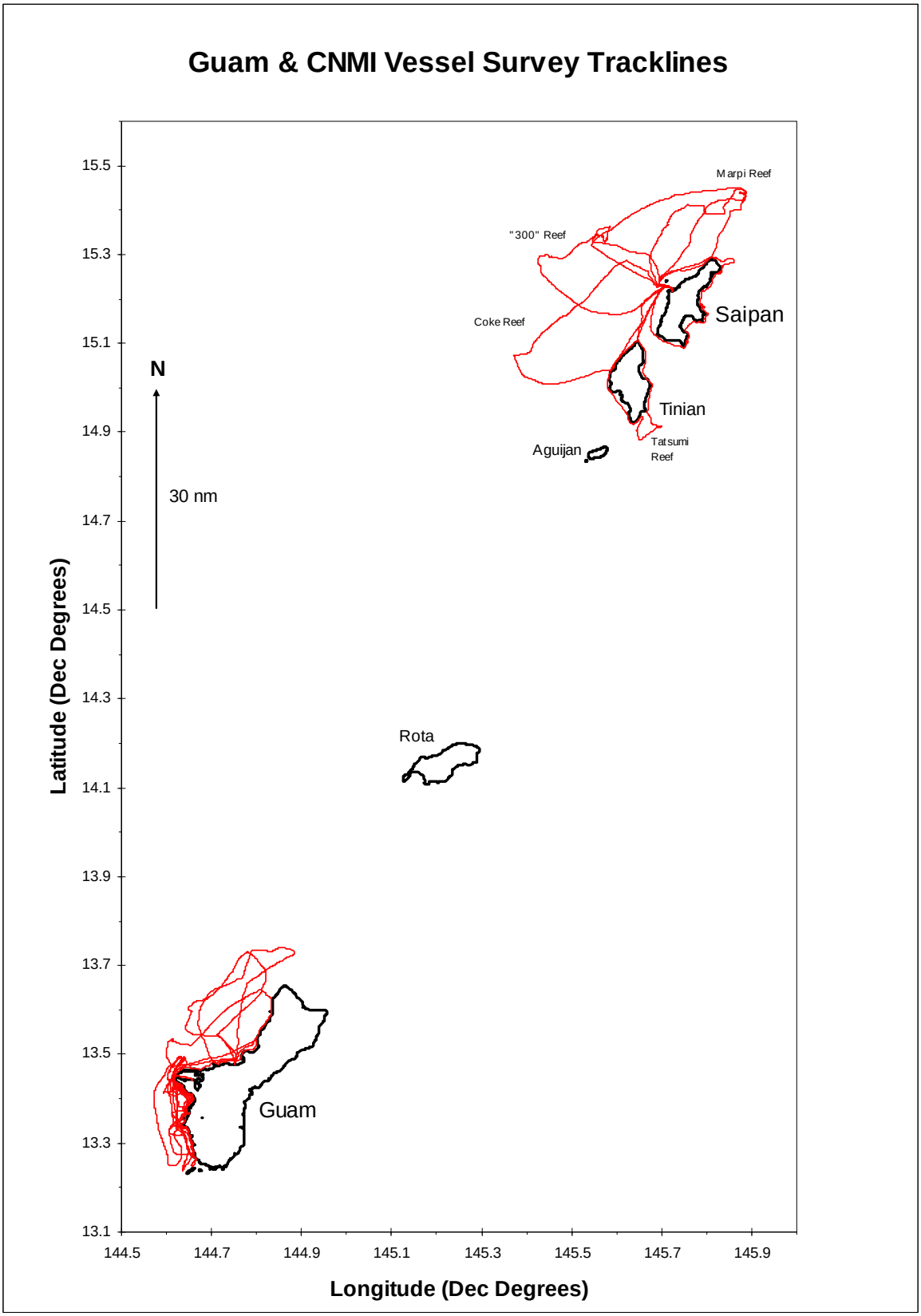

Figure 3: Map showing Mariana survey area with track-lines (in red) from vessel search effort during February and March 2010.

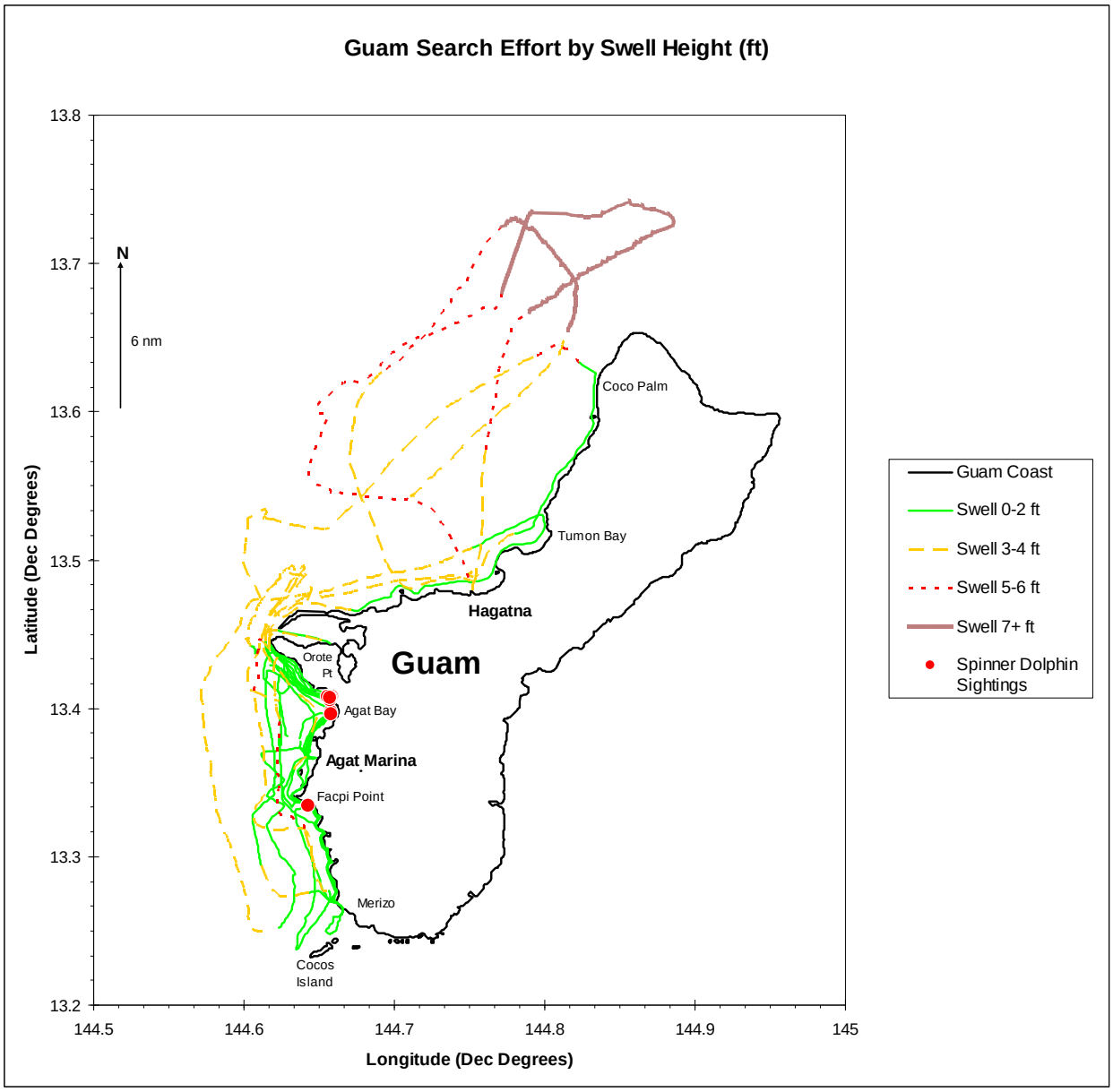

Figure 4: Map of vessel survey tracks off Guam color-coded by wave/swell height. This figure is provided as a visualization of the protective effect of islands lees. During the 10 consecutive field days off Guam, we experienced consistently strong trade winds from the east/northeast direction. The green color-coded tracks depict the lowest wave heights off the areas close to shore along the southwest part of Guam, opposite from the strong prevailing winds. Note the narrowness of the protected area – not much more than 1 – 2 nm from shore. Note also the spinner dolphin sightings (resting areas) marked with red dots tucked in close on the protected side of the island. If it were not for the protective lee area, as small as it is, and the convenience of spinner dolphin resting areas in the protected waters, we would not have been able to collect much sighting data during this project.

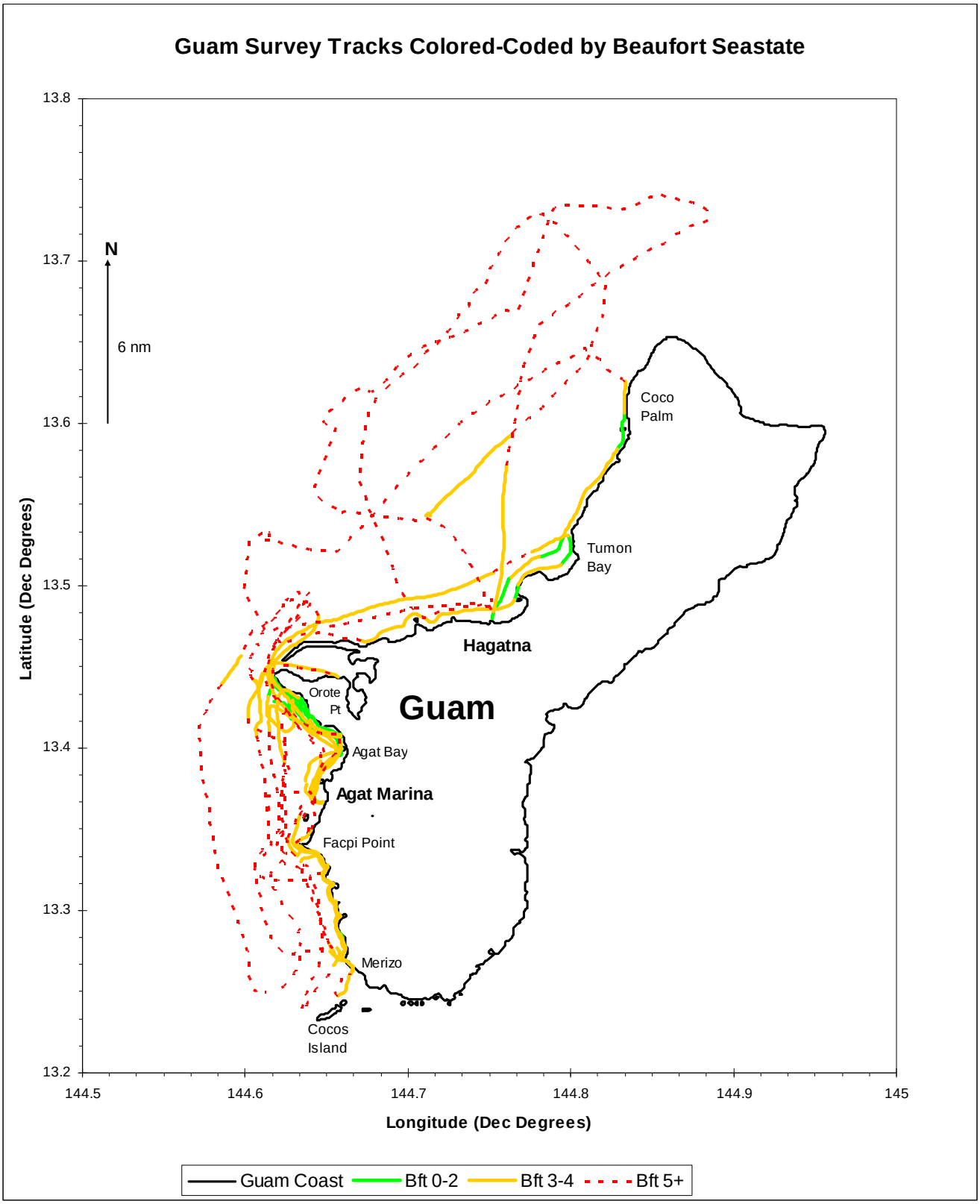

Figure 5: Guam map showing survey effort tracks color-coded by Beaufort sea state.

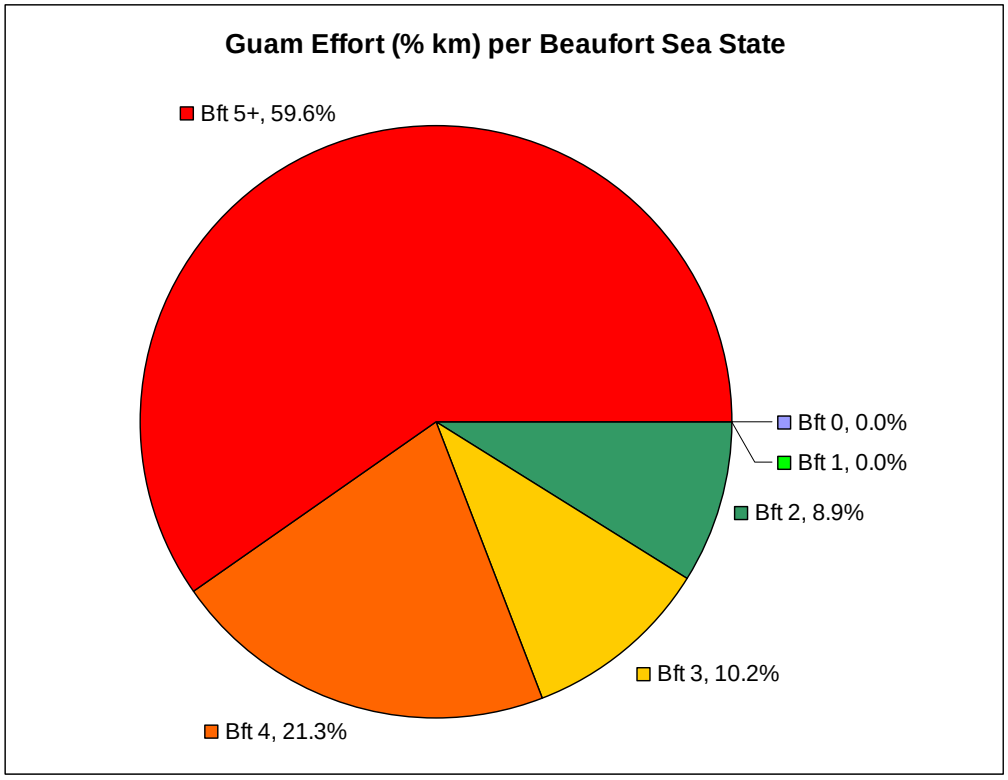

Figure 6: Pie chart depicting the amount of search effort per Beaufort sea state off Guam.

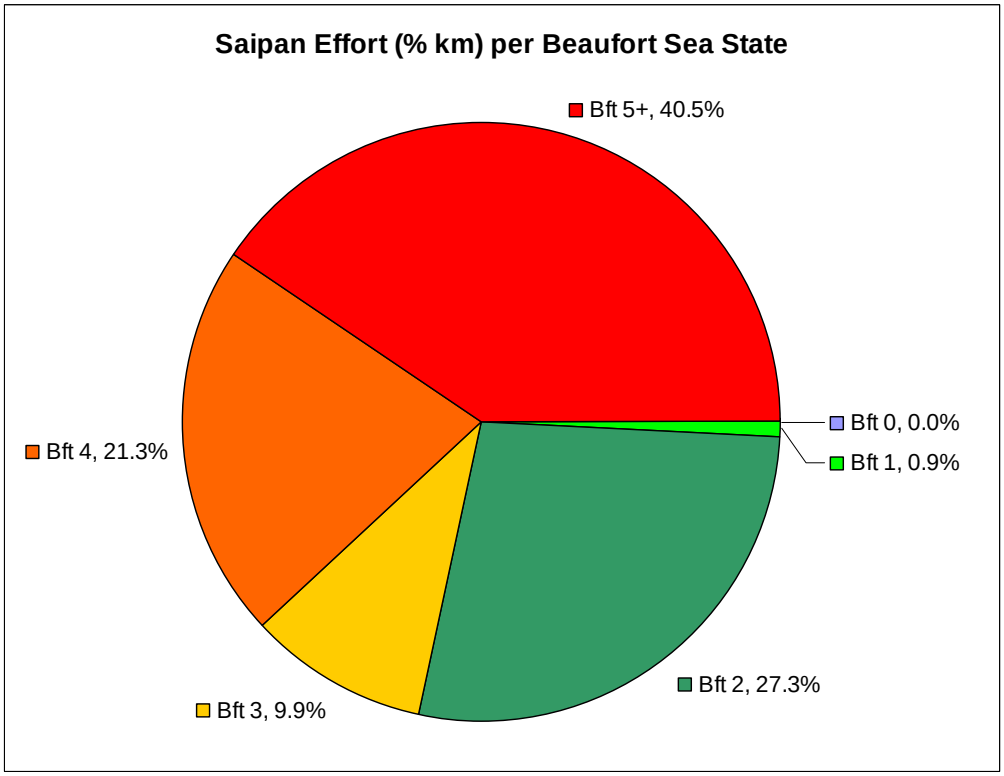

Figure 7: Pie chart depicting the amount of search effort per Beaufort sea state off Saipan.

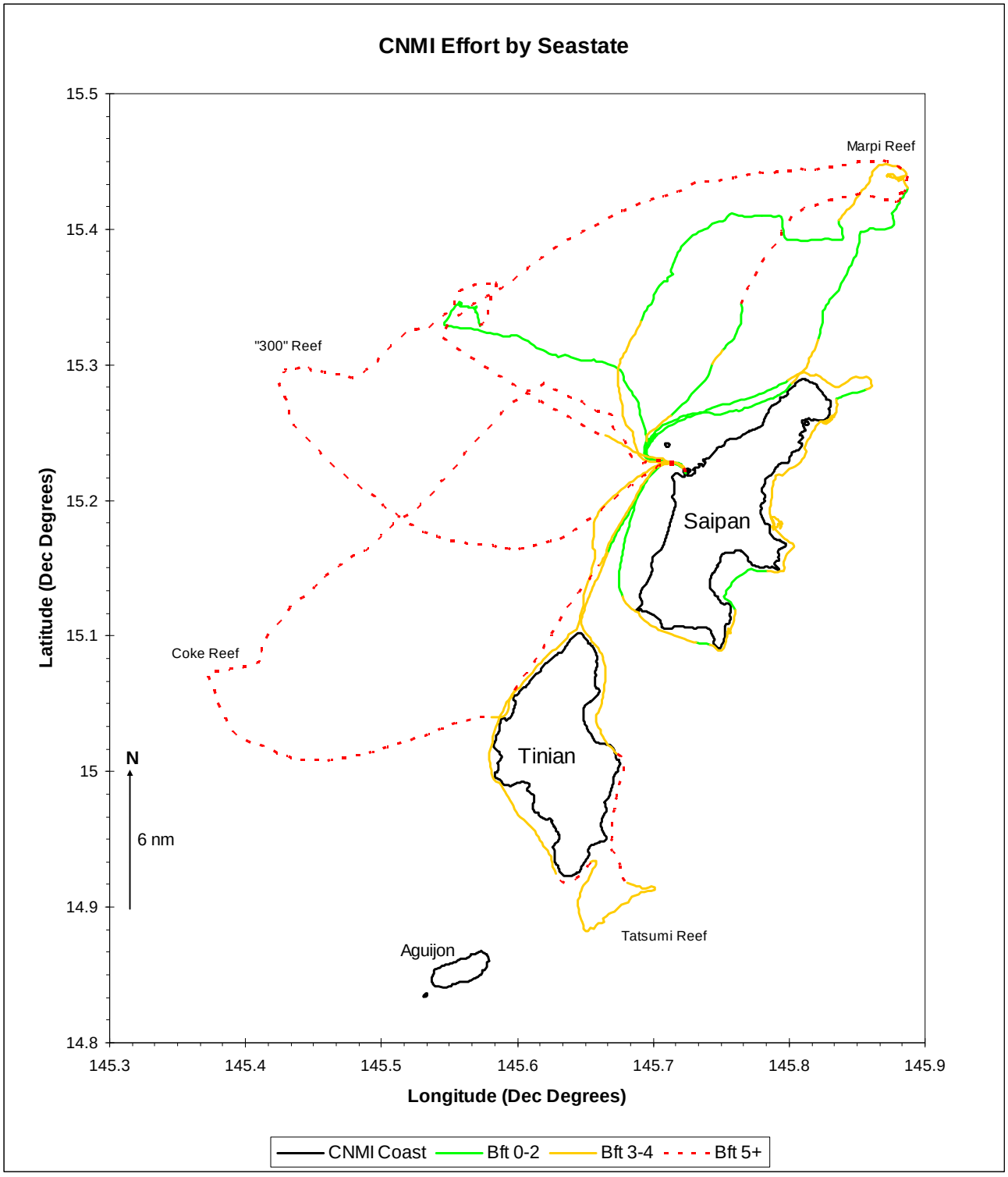

Figure 8: Search Effort off Saipan, color-coded relative to Beaufort sea conditions. Almost all of the green and yellow lines (Beaufort 0 – 4) are in the first 3 survey days when we experienced an unseasonably calm weather pattern. We took advantage of this calm period by circumnavigating Saipan and Tinian. Day 4 the wind-line moved in while we were 22 km from shore and conditions abruptly changed from Beaufort 2 to Beaufort 5 (note track color changing abruptly from green to red). Two hours later, we were battling our way back to port in Beaufort 6 & 7.

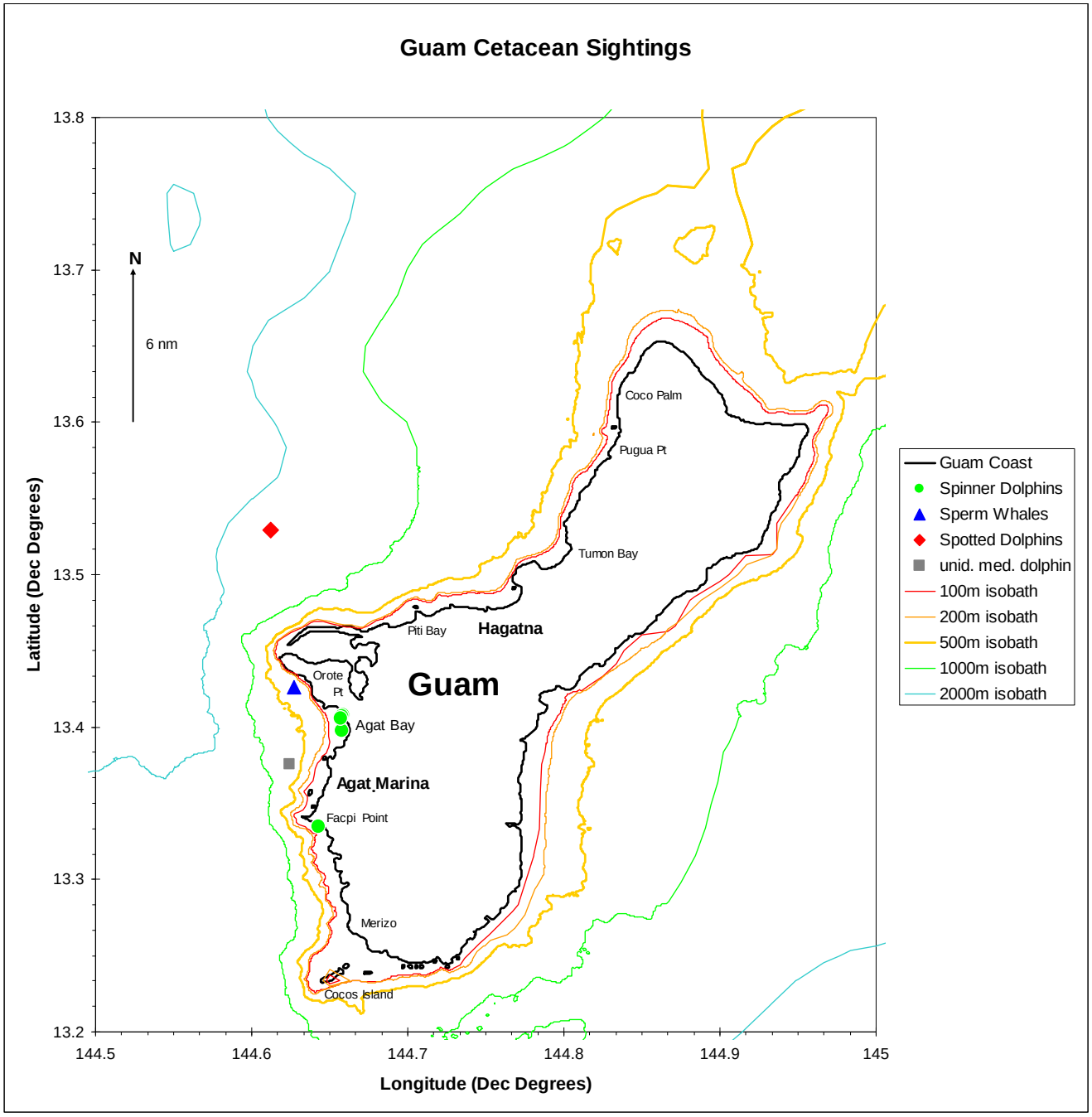

Figure 9: Guam Cetacean Sightings. There were 8 Spinner Dolphins sightings off Guam: 7 were in Agat Bay (too clustered to differentiate on the above map), and one other spinner group sighted just south of Facpi Point. Other species sightings included one encounter each of Sperm Whales, Pantropical Spotted Dolphins, and a single unidentified dolphin.

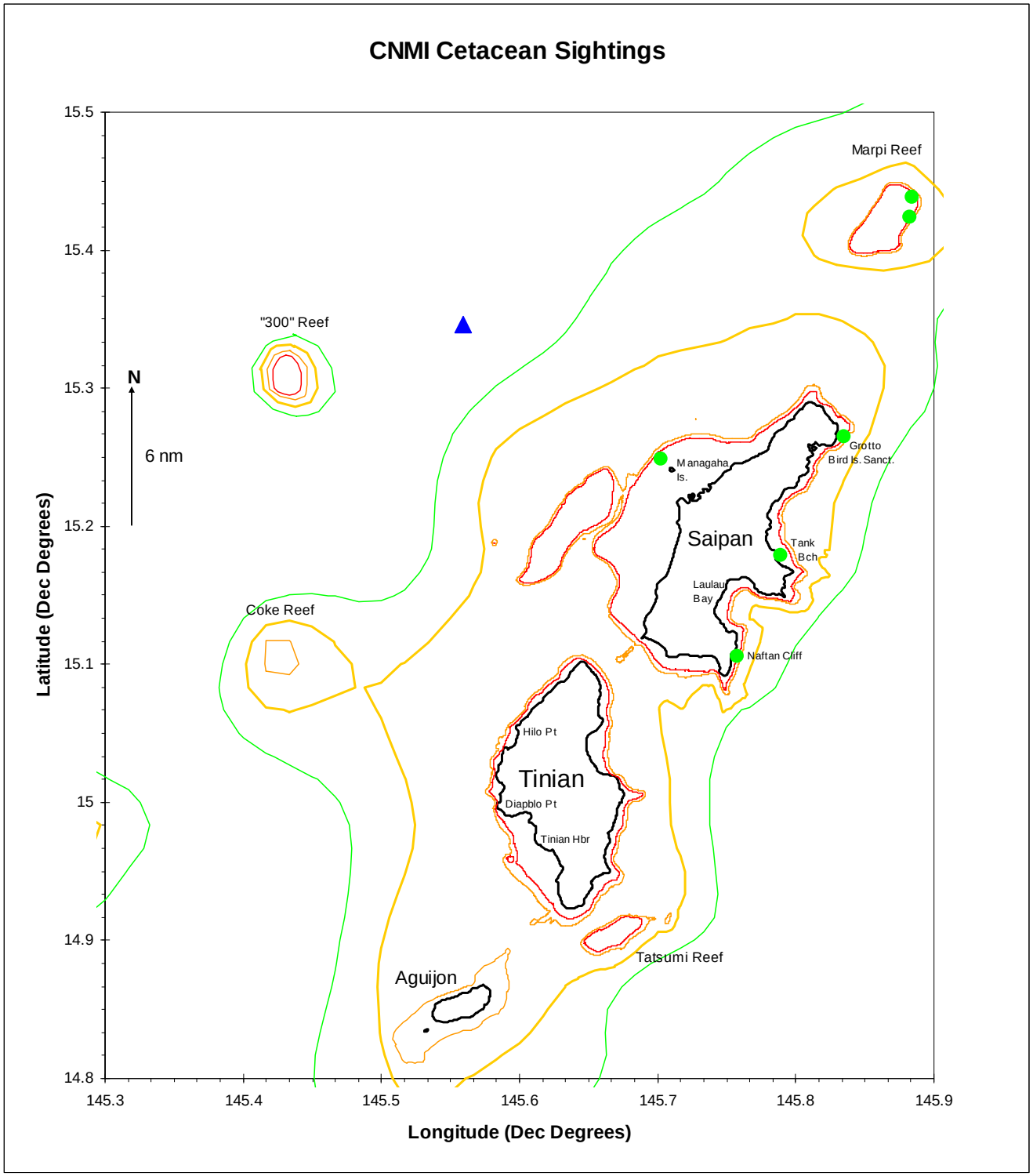

Figure 10: CNMI Cetacean Sighting Map:
● = Spinner Dolphin sightings (6)
▲ = Sperm Whale sighting (1)
Depth Contour lines: 100m (red), 200m (orange), 500m (yellow), 1000m (green).

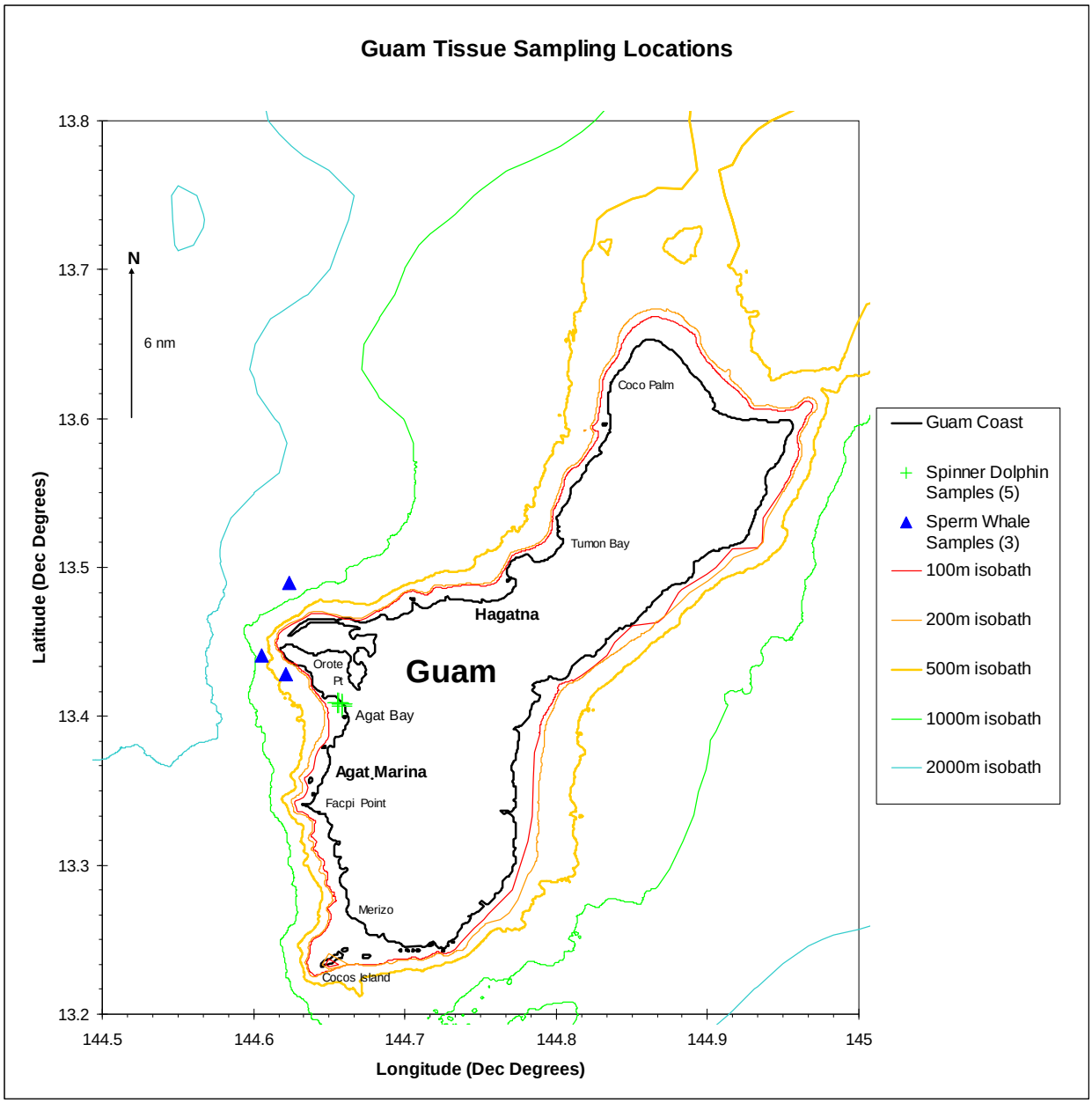

Figure 11: Cetacean tissue sampling locations off Guam: 5 spinner dolphin skin & blubber biopsy samples all collected from Agat Bay, and 3 sperm whale samples (1 sloughed skin, 2 skin & blubber biopsy samples) collected as whales swam around Orote Point.

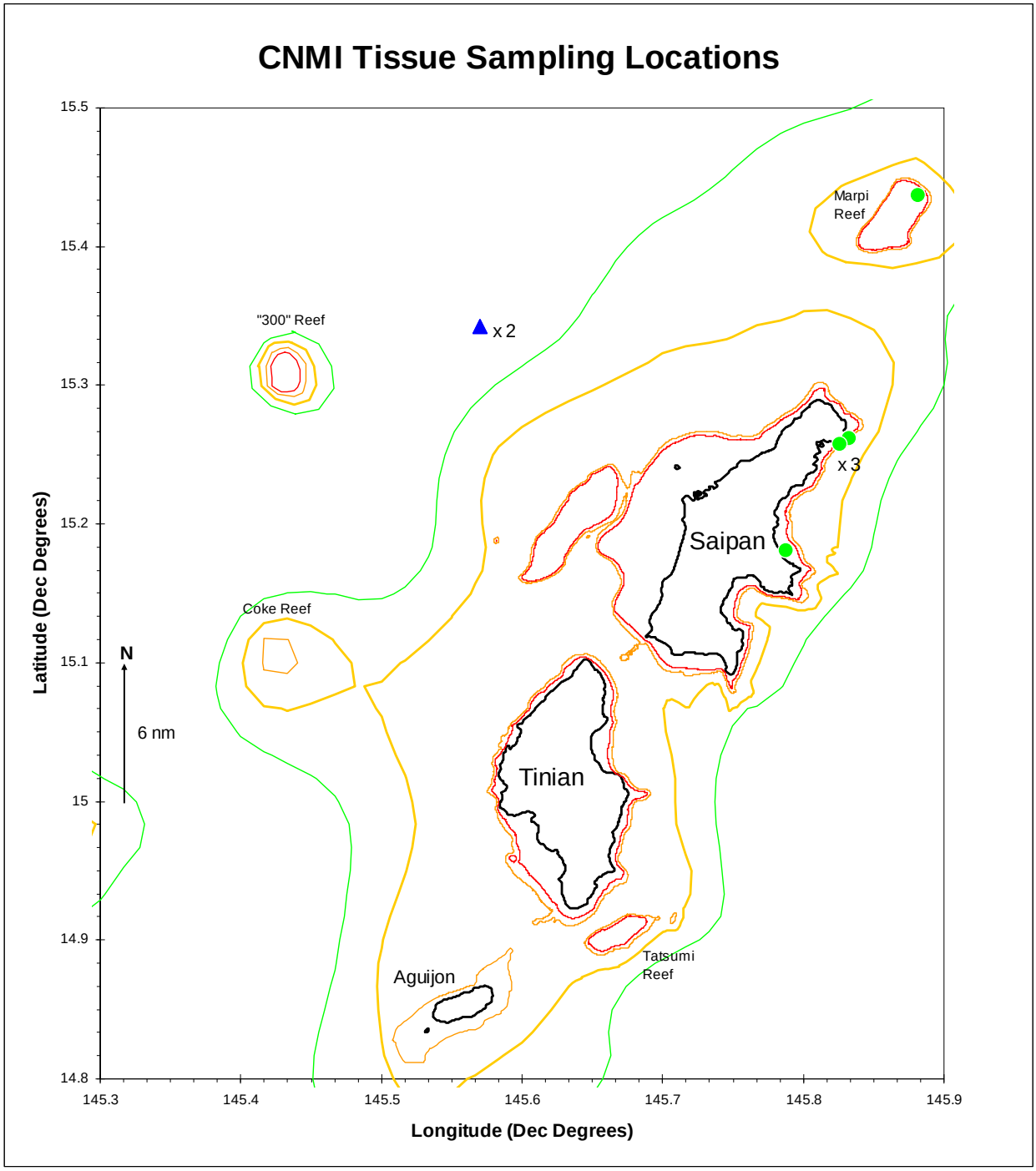

Figure 12: CNMI Cetacean Tissue Sampling Locations:
● = Spinner Dolphin samples (5 skin & blubber biopsies)
▲ = Sperm Whale samples (2 skin & blubber biopsies collected simultaneously)
Depth Contour lines: 100m (red), 200m (orange), 500m (yellow), 1000m (green).

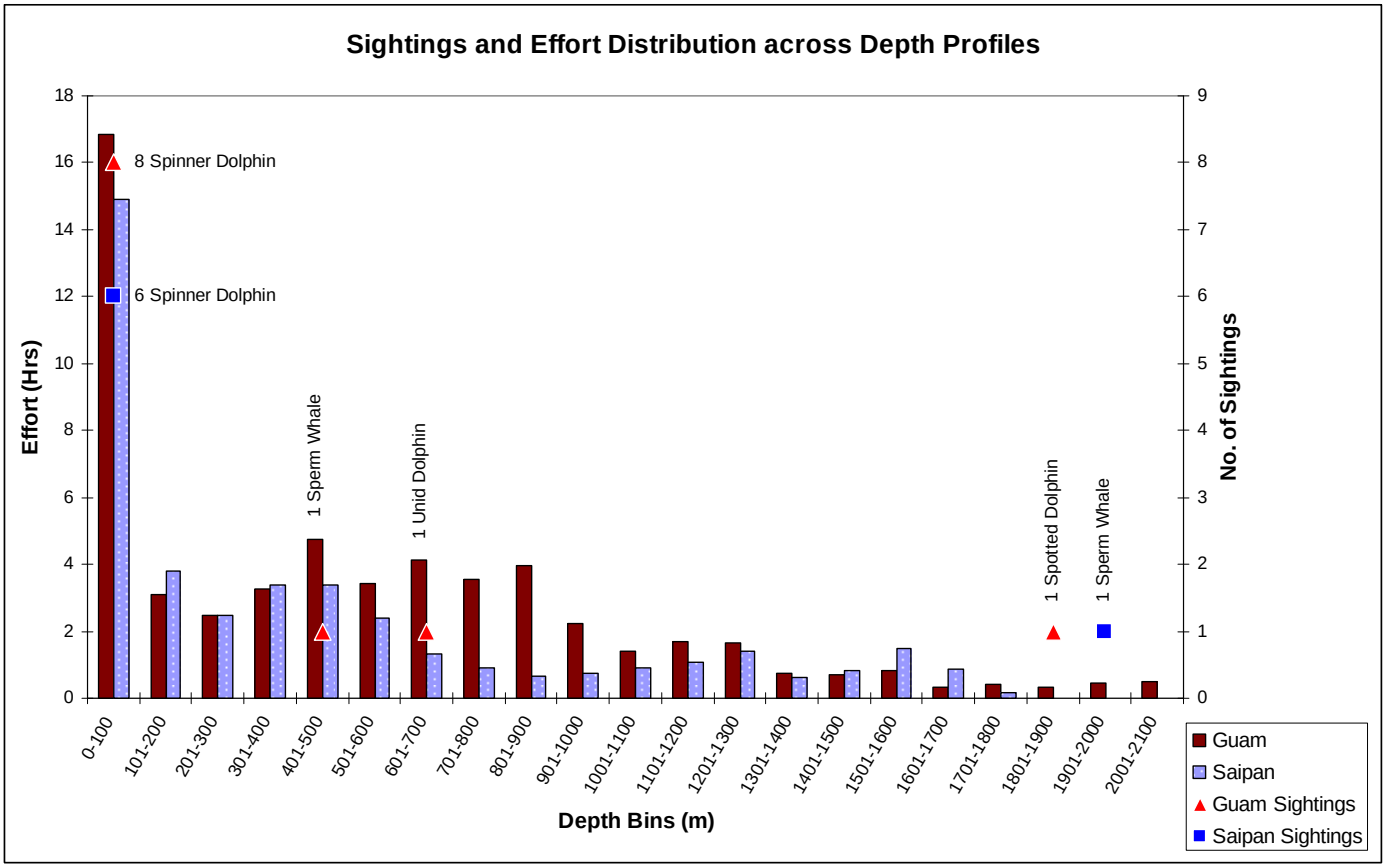

Figure 13: Distribution of sightings and search effort across depth profiles. All values shown include on-effort data only. Percentage of search in waters between 0-500m depth was approximately 54.4% off Guam, and 67.6% off Saipan. Overall, for both islands, 32.3% of search effort was spent in waters less than 100 m, and 59.5% in less than 500 m. Note: all spinner dolphin sightings were encountered in less than 100m of water, even those observed near offshore reefs. Mean Depth for spinner dolphins was 9.5 m off Guam, and 63.5 m off Saipan.

Table 1: Daily Effort Details

Day	Date	Island	Vessel	Platform Type	No. of Crew	Depart	Return	Effort (hrs)	Effort (km)	Harbor	Daily Coverage Area
1	2/9/2010	Guam	*Melakai*	5.8m Whaler	4	07:24	12:43	5.2	66.8	Agat Marina	Agat Bay - Merizo
2	2/10/2010	Guam	*Melakai*	5.8m Whaler	4	07:11	13:00	5.7	61.9	Agat Marina	Agat Bay - Merizo
3	2/11/2010	Guam	*Melakai*	5.8m Whaler	4	07:11	13:06	5.4	67.0	Agat Marina	Agat Bay - Merizo
4	2/12/2010	Guam	*Melakai*	5.8m Whaler	4	07:14	11:51	4.6	51.3	Agat Marina	Agat Bay - Merizo
5	2/13/2010	Guam	*Melakai*	5.8m Whaler	4	06:39	14:06	7.5	86.4	Agat Marina	Agat Bay - Tumon Bay
6	2/14/2010	Guam	*Melakai*	5.8m Whaler	4	06:38	12:46	6.0	73.9	Agat Marina	Agat Bay - N. Orote Pt - Merizo
7	2/15/2010	Guam	*Melakai*	5.8m Whaler	4	06:32	12:26	5.9	75.7	Hagatna Boat Basin	Hagatna - Tumon Bay - Coco Palm
8	2/16/2010	Guam	*Lucky Strike*	9.4m Bertram	4	05:53	11:54	5.4	68.3	Hagatna Boat Basin	Hagatna - Offshore North
9	2/17/2010	Guam	*Ten-III*	11.6m Sport Fisher	4	07:08	13:06	6.0	90.7	Hagatna Boat Basin	Hagatna - Offshore North
10	2/18/2010	Guam	*Melakai*	5.8m Whaler	4	06:44	13:54	5.3	51.1	Agat Marina	Agat Bay - N Orotoe Pt
	(10 days)			**Guam Median Values :**	**4.0**	**06:56**	**12:53**	**5.6**	**67.7**		
				Guam Subtotals :				**56.9**	**693.1**		
11	2/22/2010	Saipan	*Sea Hunter*	12.2m Sport Fisher	5	06:41	13:34	6.9	96.5	Smiling Cove Marina	Garapan - Marpi Reef
12	2/23/2010	Saipan	*Sea Hunter*	12.2m Sport Fisher	5	06:40	13:35	6.9	90.1	Smiling Cove Marina	Garapan - Circumnav Saipan
13	2/24/2010	Saipan	*Sea Hunter*	12.2m Sport Fisher	6	06:40	13:04	6.4	103.0	Smiling Cove Marina	Garapan - Circumnav Tinian
14	2/25/2010	Saipan	*Sea Hunter*	12.2m Sport Fisher	7	06:43	13:50	7.1	100.0	Smiling Cove Marina	Garapan - Offshore West - "300" Reef
15	3/2/2010	Saipan	*Sea Hunter*	12.2m Sport Fisher	4	06:34	13:35	7.0	107.0	Smiling Cove Marina	Garapan - Offshore West - "Coke" Reef
16	3/3/2010	Saipan	*Sea Hunter*	12.2m Sport Fisher	4	06:43	13:45	7.0	107.0	Smiling Cove Marina	Garapan - Marpi Reef - Offshore West
	(6 days)			**Saipan Median Values :**	**5.0**	**06:40**	**13:35**	**7.0**	**101.5**		
				Saipan Subtotals :				**41.4**	**603.6**		
	(16 days overall)			**Overall Median Values :**	**4.0**	**06:42**	**13:06**	**6.0**	**81.1**		
				Overall Subtotals :				**98.3**	**1296.7**		

Table 2: Wind speed data for survey days off Guam and Saipan. The wind speed data summarized below includes only those days spent on the water searching for cetaceans. Generally, winds were fairly calm in the early morning and nighttime hours, but would begin to strengthen by 9 - 10 a.m. Since surveys occur during the stronger daylight wind pattern, the "Daily Maximum Sustained Windspeed" values are more pertinent to what was experienced by the boat, as also are the "Daily Maximum Recorded Wind Gusts". The "Daily (24-hr avg) Windspeed" values take into account the calmer winds during evening/early morning hours and give some indication of how much the wind speeds vary across a 24 hour period. Note and compare the "Saipan (Day 1-3)" values when an unseasonably calm weather pattern passed through during our first three survey days off Saipan.

			Daily (24hr avg) Windspeed (knts)			Daily Max Sustained Windspeed (knts)			Daily Max Recorded Wind Gusts (knts)		
	Dates	Days	Range	Mean	StDev	Range	Mean	StDev	Range	Mean	StDev
Guam	Feb 9-18	10	6.3 - 15.2	11.5	2.32	14 - 22	18.8	2.35	19 - 28	24.2	2.83
Saipan (Day 1-3)	Feb 22-24	3	3.9 - 5.3	4.7	0.71	8 - 9.9	8.9	0.95	14		
Saipan (All Days)	Feb 22-25, Mar 2-3	6	3.9 - 9.8	6.8	2.42	8 - 16.9	12.3	3.97	14 - 22.9	20.0	4.20
Overall		**16**	**3.9 - 15.2**	**9.7**	**3.28**	**8 - 22**	**16.4**	**4.39**	**14 - 28**	**23.0**	**3.69**

Data source: Data was retrieved from the National Climactic Data Center weather archives recorded by the Agana National Weather Service Office (Station # 912120 in Hagatna, Guam).

Table 3: Summary of Percentage Effort by Sea State

Island	Survey Days	Study Area Size (km^2)	Effort (Hrs)	Effort (km)	Bft 0 (% km)	Bft 1 (% km)	Bft 2 (% km)	Bft 3 (% km)	Bft 4+ (% km)
Guam	10	596.3	56.9	693.1	0.0%	0.0%	8.9%	10.2%	80.90%
Saipan	6	1313.8	41.4	603.6	0.0%	0.9%	27.3%	9.9%	61.83%
Sum	**16**	**1910.1**	**98.3**	**1296.7**	**0.0%**	**0.4%**	**17.5%**	**10.1%**	**72.02%**

Table 4: Daily Search Effort by Sea State (Time in Hrs)

Guam :										
	Beaufort Sea State Levels (Hrs/Day)								**Cumulative**	**Hr-Avg**
Date	**0**	**1**	**2**	**3**	**4**	**5**	**6 ***	**7 ***	**(Hrs)**	**(Bft)**
2/9/2010	0.00	0.00	0.73	0.77	1.58	2.07	0.00	0.00	**5.15**	**3.97**
2/10/2010	0.00	0.00	0.85	1.83	0.82	2.22	0.00	0.00	**5.72**	**3.77**
2/11/2010	0.00	0.00	0.68	1.18	1.08	2.47	0.00	0.00	**5.42**	**3.98**
2/12/2010	0.00	0.00	0.90	0.40	1.28	1.97	0.00	0.00	**4.55**	**3.95**
2/13/2010	0.00	0.00	1.78	0.68	2.87	2.12	0.00	0.00	**7.45**	**3.71**
2/14/2010	0.00	0.00	1.13	0.30	0.58	4.02	0.00	0.00	**6.03**	**4.24**
2/15/2010	0.00	0.00	0.62	0.48	0.38	4.42	0.00	0.00	**5.90**	**4.46**
2/16/2010	0.00	0.00	0.00	0.00	0.73	4.68	0.00	0.00	**5.42**	**4.86**
2/17/2010	0.00	0.00	0.00	0.00	0.47	5.50	0.00	0.00	**5.97**	**4.92**
2/18/2010	0.00	0.00	0.98	0.33	1.15	2.83	0.00	0.00	**5.30**	**4.10**
Subtotal:	**0.00**	**0.00**	**7.68**	**5.98**	**10.95**	**32.28**	**0.00**	**0.00**	**56.90**	**4.19**
Percent:	**0.0%**	**0.0%**	**13.5%**	**10.5%**	**19.2%**	**56.7%**	**0.0%**	**0.0%**	**57.9% of Overall Hrs**	
Saipan :										
2/22/2010	0.00	0.33	3.93	1.92	0.70	0.00	0.00	0.00	**6.88**	**2.43**
2/23/2010	0.00	0.00	2.57	2.33	2.02	0.00	0.00	0.00	**6.92**	**2.92**
2/24/2010	0.00	0.00	0.65	0.48	4.30	0.97	0.00	0.00	**6.40**	**3.87**
2/25/2010	0.00	0.00	3.18	0.00	0.00	1.35	1.48	1.10	**7.12**	**4.18**
3/2/2010	0.00	0.00	0.00	0.00	0.93	2.92	3.17	0.00	**7.02**	**5.32**
3/3/2010	0.00	0.00	0.88	0.08	0.62	5.45	0.00	0.00	**7.03**	**4.51**
Subtotal:	**0.00**	**0.33**	**11.22**	**4.82**	**8.57**	**10.68**	**4.65**	**1.10**	**41.37**	**3.88**
Percent:	**0.0%**	**0.8%**	**27.1%**	**11.6%**	**20.7%**	**25.8%**	**11.2%**	**2.7%**	**42.1% of Overall Hrs**	
Overall :										
Totals (hrs):	**0.00**	**0.33**	**18.90**	**10.80**	**19.52**	**42.97**	**4.65**	**1.10**	**98.27**	**4.06**
Percentage:	**0.0%**	**0.3%**	**19.2%**	**11.0%**	**19.9%**	**43.7%**	**4.7%**	**1.1%**		

* Specific data for time/distance spent in Beaufort 5, 6 & 7 conditions are not available from Guam as these were collectively recorded as "5+"

Table 5: Daily Search Effort by Sea State (Distance in Km**)**

Guam :										
	Beaufort Sea State Levels (Km/Day)								**Cumulative**	**Km-Avg**
Date	**Bft 0**	**Bft 1**	**Bft 2**	**Bft 3**	**Bft 4**	**Bft 5+**	**6 ***	**7 ***	**(Km)**	**Bft**
2/9/2010	0.00	0.00	6.50	10.30	18.90	31.10	0.00	0.00	**66.80**	**4.12**
2/10/2010	0.00	0.00	6.90	14.80	12.30	27.90	0.00	0.00	**61.90**	**3.99**
2/11/2010	0.00	0.00	3.10	16.70	17.30	29.90	0.00	0.00	**67.00**	**4.10**
2/12/2010	0.00	0.00	3.80	6.50	17.20	23.80	0.00	0.00	**51.30**	**4.19**
2/13/2010	0.00	0.00	13.90	7.40	35.20	29.90	0.00	0.00	**86.40**	**3.94**
2/14/2010	0.00	0.00	11.00	4.00	7.40	51.50	0.00	0.00	**73.90**	**4.35**
2/15/2010	0.00	0.00	8.50	6.20	5.10	55.90	0.00	0.00	**75.70**	**4.43**
2/16/2010	0.00	0.00	0.00	0.00	8.90	59.40	0.00	0.00	**68.30**	**4.87**
2/17/2010	0.00	0.00	0.00	0.00	10.50	80.20	0.00	0.00	**90.70**	**4.88**
2/18/2010	0.00	0.00	8.30	4.50	14.60	23.70	0.00	0.00	**51.10**	**4.05**
Subtotal:	**0.00**	**0.00**	**62.00**	**70.40**	**147.40**	**413.30**	**0.00**	**0.00**	**693.10**	**4.32**
Percent:	**0.0%**	**0.0%**	**8.9%**	**10.2%**	**21.3%**	**59.6%**	**0.0%**	**0.0%**	**53.5% of Overall Km**	
Saipan :										
2/22/2010	0.00	5.50	57.00	21.60	12.40	0.00	0.00	0.00	**96.50**	**2.42**
2/23/2010	0.00	0.00	40.60	29.00	20.50	0.00	0.00	0.00	**90.10**	**2.78**
2/24/2010	0.00	0.00	10.20	8.00	69.10	15.70	0.00	0.00	**103.00**	**3.88**
2/25/2010	0.00	0.00	42.40	0.00	0.00	18.40	22.30	16.90	**100.00**	**4.29**
3/2/2010	0.00	0.00	0.00	0.00	15.50	59.80	31.70	0.00	**107.00**	**5.15**
3/3/2010	0.00	0.00	14.70	1.40	11.00	79.90	0.00	0.00	**107.00**	**4.46**
Subtotal:	**0.00**	**5.50**	**164.90**	**60.00**	**128.50**	**173.80**	**54.00**	**16.90**	**603.60**	**3.88**
Percent:	**0.0%**	**0.9%**	**27.3%**	**9.9%**	**21.3%**	**28.8%**	**8.9%**	**2.8%**	**46.5% of Overall Km**	
Combined :										
Totals (km):	**0.00**	**5.50**	**226.90**	**130.40**	**275.90**	**587.10**	**54.00**	**16.90**	**1296.70**	**4.11**
Percentage:	**0.0%**	**0.4%**	**17.5%**	**10.1%**	**21.3%**	**45.3%**	**4.2%**	**1.3%**		

* Specific data for time/distance spent in Beaufort 5, 6 & 7 conditions are not available from Guam as these were collectively recorded as "5+"

Table 6: Sighting Data Details

Seq	Species Common	Species Scientific	Date	Time	Latitude	Longitude	Sea State (Bft)	Depth (m)	Dx to Shore (km)	Group Size	Behav	No. of Photos	No. of Tissue Samples
Guam:													
1	Spinner Dolphin	*Stenella longirostris*	2/9/2010	7:44	N13.40781	E144.65838	2	7	0.23	40	Rest	272	-
2	Spinner Dolphin	*Stenella longirostris*	2/9/2010	11:42	N13.40738	E144.65787	4	9	0.31	40	Rest	161	-
3	Spinner Dolphin	*Stenella longirostris*	2/10/2010	7:28	N13.39736	E144.65806	2	7	0.43	35	Rest	248	-
4	Spinner Dolphin	*Stenella longirostris*	2/10/2010	11:43	N13.33470	E144.64268	3	7	0.12	22	Rest	347	-
5	Spinner Dolphin	*Stenella longirostris*	2/11/2010	7:30	N13.40539	E144.65748	2	13	0.35	75	Rest	488	-
6	unid. med. dolphin	family *Delphinidae*	2/11/2010	10:24	N13.37534	E144.62434	5	689	2.90	1	S.Trvl	6	-
7	Spinner Dolphin	*Stenella longirostris*	2/12/2010	7:41	N13.39606	E144.65813	2	8	0.36	85	Rest	502	-
8	Spinner Dolphin	*Stenella longirostris*	2/13/2010	7:02	N13.40806	E144.65610	2	13	0.44	55	Rest	239	2
9	Spinner Dolphin	*Stenella longirostris*	2/14/2010	7:05	N13.40707	E144.65724	2	12	0.67	60	Rest	77	3
10	Pantropical Spotted D.	*Stenella antenuatta*	2/15/2010	10:15	N13.52893	E144.61183	5	1864	7.60	17	Trv	13	-
11	Sperm Whale	*Physeter macrocephalus*	2/18/2010	9:13	N13.42637	E144.62737	2	404	1.30	9	Logging	416	3 *
Saipan:													
1	Spinner Dolphin	*Stenella longirostris*	2/22/2010	7:04	N15.24874	E145.70226	2	42	3.6 **	6	S. Trv	45	-
2	Spinner Dolphin	*Stenella longirostris*	2/22/2010	9:40	N15.43917	E145.88391	3	74	18.30	36	Mill	154	1
3	Spinner Dolphin	*Stenella longirostris*	2/23/2010	8:38	N15.26545	E145.83460	4	80	0.52	10	Bowride	35	3
4	Spinner Dolphin	*Stenella longirostris*	2/23/2010	9:51	N15.17908	E145.78901	3	33	0.49	32	Mill	233	1
5	Spinner Dolphin	*Stenella longirostris*	2/23/2010	11:33	N15.10629	E145.75748	4	81	0.42	35	Mill	188	-
6	Sperm Whale	*Physeter macrocephalus*	2/25/2010	8:20	N15.34583	E145.55879	2	1923	21.90	6	Logging	279	2
7	Spinner Dolphin	*Stenella longirostris*	3/3/2010	9:02	N15.42441	E145.88222	5	71	16.80	12	Mill	37	-

* All tissue samples were skin and blubber biopsies, except 1 was sloughed skin sample from a sperm whale.

** 3.6 km from closest point of shore on Saipan, but only 670m from barrier reef bounding Saipan Lagoon

Table 7: Sighting Summary by Species

Seq	Species Common	Species Scientific	N	No. of Photos	No. of Tissue Samples	Mean Depth (m)	Depth Std Dev (m)	Dx to Shore Mean (km)	Dx to Shore Std Dev (km)	Group Size (mean)	Group Size (Std Dev)
Guam:											
1	Spinner Dolphin	*Stenella longirostris*	8	2334	5	9.5	2.8	0.36	0.16	51.5	21.3
2	Sperm Whale	*Physeter macrocephalus*	1	416	3	404		1.30		9.0	
3	Pantropical Spotted D.	*Stenella antenuatta*	1	13	-	1864		7.60		17.0	
4	unid. med. dolphin	*Delphinidae*	1	6	-	689		2.90		1.0	
		Subtotal:	**11**	**2769**	**8**						
Saipan:											
1	Spinner Dolphin	*Stenella longirostris*	6	692	5	63.5	20.7	6.69	8.51	21.8	13.9
2	Sperm Whale	*Physeter macrocephalus*	1	279	2	1923		21.90		6.0	
		Subtotal:	**7**	**971**	**7**						
Both islands combined:											
1	Spinner Dolphin	*Stenella longirostris*	14	3026	10	32.6	30.6	3.07	6.20	38.8	23.4
2	Sperm Whale	*Physeter macrocephalus*	2	695	5	1163.3	1074.4	11.60	14.57	7.5	2.1
3	Pantropical Spotted D.	*Stenella antenuatte*	1	13	-	1864		7.60		17.0	
4	unid. med. dolphin	*Delphinidae*	1	6	-	689		2.90		1.0	
		Totals:	**18**	**3740**	**15**						

Table 8: Sighting rate values per species per island. The values listed under "Standard" incorporate all project sightings and all time spent "on-effort". The "Adjusted *" values compensate for positive biasing of the sighting rate by our recurrent practice of starting most surveys with transiting directly from the harbor to a known spinner dolphin resting area in Agat Bay. After working with the Agat Bay spinner group, a more rigorous search would commence for other sightings. (See Discussion for more details.)

	Standard Sighting Rates (#/100 km)			Adjusted * Sighting Rates (#/100 km)		
Species	**Guam**	**Saipan**	**Overall**	**Guam**	**Saipan**	**Overall**
Spinner Dolphin	1.15	0.99	**1.08**	0.31	0.99	**0.64**
Sperm Whale	0.14	0.17	**0.16**	0.15	0.17	**0.16**
Pantropical Spotted Dolphin	0.14	0.00	**0.08**	0.15	0.00	**0.08**
unid. med. dolphin	0.14	0.00	**0.08**	0.15	0.00	**0.08**
All Sightings:	**1.59**	**1.16**	**1.39**	**0.77**	**1.16**	**0.96**

Table 9: Sighting rates relative to sea conditions. The values listed under "Standard" incorporate all project sightings and all time spent "on-effort". The "Adjusted *" values compensate for positive biasing of the sighting rate by repeated targeting of a known spinner dolphin resting area in Agat Bay. The adjusted Beaufort sighting rate values were calculated in the same manner as that described under Table 8.

	Standard Sighting Rates (#/100 km)			Adjusted * Sighting Rates (#/100 km)		
Sea State	**Guam**	**Saipan**	**Overall**	**Guam**	**Saipan**	**Overall**
Beaufort 0	---	---	**---**	---	---	**---**
Beaufort 1	---	0.00	**0.00**	---	0.00	**0.00**
Beaufort 2	11.29	1.21	**3.97**	12.32	1.21	**1.95**
Beaufort 3	1.42	3.33	**2.30**	0.00	3.33	**2.53**
Beaufort 4	0.68	1.56	**1.09**	0.72	1.56	**0.75**
Beaufort 5+	0.48	0.41	**0.46**	0.00	0.41	**0.46**
Total	**1.59**	**1.16**	**1.39**	**0.93**	**1.16**	**0.96**

Table 10: Comparison of sighting rates between this project and other projects occurring in the Marianas or other Central Pacific island areas.

Project	**Region**	**Sighting Rate (#/100km)**	**% Effort Bft < 4**	**Platform**	**Reference Source**
This Project	**Marianas**	**0.96**	**28.0%**	**Small-Boat Survey**	**This Report.**
Mobley, 2007.	Marianas	0.3	98%*	Aerial Survey	Mobley, 2007.
MISTCS-2007	Marianas	1.1	5.1%	Large-Ship Survey	US Navy, 2007.
OES-2010-01	HI -> Guam	1.05	4.25 avg**	Large-Ship Survey	PIFSC, 2010-a.
OES-2010-04	Guam -> HI	0.77	4.37 avg**	Large-Ship Survey	PIFSC, 2010-c.
HICEAS-2002	Hawaii	1.24	24.7%	Large-Ship Survey	Barlow et al, 2004.
PICEAS-2005	Hawaii	1.11	11.0%	Large-Ship Survey	Barlow et al, 2008.
RWB-MHI 2003	Hawaii	1.62	91.1%	Small-Boat Survey	Baird et al, 2003.
RWB-Kauai-2005	Hawaii	2.55	73.7%	Small-Boat Survey	Baird et al, 2006.

* Effort values were approximated from bar graph in cited report.

** Breakdown of effort by sea state not available in cited cruise reports, so the projects' approximate Beaufort averages were given instead. (Overall Beaufort average for our small boat project was 4.11)