

Included as Appendix A within the 2014 Comprehensive Exercise and Marine Species Monitoring Report for the U.S. Navy's Mariana Islands Range Complex 2010-2014

APPENDIX A

Summary Report: Compilation of Visual Survey Effort and Sightings for Marine Species Monitoring in the Mariana Islands Range Complex

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This report presents a geographic information system (GIS)-based overview of the sighting records obtained during marine species monitoring effort (a total of 12 U.S. Pacific Fleet-funded surveys) to date in the MIRC. Also included are incidental marine mammal and sea turtle sightings made since 1965 on non-dedicated surveys in the region (Uyeyama 2014). The structure and objectives of this report mirror those of a similar sightings atlas created for the Hawaii Range Complex in 2012 (HDR 2012a). Available data from visual surveys performed by both contractor-led efforts and U.S. Pacific Fleet in-house surveys were compiled and processed in order to:

- Create a GIS-based summation of all survey tracks, which can be easily visualized.
- Construct a geo-referenced database of sightings that can be queried by species, observer platform, Beaufort sea state (BSS), season, or other sighting/survey variables.
- Provide information to enhance informed management of marine protected species in the MIRC and support the adaptive management process that is part of the ICMP.

Additionally, the following monitoring questions will be addressed:

1. What is the total diversity of marine mammal/sea turtle species observed during U.S. Navy-funded monitoring?
2. Are there patterns of distribution of marine mammal sightings during monitoring?

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Cover Photo:

False killer whales (*Pseudorca crassidens*) photographed off Guam during the NMFS-PIFSC small-vessel survey (Photo credit: Adam Ü).

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Acronyms and Abbreviations

BSS	Beaufort sea state
CNMI	Commonwealth of the Northern Mariana Islands
DAWR	Division of Aquatic and Wildlife Resources
EAR	ecological acoustic recorder
ESA	Endangered Species Act
FDM	Farallon de Medinilla
FY	fiscal year
GIS	geographic information system
HARP	high-frequency acoustic recording package
HFAS	high-frequency active sonar
Hz	Hertz
ICMP	Integrated Comprehensive Monitoring Program
kHz	kilohertz
km	kilometer(s)
LOA	Letter of Authorization
m	meter(s)
MFAS	mid-frequency active sonar
MIRC	Mariana Islands Range Complex
MISTCS	Mariana Islands Sea Turtle and Cetacean Survey
MMPA	Marine Mammal Protection Act
NMFS	National Marine Fisheries Service
OES	R/V <i>Oscar Elton Sette</i>
PAM	passive acoustic monitoring
PIFSC	Pacific Islands Fisheries Science Center
UNDET	underwater detonation
U.S.	United States

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Section 1 Introduction

1.1 Background and History

The United States (U.S.) Navy is responsible for compliance with a suite of Federal environmental and natural resources laws and regulations that apply to the marine environment. The U.S. Navy developed Range Complex monitoring plans to provide monitoring for marine mammals and other protected marine species (e.g., sea turtles), as required under the Endangered Species Act (ESA) of 1973 and the Marine Mammal Protection Act (MMPA) of 1972. Section 101(a)(5)(A) of the MMPA states that the National Marine Fisheries Service (NMFS) must set forth “requirements pertaining to the monitoring and reporting of such taking” in order to issue an Incidental Take Authorization for an activity. The MMPA implementing regulations at Code of Federal Regulations, Title 50, Section 216.104(a)(13) note that requests for Letters of Authorization (LOAs) must include the suggested means of accomplishing the necessary monitoring and reporting that will result in increased knowledge of the species and of the level of takes or impacts on populations of marine mammals that are expected to be present. While the ESA does not have specific monitoring requirements, Biological Opinions issued by NMFS also have included terms and conditions requiring the U.S. Pacific Fleet to develop a monitoring program. Requirements set forth by issuance of the LOAs necessitate that the U.S. Pacific Fleet submits a report analyzing and summarizing marine mammal information gathered.

The U.S. Pacific Fleet predicted that some training activities in the Mariana Islands Range Complex (MIRC) would result in the generation of sound levels in the water that NMFS has indicated is likely to result in the harassment of marine mammals. These activities involve the use of sonar (mid-frequency active sonar [MFAS] and high-frequency active sonar [HFAS]) and/or the use of live ordnance, including underwater detonation (UNDET) of explosives. In order to train in realistic conditions (i.e., with sonar and explosives), the U.S. Navy obtains Incidental Take Statements and LOAs from NMFS under the ESA and MMPA, respectively.

The U.S. Pacific Fleet has supported marine species monitoring in the MIRC since 2007 (refer to **Section 2** of this report). Although not required under the National Environmental Policy Act, the U.S. Navy proactively initiated the Mariana Islands Sea Turtle and Cetacean Survey (MISTCS) in 2007. The objective of MISTCS was to gather data in support of the analysis of potential effects in the Mariana Islands Range Complex Environmental Impact Statement/Overseas Environmental Impact Statement and associated MMPA and ESA consultations by providing species identification and density data to support ongoing activities. Subsequent to MISTCS, a U.S. Pacific Fleet-funded aerial monitoring survey was conducted after the Valiant Shield training exercise in August 2007.

The Draft MIRC Monitoring Plan (submitted to NMFS in September 2009) outlined study questions directed at data gathering to determine if there are any adverse effects from U.S. Navy training. NMFS recommended that the U.S. Navy revise the monitoring plan to augment the limited distribution and abundance data for the MIRC region. The Final MIRC Monitoring Plan (DoN 2010) committed to monitoring in fiscal year (FY) 2010 and FY11 in anticipation of a March 2010 Final Rule publication. The Final Rule was ultimately not issued until August 2010; however, January through April 2010 visual surveys had already been conducted in collaboration with the Pacific Islands Fisheries Science Center (PIFSC) (see **Section 2.1.1**). Field efforts

increased considerably in 2010 after issuance of the LOA (see **Section 2.1.2**). U.S. Pacific Fleet marine species monitoring conducted in the MIRC from FY10 to FY13 utilized a combination of visual line-transect surveys, non-random/non-systematic visual surveys, and passive acoustics. Through the process of adaptive management, input was solicited from an independent Scientific Advisory Group. The monitoring plan now includes visual survey from either a vessel or shore-based station, maintenance of autonomous passive acoustic monitoring devices in FY13 and FY14 and subsequent analysis, use of a dipping hydrophone during vessel surveys, support for collection of biopsy samples (including preliminary analysis and archiving) per year, support for satellite tagging including purchase of tags and analysis of data per year, mark-recapture abundance estimates, line-transect (diver) sea turtle surveys, and/or turtle tagging studies.

1.2 Report Objectives

Marine species monitoring efforts partially fulfill requirements of the *Mariana Islands Range Complex Monitoring Plan* as specified in the LOA, and meet a variety of program objectives outlined in the Integrated Comprehensive Monitoring Program (ICMP). Monitoring of marine mammals and sea turtles includes visual surveys from aircraft (e.g., fixed-wing and helicopter) and vessels, marine mammal and sea turtle tagging, and passive acoustic monitoring (PAM).

This report presents a geographic information system (GIS)-based overview of the sighting records obtained during marine species monitoring effort (a total of 12 U.S. Pacific Fleet-funded surveys) to date in the MIRC. Also included are incidental marine mammal and sea turtle sightings made since 1965 on non-dedicated surveys in the region (Uyeyama 2014). The structure and objectives of this report mirror those of a similar sightings atlas created for the Hawaii Range Complex in 2012 (HDR 2012a). Available data from visual surveys performed by both contractor-led efforts and U.S. Pacific Fleet in-house surveys were compiled and processed in order to:

- Create a GIS-based summation of all survey tracks, which can be easily visualized.
- Construct a geo-referenced database of sightings that can be queried by species, observer platform, Beaufort sea state (BSS), season, or other sighting/survey variables.
- Provide information to enhance informed management of marine protected species in the MIRC and support the adaptive management process that is part of the ICMP.

Additionally, the following monitoring questions will be addressed:

1. What is the total diversity of marine mammal/sea turtle species observed during U.S. Navy-funded monitoring?
2. Are there patterns of distribution of marine mammal sightings during monitoring?

Section 2 Methods

The MIRC presents a challenging environment for marine species monitoring. The area is well-known for its year-round high sea states and frequent, unpredictable typhoons. It is also less commercially developed than other naval range complexes, limiting access to survey platforms such as large research vessels and non-military aircraft appropriate for offshore field surveys.

Detailed sighting and effort data from all 12 surveys were entered into a comprehensive MIRC monitoring survey database, which was used to generate the tables, figures, and survey effort and sightings maps found in **Section 3** and in the appendices to this report.

2.1 Compiled Monitoring Effort

The U.S. Pacific Fleet has supported marine species monitoring in the MIRC since 2007. This report presents sightings (see **Section 3**) made during vessel, aerial, and shore-based surveys. The report also includes a compilation of sightings made incidentally. Not included are results of PAM efforts from autonomous recorders. A brief summary of each of those efforts is presented below. Monitoring that took place in advance of the 2010 NMFS-issued LOA for MIRC is presented in **Section 2.1.1**, while monitoring subsequent to issuance of the 2010 LOA is found in **Section 2.1.2**. Information on the compilation of incidental sighting data is presented in **Section 2.1.3**.

2.1.1 Prior to Issuance of the 2010 MIRC LOA

Monitoring that took place in advance of the 2010 NMFS-issued LOA for MIRC is presented here, while monitoring subsequent to issuance of the LOA is found in **Section 2.1.2**.

Mariana Islands Sea Turtle and Cetacean Survey (MISTCS). During January-April 2007 (i.e., boreal winter), waters around Guam and the Northern Mariana Islands were part of the first systematic visual vessel and acoustic survey effort for marine mammals in this region (DoN 2007; Thorson et al. 2007; Fulling et al. 2011). The survey was conducted on the M/V *Kahana* using systematic line-transect survey protocol consistent with that used by NMFS-Southwest Fisheries Science Center. The objective of MISTCS was to determine marine mammal and sea turtle densities in the region of the Mariana Islands. On 18 February 2007, an “off-effort” focal study of humpback whales (*Megaptera novaeangliae*) was conducted north of Saipan to search for humpback whales acoustically detected on 17 February (DoN 2007; Norris et al. 2007; Rivers et al. 2007; Fulling et al. 2011).

The majority of the survey was conducted in high sea states (i.e., BSS > 4), with one hawksbill turtle (*Eretmochelys imbricata*) and 13 cetacean species sighted (DoN 2007; Fulling et al. 2011). Fulling et al. (2011) provided line-transect abundance estimates for 12 cetacean species. Numerous cetacean sightings were associated with steep bathymetric features including the West Mariana Ridge, the Mariana Ridge, and the Mariana Trench (DoN 2007; Fulling et al. 2011). The sperm whale (*Physeter macrocephalus*) had the highest sighting frequency followed by Bryde's (*Balaenoptera brydei*) and sei (*Balaenoptera borealis*) whales. The most frequently sighted delphinid was the pantropical spotted dolphin (*Stenella attenuata*) followed by the false killer whale (*Pseudorca crassidens*) and the striped dolphin (*Stenella coeruleoalba*).

The sperm whale was the most frequently sighted cetacean (Fulling et al. 2011), and acoustic detections were three times higher than visual detections (DoN 2007). During the survey, there were multiple sightings of groups that included calves (DoN 2007). Observations were made of several large bulls with fresh tooth marks (including one male ramming the survey ship), suggesting that these males were engaged in competition for mates (Fulling and Salinas Vega 2009). These observations suggest that this area is used for breeding and calving by sperm whales.

Passive acoustic monitoring was used to detect and locate cetaceans in the study area and to supplement visually based observations (DoN 2007; Norris et al. 2012a,b). A two-element towed hydrophone array (frequency response from approximately 100 Hertz [Hz] to 45 kilohertz [kHz]) was monitored and recorded continuously during daylight hours concurrent with the visual effort. Although not a part of the original research plan, two types of sonobuoys were deployed: the AN/SSQ-53D (directional with frequency response of 10 Hz to 2.5 kHz) and AN/SSQ-57B (omnidirectional with an effective frequency response of 10 Hz to 20 kHz), with the latter type predominantly deployed (DoN 2007). Acoustic data highlights included numerous detections of and information on sperm whale codas in the region; the distribution of calling (i.e., “boing”) minke whales (*Balaenoptera acutorostrata*, previously undocumented in the region); the first recordings of sei whales in the western Pacific; and a night-time survey of singing humpback whales off Saipan (DoN 2007; Norris et al. 2007; Morse et al. 2008; Norris et al. 2008; Norris et al. 2012a,b; Ferguson et al. 2013a,b). Humpback whales were acoustically detected and later seen off Saipan, with some suggesting the area north of Saipan may serve as an active breeding area for a small wintering population (DoN 2007; Norris et al. 2007; Rivers et al. 2007; Thorson et al. 2007; Morse et al. 2008; Fulling et al. 2011; Norris et al. 2012a,b). Acoustic detections are not included in this report.

Aerial Survey during Exercise Valiant Shield. Exercise Valiant Shield 2007 (VS 07) was conducted in waters off the coast of Guam during eight days in August 2007 as a joint U.S. military service training exercise incorporating the use of sonar. Marine protected species monitoring aerial surveys were performed on five consecutive days comprising a total linear effort of 2,352 kilometers (km) (Mobley 2007). The relatively calm sea states (mean BSS = 2.2) during the Mobley (2007) survey allowed the detection of cryptic species in the study area—species that were not seen during the MISTCS due to high sea states. Cetacean species sighted included dwarf/pygmy sperm whales (*Kogia* sp.) and a Cuvier’s beaked whale (*Ziphius cavirostris*), as well as a Bryde’s whale, pantropical spotted dolphins, and rough-toothed dolphins (*Steno bredanensis*).

Pacific Islands Fisheries Science Center’s Shipboard Surveys. During January-May 2010, the Cetacean Research Program at the PIFSC conducted cetacean and oceanographic shipboard surveys aboard the R/V *Oscar Elton Sette* (OES) between Honolulu and Guam and within the Exclusive Economic Zones of Guam and the Commonwealth of the Northern Mariana Islands (CNMI) (Oleson and Hill 2010). The high-seas survey effort is discussed here under shipboard surveys, while the small-vessel survey effort is discussed separately in the PIFSC small-vessel surveys sections of this report.

Shipboard visual surveys were conducted using Fujinon 25 × 150-millimeter “bigeye” binoculars. During the two transit legs, a towed hydrophone array was monitored for acoustic detections of vocal cetacean groups for future comparison of vocalization types by species and for eventual calibration of visual versus acoustic detection rates. Marine mammal observers obtained photo-identification and biopsy samples to examine local cetacean stock structures.

- 20 January–6 February 2010 (OES10-01): cetacean visual and acoustic observations were made on the high-seas survey on this transit leg between Honolulu and Guam (NMFS-PIFSC 2010a; Oleson and Hill 2010). Marine mammal observers encountered 25 cetacean groups; eight of the 25 cetacean groups were identified to species, and included sperm whales, striped dolphins, sei whales, sei/Bryde’s whales, melon-headed whales

(*Peponocephala electra*), and false killer whales. Over 100 acoustic detections were noted, consisting primarily of sperm and minke whales. Thirty-seven sonobuoys were deployed; acoustic detections from the sonobuoys included humpback whales, sperm whales, minke whales, fin whales (*Balaenoptera physalus*), and sei whales, and possible delphinid clicks and whistles.

- 20 March–11 April 2010 (OES10-03): cetacean visual observations during daylight hours during the Ecosystem Observation Program's oceanography cruise around Guam and the southern portion of the CNMI (NMFS-PIFSC 2010b; Oleson and Hill 2010). Marine mammal observers encountered nine cetacean groups and were able to identify three to species as Risso's dolphin (*Grampus griseus*), striped dolphin, and short-finned pilot whale (*Globicephala macrorhynchus*). Neither photos nor biopsy samples were collected during any of the encounters, as cetacean observation was ancillary to the primary cruise objectives and there was no time available to stop the ship for photographing groups or collecting biopsies.
- 19 April–3 May 2010 (OES10-04): cetacean visual and acoustic observations on the high-seas survey on this transit leg between Guam and Honolulu (NMFS-PIFSC 2010c; Oleson and Hill 2010). Marine mammal observers encountered 21 cetacean groups. Sixteen were identified to species—pantropical spotted dolphin, sei/Bryde's whale, false killer whale, melon-headed whale, sperm whale, short-finned pilot whale, and spinner dolphin (*Stenella longirostris*). Sixty-seven acoustic detections were noted, consisting primarily of sperm and minke whales. Other acoustic detections include pilot whales, melon-headed whales, and false killer whales. Thirty-seven sonobuoys were deployed; detections included delphinid whistles and sperm, minke, and sei whales.

Pacific Islands Fisheries Science Center Small-Vessel Surveys. In an effort to further develop a record of cetacean occurrence in the region, the PIFSC's Cetacean Research Program has conducted surveys for cetaceans in the waters surrounding Guam and the CNMI since 2010 (Hill et al. 2013a, 2014a). This research was carried out in partnership with the U.S. Pacific Fleet and is expected to continue through 2015 (Hill et al. 2014a). The primary objectives were to locate cetacean species, assess group sizes, obtain photos, and analyze collected genetic samples to determine sightings rates and assess the structure, abundance, and movement habits of these populations. This includes producing population abundance estimates using mark-recapture techniques. The first step in the process is the creation of species photo-identification catalogs, which began during the summer of 2012. Detailed reports for each survey year were submitted to the U.S. Navy (Oleson and Hill 2010; Ligon et al. 2011; Hill et al. 2012, 2013b). The summary of the combined surveys is reported by Hill et al. (2013a) and through April 2014 by Hill et al. (2014a).

- During February–March 2010, surveys were conducted from small vessels (the 9.4-meter [m] *Lucky Strike*; 5.8-m *Melakai*; 11.6-m *Ten-III* used off Guam and the 12.2-m *Sea Hunter* off the CNMI) chartered in Guam, Tinian, and Saipan for 16 days of effort (Oleson and Hill 2010, Ligon et al. 2011; Hill et al. 2013a, 2014a). Strong trade winds persisted during most of the survey period with 72 percent of overall effort occurring in BSS 4 or greater (Ligon et al. 2011). A total of 18 sightings were made, consisting of four species. Around Guam, 11 groups of cetaceans were encountered, with 10 identified to species as spinner dolphin, pantropical spotted dolphin, and sperm whale. Around Saipan

and Tinian, seven cetacean groups were encountered, and all were identified to species as spinner dolphin and sperm whale.

2.1.2 After Issuance of the 2010 MIRC LOA

As noted earlier, NMFS issued the MIRC LOA during August 2010 (NMFS 2010). Visual monitoring efforts post-August 2010 include small-vessel surveys conducted by the PIFSC, and small-vessel and a shore-based (i.e., shore station) survey conducted by HDR (U.S. Navy contractor). As noted in **Section 1**, these efforts reflect adaptive management decisions that included input from the NMFS and the Scientific Advisory Group.

Pacific Islands Fisheries Science Center Small-Vessel Surveys. The PIFSC has conducted small-vessel surveys during 2011 through 2014 (refer also to **Section 2.1.1** for additional explanation of the purpose of the PIFSC's survey efforts). Survey effort and sighting data from 2011 through 2013 were included in this data compilation and the maps in **Appendices C and D**. Data from the 2014 surveys are being processed, and therefore, were not available for inclusion in this report.

- During August–September 2011 (Summer 2011), 30 survey days were conducted off Guam and Rota, and in the waters surrounding Saipan, Tinian, and Aguijan (Hill et al. 2012; Hill et al. 2013a). All Guam surveys, except one, were conducted aboard the 9.4-m *Lucky Strike*. One survey utilized the 7.0-m *Anna Marie*. Surveys off Saipan, Tinian, and Aguijan were conducted aboard the 12.2-m *Sea Hunter*, and the 12.2-m *Sr. Dung* was used in the waters surrounding Rota. Bottlenose dolphins (*Tursiops truncatus*), pantropical spotted dolphins, spinner dolphins, and short-finned pilot whales were sighted off Guam. Off Saipan, Tinian, and Aguijan, bottlenose dolphins, a dwarf sperm whale, pantropical spotted dolphins, pygmy killer whales (*Feresa attenuata*), short-finned pilot whales, and spinner dolphins were identified.
- During May–July 2012 (Summer 2012), small-vessel surveys were conducted during 31 days off Guam, Rota, and in the waters surrounding Saipan, Tinian, and Aguijan (Hill et al. 2013b). The Guam surveys were conducted aboard four different vessels: the 11-m *Ten-II*; 11.6-m *Ten-III*; 9.4-m *Lucky Strike*; and 7.6-m *Proline 25*. Surveys off Saipan, Tinian, Aguijan, were conducted aboard the 12.2-m *Sea Hunter* and surveys off Rota aboard the 12.2-m *Sr. Dung*. Off Guam, 17 sightings were made and included bottlenose dolphins, spinner dolphins, pantropical spotted dolphins, and short-finned pilot whales. Twenty-two sightings were made off Saipan, Tinian, and Aguijan and included pantropical spotted dolphins, spinner dolphins, bottlenose dolphins, short-finned pilot whales, and beaked whales. Twelve turtle sightings were recorded during all Guam surveys. Most of the sightings were of unidentified hardshell turtles. Three were identified as the green turtle (*Chelonia mydas*). No hawksbill turtles were confirmed. Thirty-nine turtle sightings were recorded during all CNMI surveys. Most of the sightings (64 percent) were unidentified hardshell turtles, although notable was a hawksbill turtle sighting off Saipan.
- During June–July 2013 (Summer 2013), 30 days of survey effort were conducted in waters around the islands of Guam, Rota, Tinian, Saipan, and Aguijan (Hill et al. 2013c). Forty-two sightings of eight cetacean species (bottlenose dolphin, false killer whale, pantropical spotted dolphin, pygmy killer whale, rough-toothed dolphin, short-finned

pilot whale, sperm whale, and spinner dolphin) were recorded. Ten satellite tags were deployed (on two bottlenose dolphins, four false killer whales, one rough-toothed dolphin, and three short-finned pilot whales). A total of 68 turtles was observed.

- During April–June 2014, small-vessel surveys were conducted to survey for cetaceans in the waters surrounding Saipan, Tinian, Aguijan, Guam, and Rota (Hill 2014; Hill et al. 2014a,b,c). Surveys were timed with humpback whales in mind (Hill et al. 2014a). As noted earlier, data from the PIFSC small-vessel surveys conducted during 2014 were not available for inclusion in this report.

During 11–27 April 2014, 15 days of survey effort were completed off Guam, Saipan, Tinian, and Aguijan, covering 1,194 km of trackline (Hill et al. 2014a). Six species were encountered (spinner dolphin, pygmy killer whale, rough-toothed dolphin, melon-headed whale, bottlenose dolphin, and pantropical spotted dolphin) and three melon-headed whales were tagged (Hill et al. 2014a). Green and hawksbill turtles were also recorded.

During 15–27 May 2014, 11 days of survey effort were completed off Guam, covering 1,045 km of trackline (Hill 2014). Six species were encountered (short-finned pilot whale, false killer whale, pantropical spotted dolphin, spinner dolphin, bottlenose dolphin, and mesoplodont whale (Hill 2014).

During 30 May–14 June 2014, 14 days were spent surveying the waters surrounding Saipan, Tinian, and Aguijan, for over 1,500 km of trackline effort (Hill et al. 2014b). There were 13 encounters with 5 different cetacean species (spinner dolphin, bottlenose dolphin, Cuvier's beaked whale, false killer whale, and mesoplodont whale).

During 16–20 June 2014, 5 days of surveys were conducted off Rota, covering 488 km of trackline (Hill et al. 2014c). Fourteen groups of cetaceans were sighted, including Blainville's beaked whale (*Mesoplodon densirostris*), bottlenose dolphin, pantropical spotted dolphin, short-finned pilot whale, spinner dolphin, and unidentified beaked whales.

Guam Marine Species Monitoring Survey. During February to March 2011, a small-vessel survey using the M/V *Island Girl* documented marine mammal and sea turtle occurrence in nearshore waters around the island of Guam (HDR 2011). The approach primarily followed opportunistic survey protocols used by Ligon et al. (2011) (NMFS-PIFSC small-vessel surveys conducted around Guam), which remained nearshore (within 5.6 km of the coastline). Additional lines of effort following standard line-transect protocols were attempted (out to 20 km from shore) when sea conditions permitted. Spinner dolphins comprised most of the sightings, although there was also a mixed-species aggregation of bottlenose dolphins and short-finned pilot whales (*Globicephala macrorhynchus*). Green turtles were also sighted.

Guam and Saipan Marine Species Monitoring Survey. The objective of the March 2012 survey was to conduct small-vessel surveys to further document marine mammal and sea turtle occurrence in nearshore waters around the islands of Guam and Saipan using the M/V *Sea Fantasy* and M/V *Super Emerald*, respectively (HDR 2012b). The approach primarily followed opportunistic survey protocols used previously around Guam (Ligon et al. 2011; HDR 2011), which remained within 10 km of the coastline. Due to the higher than expected sea state conditions and the smaller survey vessels' inability to provide stable platforms in those conditions, the Guam survey (intended to incorporate waters surrounding the island) was

modified to survey the nearshore waters out to 18 km on the western side. This approach was similar to a previous survey in Guam (Ligon et al. 2011; HDR 2011). Even restricting the survey to the leeward side of the island, 94 percent of the effort was conducted in BSS of 3 to 6, and 71 percent were in BSS of 4 to 5, making sighting conditions difficult. Despite the high BSS, 10 cetacean and six sea turtle sightings were made during the 11 days of surveys off the islands of Guam and Saipan. The spinner dolphin was the most frequently sighted (40 percent) cetacean species. The majority (60 percent) of cetacean sightings occurred off Guam, which also had the highest marine mammal species diversity—five cetacean species compared to two at Saipan. There were twice as many sightings of sea turtles at Saipan compared to Guam.

Shore-Based Marine Mammal Monitoring with a Theodolite on Guam. During 11–20 May 2013, HDR conducted a shore-based survey from two shore stations (elevations of 157 m and 193 m) at the Andersen Air Force Base on Guam (Deakos et al. 2014). The shore-based observers were equipped with a theodolite for fixing sighting locations, and a pair of Fujinon 25 × 150-millimeter “bigeye” binoculars for scanning long distances away from the shore station. This was a pilot study to determine the feasibility of a cost-effective platform for visually surveying waters within the MIRC, where prevailing sea states typically make small-vessel visual surveys challenging. Twenty-six marine mammal sightings were recorded; the majority ($n=18$, 69 percent) were spinner dolphins. A total of 19 sea turtles were sighted over the 10-day survey.

Pacific Islands Fisheries Science Center Sea Turtle Tagging Surveys. The PIFSC Marine Turtle Assessment Group has conducted in-water capture and GPS tagging of sea turtles in Guam and the CNMI during 2013 and 2014 to investigate habitat use and movement patterns (Jones & Van Houtan 2014). During August 2013, sea turtles were captured and tagged at Tinian. Tagging was also attempted at Cocos Lagoon in Guam. During June 2014, sea turtles were captured and tagged at Apra Harbor, Guam. Data from these surveys are not included in this report as they are still being processed, and progress to date is provided in Jones and Van Houtan (2014).

Navy In-water Sea Turtle Diver Surveys. The Scientific Diving Services of the Naval Facilities Engineering Command Expeditionary Warfare Center has performed a long term series of in-water sea turtle surveys conducted periodically off Guam and Tinian from 2004–2014. These surveys were conducted by divers at depths ranging approximately from 20 to 120 ft., and sighted turtles were recorded with respect to their size, sex, behavior, and the presence of any fibropapilloma tumors. These surveys were performed in reference to pre-defined survey zones, and the resulting data therefore were not comprised of discretely geo-referenced sightings and tracklines; analysis is ongoing through a separate effort. Therefore these data were not compatible with the GIS-based methods utilized for this report, and are not included here.

Navy Sea Turtle Nesting Surveys. Naval Base Guam personnel began monthly surveys of sea turtle activity along the shorelines of the Tinian Military Lease Area in 1998, which has continued to the present. The effort on Tinian is focused at six beaches: Unai Chulu, Unai Babui, Unai Lamlam, Unai Chiget, Unai Masalok, and Unai Dankulo. Because the purpose of this report is on compiling sightings and survey effort in the marine environment, these data are not included here.

2.1.3 Incidental Sightings

Uyeyama (2014) compiled previously unpublished reports of sightings of marine mammals and sea turtles made within the MIRC. The original primary goal of the Uyeyama (2014) report was to compile sightings incidentally made during U.S. Pacific Fleet-funded field efforts or other U.S. Navy training. However during the course of compiling these data, additional incidental sightings made by other sources were discovered. Because these additional sightings were numerous and generally unavailable in existing reports or publications, these too were included in the incidental sightings database. Uyeyama (2014) reviewed these data sources that are included in this current compilation, including incidental sightings during Farallon de Medinilla (FDM) aerial avian surveys, assessments of marine and fisheries resources at FDM, U.S. Pacific Fleet survey to Sarigan; Explosive Ordnance Disposal Detachment Marianas (EOD DET MARI) transit from Guam to Saipan, incidental sightings during servicing of MIRC ecological acoustic recorders (EARs) by HDR, Andersen Air Force Base Marine Patrol Volunteer Program; and Guam Department of Agriculture's Division of Aquatic and Wildlife Resources (DAWR) compilation of sightings and strandings. Data range from 1965 to 2013.

There were no survey tracklines associated with these sighting data, since all were made incidentally, and not as a result of a directed survey effort. Also, for the purposes of later entry into the database, data fields for time, latitude, and longitude were populated with best estimates based on information accompanying the data sources.

2.2 Survey Data Processing and Map Creation

Survey data, including sightings, vessel position, and environmental conditions for visual (aerial and vessel) surveys, were provided by multiple researchers and organizations. Survey data were collected using a variety of data-logging software, including WinCruz (developed by Robert Holland at the NMFS Southwest Fisheries Science Center; <http://swfsc.noaa.gov/textblock.aspx?Division=PRD&ParentMenuId=147&id=1446>) and Whale Identification Logging and Display (WILD) geospatial mapping software (developed by the Space and Naval Warfare Systems Command; <http://sea-inc.net/2011/09/27/socal-brs-tools-wild-geospatial-mapping-software/>). Survey data files were imported into a web-based database created with Microsoft SharePoint collaboration software (2010 version) (**Figure 1**).

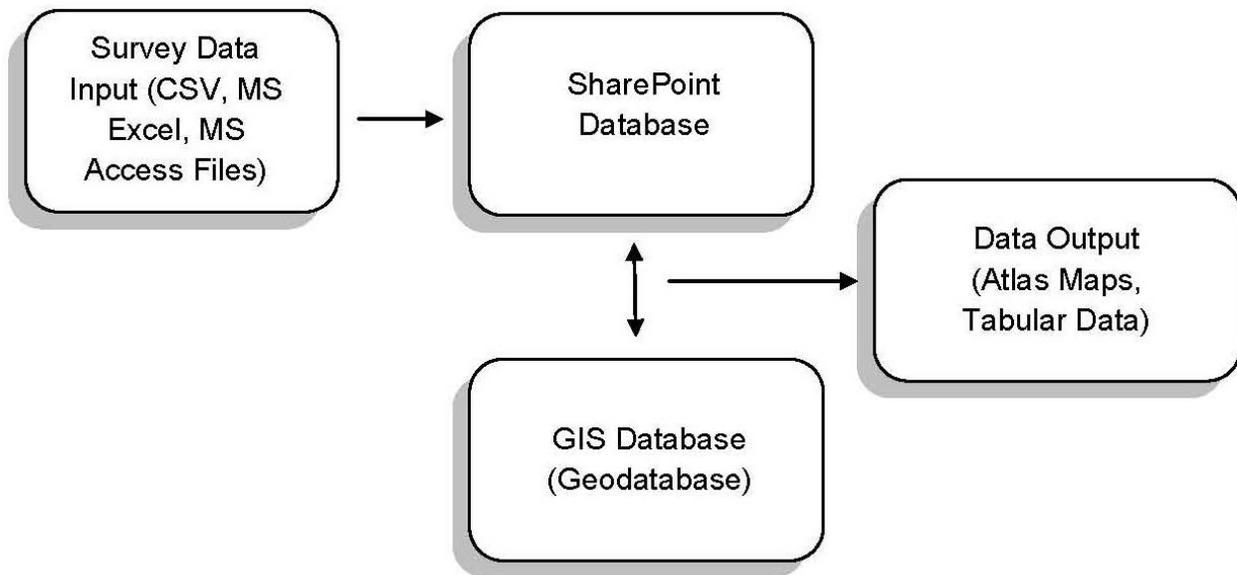


Figure 1. Data processing steps.

A collaborative SharePoint site was created to house all data in both unedited and modified forms. Each time new data files were received, they were uploaded to the SharePoint site in their raw format for archival purposes, as well as in formats that were more conducive to editing. The raw files were not edited during the data development process. In order to undergo editing, data files were “checked out” of the SharePoint site so that only one person at a time could edit a file. Once editing was complete, the file was “checked-in” to the SharePoint site, and people with appropriate privileges could then access the edited file. This procedure ensured file version control and effectively tracked edits as new data were received.

Data were compiled into a series of “key” files and cross-referenced against a standardized set of fields in a comprehensive database that incorporated all fields from all datasets. Where appropriate, fields were added that further standardized the data. To provide a link between sightings data and trackline data, a field called “SurveyLink” was created in the comprehensive sightings database that combined a unique Survey ID for each survey and the date of each sighting.

Geographic information system data layers for species sightings and survey tracklines were created as part of the Atlas data development and mapping process. Survey data included surveys conducted by the U.S. Pacific Fleet, HDR, and other U.S. Navy contractors and subcontractors. Once the data were consolidated from the original formats into a common format and table structure, a combination of processes was used to convert them to a GIS format. The species sightings locations were manipulated and stored in a tabular data format with all relevant attribute fields populated where the information was available. This table was imported into ArcGIS Desktop and the points were plotted using the Add XY function. The latitudes and longitudes were used as the location information for each point and a shapefile was created from the resulting plotted locations. The shapefile data layer was then loaded into a geodatabase and maps were created for specific species using the four-letter species codes. A bathymetry shapefile was used to create all effort and sightings maps, and to provide maximum, minimum, and mean depth data for all sightings and survey effort. This GIS bathymetry data layer had been

created for use in the U.S. Navy's Final *Marine Resource Assessment for the Japan and Mariana Archipelagos* (DoN 2013), which summarizes marine resources data and information relevant to the MIRC.

The survey trackline data were received in multiple data formats including *.csv, *.xls/xlsx or *.mdb tabular format. The raw data included point locations along a survey track that marked where certain environmental elements of the survey changed. Each point location contained related environmental elements including BSS (see **Appendix B** for explanation of BSS), cloud cover, and glare, among others. Sightings and trackline data were converted to GIS point and line layers, respectively, with all available attributes included.

The Points-to-Lines tool was used to create a single line that connected all of the points generated from the raw survey track data. The final output layer for each survey track contained all linear features and associated attributes for an individual day of a survey. This process was repeated for all survey days, the individual layers were combined, and the final data layer was stored in a personal geodatabase. Attribute fields were added to the final survey trackline data layer to store the SurveyLink and a unique Segment ID. A relationship class was built in the geodatabase using the SurveyLink field. This created a relationship between the species sightings points and the associated survey tracklines for use in a GIS desktop environment that allows users to use the Identify tool on a species sightings point and see the associated survey tracklines, and vice versa.

Once the GIS database was completed, two types of maps were created: (1) survey effort maps displaying comprehensive tracklines for all surveys (with available data) grouped by survey type, survey effort relative to BSS, and the bathymetry of the survey area; and (2) sighting maps with animal locations layered on top of the plotted survey effort. Sighting maps depict sightings of a particular species seen during multiple surveys. Tracklines were color-coded for BSS 0-7. No survey data were available for BSS greater than 7, and sighting conditions in fact deteriorate quickly in conditions with BSS above 4 (see **Appendix B**). Sighting events are denoted by closed circles. If the group size of the sighting event is being shown, open circles are used with larger circles representing larger group sizes, as indicated in each map legend. Sighting events on maps showing multiple species also have labels associated with the closed or open circle to differentiate between species.

High resolution bathymetry data were obtained from the Pacific Islands Benthic Habitat Mapping Center, http://www.soest.hawaii.edu/pibhmc/pibhmc_cnmi.htm for multiple MIRC regions at resolutions ranging from 1 to 60 m. Datasets were downloaded and mosaicked using ArcGIS. Depth values were extracted for each sighting using the highest available resolution at the sighting location. Where high-resolution bathymetry data were not available, depths were determined using SRTM (NASA Shuttle Radar Topography Mission) data, http://topex.ucsd.edu/WWW_html/srtm30_plus.html. This dataset has a resolution of 30 arc-seconds. Generally speaking, the closer to shore, the better the bathymetric resolution available. However, some near shore sightings did not have high-resolution data available and the lower resolution SRTM value was used.

Section 3 Results

3.1 Survey Effort

A total of 12 U.S. Pacific Fleet monitoring surveys performed in the MIRC from 2007 through 2013 are described in this report, as are incidental sightings collected from 1965 to 2013 on various non-dedicated surveys in the region (**Appendix A**). The compiled survey effort and sightings are displayed in **Figure 2** and in maps located in **Appendices C and D, respectively**. Survey effort is presented on the maps by sea state in four classes (BSS 0–2, 3–4, 5–7, and not recorded). **Figure C-1** depicts systematic (i.e., line-transect) surveys consisting of large vessel/shipboard and aerial surveys (e.g., PIFSC shipboard surveys, MISTCS, Valiant Shield aerial survey). Pacific Island Fisheries Science Center small-vessel survey effort is plotted in **Figure C-2**, while small-vessel surveys and the horizon of the shore-station survey conducted by HDR are plotted in **Figure C-3**.

In general, calmer conditions were encountered close to shore and in the lee (west side) of the islands, since winds in the study area are dominated by trade winds, which generally come from a direction between east and northeast (**Figure 2**). Challenging weather and sea states in the MIRC restrict the areas that can be safely surveyed with a small vessel to a greater degree than in the Hawaiian Islands, particularly in the winter months when the sea states are consistently high, as experienced in recent large vessel, small vessel, and aerial surveys in the region. However, lower sea states do occur in the region. For example, during the VS 07 monitoring, a low-pressure weather system located northwest of the CNMI suspended normal prevailing trades, which made for excellent sighting conditions (low BSS, $\bar{X} = 2.2$), due to light and variable winds (Mobley 2007). Weather conditions and their resulting impact on BSS reduce the amount of information known about marine mammal distributions in the offshore areas and on the windward side of Guam and the CNMI.

Included in **Figure 2** are the locations of four EAR buoys that were deployed in September 2011—two off Guam (northwest and southwest), one north of Saipan, and one southwest of Tinian (Richlen and Ampela 2012). The four EARs were retrieved and redeployed at the same sites in April 2012; three of the four EARs were retrieved in January 2013 (Munger et al. 2014). The EAR deployed to the southwest of Guam was unable to be recovered due to presumed loss of battery power (Munger et al. 2014). For details on acoustic analyses, the reader is referred to Munger et al. (2014). Acoustic detections are not included in this report.

NMFS' PIFSC deployed high-frequency acoustic recording packages (HARPs) near Saipan in March to August 2010, and at two sites near Saipan and Tinian in April to October 2011 and June 2012 to May 2013 (one located off the west side of Saipan near 300 Reef and off the east side of Tinian) (see **Figure 2**) (Oleson 2014). The U.S. Pacific Fleet funded NMFS to analyze some of these data; the reader is referred to Oleson (2014) for the preliminary analyses. Acoustic detections are not included in this report.

Mariana Islands Sea Turtle and Cetacean Survey. During January to April 2007, a shipboard survey was conducted in an area that encompassed approximately 584,800 square km. The northern boundary of the MISTCS survey area was south of Pagan (DoN 2007; Norris et al. 2012a,b; **Figure C-4**). Observers visually surveyed 11,033 km of trackline during the MISTCS

cruise (DoN 2007; Fulling et al. 2011). The area surveyed had a bottom depth ranging from <200 to 10,525 m and a distance from shore of 1.2 to 427 km. Sea states for the survey ranged from 0 to 7. Most of the survey was conducted in BSS >4 (66 percent) (DoN 2007; Fulling et al. 2011).

Pacific Islands Fisheries Science Center Shipboard Surveys. Marine protected species observations were collected by marine mammal observers while transiting from Honolulu to Guam during January to February 2010 (OES 10-01); during an oceanography cruise off Guam and the southern Mariana Islands in March to April 2010 (OES 10-03); and transiting from Guam to Honolulu during April to May 2010 (OES 10-04). **Figure C-5** shows the survey effort in MIRC during these three cruises. The area surveyed had bottom depths of 691 to 8,167 m and a distance from shore of 5 to 515 km during OES 10-01; 1,182 to 9,762 m and a distance from shore of 4 to 42 km during OES 10-03; and 1,182 to 9,764 m and a distance from shore of 10 to 214 km during OES 10-04. Sea states for these surveys were BSS 3 to 5 during OES 10-01; BSS 0 to 7 during OES 10-03; and BSS 5 to 6 during OES 10-04.

Exercise Valiant Shield. An aerial survey was conducted in August 2007 off Guam (see **Figure C-6**) over waters with bottom depths <200 to 10,522 m with a distance from shore of <1 to 300 km. The islands of Guam and Rota were circumnavigated, and tracklines covered waters south and east of Guam. Sea states were relatively calm at BSS 1 to 4.

Pacific Islands Fisheries Science Center's Small-Vessel Surveys. Small-vessel surveys were conducted around the southernmost of the Mariana Islands (Guam, Saipan, Tinian, Aguijan, and Rota) between 2010 and 2013—winter 2010 and summers of 2011 through 2013 (**Figure C-2**).

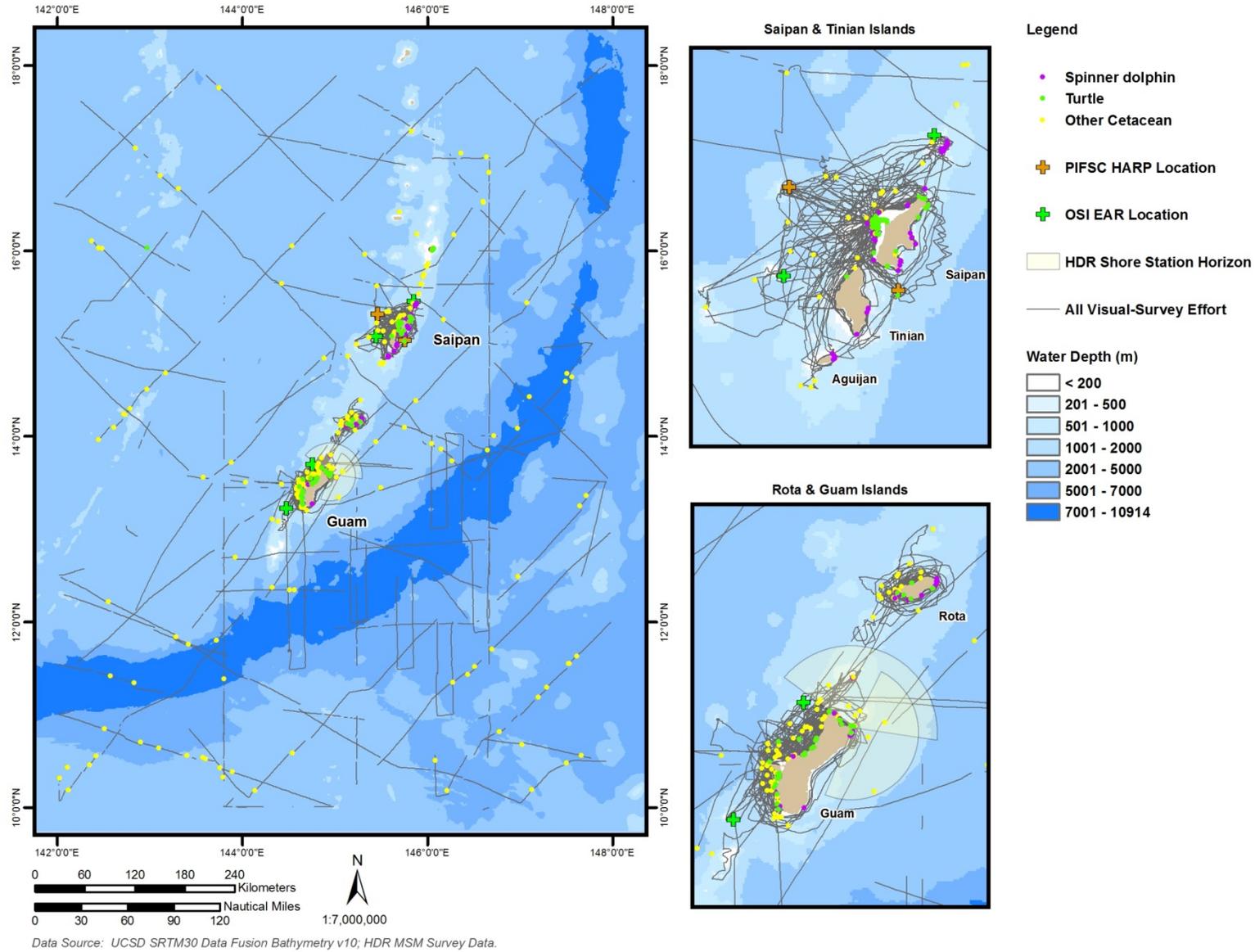


Figure 2. Combined MIRC monitoring effort and sightings.

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 winter 2010 PIFSC small-vessel survey was conducted off Guam, Saipan, and Tinian in BSS 1 to 7 and in waters with bottom depths of <200 to 1,933 m, and covered a distance from shore of <1 to 32 km. The summer 2011 PIFSC small-vessel survey was conducted off Guam, Rota, Saipan, Tinian, and Aguijan in BSS 0 to 6 and in waters with bottom depths of <200 to 2,001 m, and covered a distance from shore of <1 to 31 km. The summer 2012 PIFSC small-vessel survey was conducted off Guam, Rota, Saipan, Tinian, and Aguijan in BSS 0 to 6 and in waters with bottom depths of <200 to 3,036 m, and covered a distance from shore of <1 to 55 km. The summer 2013 PIFSC small-vessel survey was conducted off Guam, Rota, Saipan, Tinian, and Aguijan in BSS 0 to 6 and in waters with bottom depths of <200 to 2,650 m, and covered a distance from shore of <1 to 37 km.

Guam Marine Species Monitoring Survey. During February to March 2011, a small-vessel survey was conducted in nearshore waters around the island of Guam (HDR 2011). The approach primarily followed opportunistic survey protocols used by Ligon et al. (2011) (NMFS-PIFSC small-vessel surveys conducted around Guam), which remained nearshore (within 5.6 km of the coastline) (**Figure C-2**). Additional lines of effort following standard line-transect protocols were attempted (out to 19 km from shore) when sea conditions permitted. While survey tracklines were planned to surround the entire island, weather conditions constrained the survey effort to the northern and western sections of Guam (HDR 2011). Surveys were conducted in waters with bottom depths <200 to 2,289 m (see **Figure C-2**). Sea states ranged from 2 to 6, with 89 percent of effort taking place in BSS of 3 to 5 (HDR 2011).

Guam and Saipan Marine Species Monitoring Survey. During March 2012, a small-vessel survey was conducted in nearshore waters around the islands of Guam and Saipan (HDR 2012b). For Guam, the survey effort covered nearshore waters out to 18 km of the northern and western sections of the island (**Figure C-2**). For Saipan, during less than half of the survey, the boat was able to circumnavigate the island, while most of the effort remained on the western (leeward) side of the island (**Figure C-2**). Surveys were conducted in waters with bottom depths <200 to 2,501 m. Overall, BSS for the survey ranged from 2 to 7, with 95.7 percent of effort in BSS 3 to 6 (HDR 2012b).

Shore-based Station Survey. During May 2013, a shore-based survey was conducted on the east (Shore Station 1) and north (Shore Station 2) coasts of Guam (Deakos et al. 2014). **Figure C-3** shows Shore Stations 1 and 2 and the farthest small-vessel fix. The estimated sighting range in **Figure C-3** to the horizon is shaded for each of the two respective sites. The horizon was visible 30 km offshore on the eastern platform (157-m elevation) and 38 km offshore on the northern platform (193-m elevation). The shore stations' sighting range covered waters with bottom depths of <200 to 1,200 m. Sea state conditions ranged from BSS 3 to 6.

3.2 Marine Mammal and Sea Turtle Species

Monitoring Question 1: *What is the total diversity of marine mammal/sea turtle species observed during U.S. Navy-funded monitoring?*

Thirty-two marine mammal and five sea turtle species have confirmed or possible occurrence off Guam and the CNMI (DoN 2013). A total of 704 marine mammal and sea turtle records was compiled for this report—67 percent were of marine mammals ($n=471$) and 33 percent were of sea turtles ($n=233$). From the compiled 703 sighting records, 64 percent ($n=448$) were identified to species (21 marine mammal and two sea turtle species).

Of the 21 marine mammal species sighted, 17 were toothed whales and four were baleen whales (**Table 1**). Sightings for each of these species are mapped in **Appendix D**. Sighting parameters including bottom depth at sighting locations and group size ranges for species are summarized in **Table 1**. Each map in **Appendix D** displays survey tracklines and sighting locations, and therefore, shows surveyed areas where no sightings were recorded. Species' sightings trends portrayed in **Appendix D** may be due to survey design and implementation, and do not necessarily indicate biologically significant patterns in habitat use. It should also be noted that sightings information, including BSS, bottom depth, and group size, reflects surveys currently available in the MIRC monitoring survey database, and may not accurately reflect a species' occurrence, habitat preferences, etc.

The species with the greatest percentages of the 448 confirmed species sightings were the spinner dolphin ($n=123$; 27.3 percent) and the green turtle ($n=64$; 14.2 percent). The pantropical spotted dolphin ($n=48$; 10.7 percent); sperm whale ($n=43$; 9.6 percent); short-finned pilot whale ($n=39$; 8.7 percent); bottlenose dolphin ($n=22$; 4.9 percent); and Bryde's whale ($n=19$; 4.4 percent) were also frequently recorded. There was a total of eight beaked whale sightings, with three records identified to species—Cuvier's beaked whale (*Ziphius cavirostris*). Of the 233 sea turtle sightings, 28 percent ($n=66$) were identified to species—green turtle (97 percent; 64 of 66 sightings) and hawksbill turtle (3 percent; 2 of 66 sightings). Of the remaining 167 sea turtle sightings, 50 percent ($n=84$ of 167 sightings) were recorded as unidentified hardshell turtles.

3.2.1 Marine Mammal Species

3.2.1.1 Baleen Whales

***Balaenoptera borealis* (sei whale).** There were 14 sightings of sei whales for a total of 28 individuals. Group size ranged from one to four individuals. All sightings were made during the MISTCS cruise, in waters with bottom depths of 3,171 to 9,045 m and at distances of 71 to 436 km from shore (**Figure D-1**). There were several sightings in waters over and near the Mariana Trench (DoN 2007). Most sightings though were associated with bathymetric relief (e.g., steeply sloping areas), including sightings adjacent to the Chamorro Seamounts east of the CNMI (DoN 2007). All confirmed sightings of sei whales were south of Saipan.

***Balaenoptera edeni* (Bryde's whale).** There were 17 sightings of Bryde's whales for a total of 27 individuals. Group size ranged from one to three individuals. Bryde's whale records were primarily from the MISTCS cruise, with one sighting during the Valiant Shield aerial survey. This species was sighted in waters ranging from 2,412 to 8,775 m in bottom depth and at distances of 41 to 436 km from shore (**Figure D-1**). Most Bryde's whale sightings during MISTCS were associated with bathymetric relief (e.g., steeply sloping areas and seamounts), including sightings adjacent to the Chamorro Seamounts east of the CNMI and over the West Mariana Ridge. There were several sightings in waters over and near the Mariana Trench. During the Valiant Shield aerial survey, a single Bryde's whale was observed about 161 km east of Guam at the edge of the Mariana Trench (Mobley 2007).

Table 1. Marine mammal and sea turtle sightings in MIRC.

Scientific Name	Common Name	# of Animals	# of Sightings	Group Size			Bottom Depth (m)	Distance from shore (km)
				Mean (SD)	Max	Min		
Marine Mammals								
<i>Balaenoptera borealis</i>	Sei whale	28	14	1.9 (1.17)	1	4	3,171-9,045	71-436
<i>Balaenoptera edeni</i>	Bryde's whale	27	17	1.6 (0.71)	3	1	2,412-8,775	41-436
<i>Balaenoptera borealis/edeni</i>	Sei/Bryde's whale	3	3	1 (0)	1	1	3,742-5,232	61-349
<i>Balaenoptera musculus</i> ¹	Blue whale	1	1	1 (0)	1	1	384	4
<i>Delphinus</i> sp. ^{1,2}	Common dolphin	1	1	1 (0)	1	1	<200	35
<i>Feresa attenuata</i>	Pygmy killer whale	20	3	6.7 (1.15)	8	6	375-4,795	1-105
<i>Globicephala macrorhynchus</i>	Short-finned pilot whale	851	39	21.8 (32.6)	201	1	<200-4,409	<1-308
<i>Grampus griseus</i>	Risso's dolphin	3	1	3 (0)	3	3	<200-4,409	<1-308
<i>Kogia sima</i>	Dwarf sperm whale	1	1	1 (0)	1	1	663	17
<i>Kogia</i> sp.	Dwarf/pygmy sperm whale	1	1	1 (0)	1	1	1,066	11
<i>Megaptera novaeangliae</i>	Humpback whale	48	15	3.2 (2.43)	8	1	<200-1,037	<1-29
<i>Orcinus orca</i>	Killer whale	26	6	4.3 (1.21)	6	3	<200-1,435	<1-36
<i>Peponocephala electra</i>	Melon-headed whale	292	4	73 (56.9)	135	4	296-2,901	1-<61
<i>Physeter macrocephalus</i>	Sperm whale	219	41	5.3 (5.01)	25	1	<200-9,452	<1-432
<i>Pseudorca crassidens</i>	False killer whale	325	16	20.3 (48.19)	200	1	<200-7,793	<1-359
<i>Stenella attenuata</i>	Pantropical spotted dolphin	1,450	46	31.5 (38.19)	200	2	<200-5,406	<1-440
<i>Stenella coeruleoalba</i>	Striped dolphin	267	12	22.3 (14.08)	50	6	2,430-7,970	53-343
<i>Stenella longirostris</i>	Spinner dolphin	4,140	123	33.7 (28.44)	135	1	<200-1,441	<1-33
<i>Steno bredanensis</i>	Rough-toothed dolphin	25	4	6.3 (1.71)	8	4	216-5,570	<1-174
<i>Tursiops truncatus</i>	Bottlenose dolphin	146	20	7.3 (4.08)	14	1	<200-4,839	<1-218
<i>Ziphius cavirostris</i>	Cuvier's beaked whale	3	3	1 (0)	1	1	<200-8,430	<1-106
Marine Mammals (continued)								
<u>All beaked whales</u>		13	8	1.6 (0.52)	2	1	<200-8,430	<1-344
Unidentified beaked whale species		4	2	2 (0)	2	2	1,225-3,217	12-32

Scientific Name	Common Name	# of Animals	# of Sightings	Group Size			Bottom Depth (m)	Distance from shore (km)
				Mean (SD)	Max	Min		
Unidentified <i>Mesoplodon</i> sp.		6	3	2 (0)	2	2	1,035-3,912	5-344
Sea Turtles								
<i>Chelonia mydas</i>	Green turtle	73	64	1.1 (0.5)	4	1	<200-1,273	<1-8
<i>Eretmochelys imbricata</i>	Hawksbill turtle	2	2	1 (0)	1	1	<200-2,766	1-286
Unidentified hardshell turtle		90	84	1.1 (0.3)	3	1	<200-938	<1-7

Notes:

¹ Sighting from the incidental sightings database; recorded by Guam DAWR.

² Extralimital to the Mariana Islands. Refer to **Section 3.3** of this report for further details.

***Balaenoptera musculus* (blue whale).** No blue whales were recorded during U.S. Pacific Fleet-funded monitoring efforts in the Mariana Islands, although this area is within its known distribution range. There was a sighting in July 1995 of a single blue whale off Guam in the incidental sightings database, recorded by Guam DAWR (Uyeyama 2014). The sighting was in waters with a bottom depth of 384 m and at a distance of 4 km from shore (**Figure D-1**).

***Megaptera novaeangliae* (humpback whale).** There were 15 humpback whale sightings for a total of 48 individuals (see **Figure D-1**). Group sizes ranged from one to nine individuals. January through March are the months when humpback whales are most often reported in the study area (i.e., during humpback whale calving and breeding season). During MISTCS, a focal study of humpback whales was conducted north of Saipan to search for humpback whales that were acoustically detected (DoN 2007; Rivers et al. 2007; Fulling et al. 2011). A group of eight humpback whales was sighted and photographs taken for identification purposes (Rivers et al. 2007; Fulling et al. 2011). The other 14 sightings were from the incidental sightings database, with humpback whales (including mother-calf pairs) reported off FDM, Rota, and Guam (Uyeyama 2014). Humpback whales were sighted in waters with bottom depths from <200 to 1,037 m and at a distance from shore of <1 to 29 km.

3.2.1.2 Toothed Whales

***Physeter macrocephalus* (sperm whale).** There were 41 sperm whale sightings for a total of 219 individuals. Group sizes ranged from one to 25 whales. Sightings were off the west side of Guam, off Saipan, and near FDM in waters with bottom depths ranging from <200 to 9,452 m and at distances of <1 to 432 km from the shore (**Figure D-2**). Sperm whales were seen near steep bathymetric relief, with several sightings over the Mariana Trench.

***Kogia sima* (dwarf sperm whale).** There was one confirmed sighting of a solitary dwarf sperm whale made at Marpi Reef, 15 km north of Saipan in waters over a bottom depth of 663 m (**Figure D-3**). The sighting was made during the summer 2011 PIFSC small-vessel survey. An additional sighting of three *Kogia* sp. was made during the Valiant Shield aerial survey, over waters where the bottom depth was 1,066 m (**Figure D-3**). The occurrence of pygmy sperm whale (*Kogia breviceps*) in MIRC is known from stranding data (Trianni and Treoni 2012; DoN 2013).

Beaked whales. There were eight beaked whale sightings for a total of 13 individuals (**Figure D-4**). All three sightings identified to species were of the Cuvier's beaked whale. Three of the eight beaked whale sightings were of unidentified *Mesoplodon* sp. (one from the summer 2012 PIFSC small-vessel survey and two during MISTCS), while the remaining two sightings were of unidentified beaked whales (one from MISTCS, the other from the summer 2012 PIFSC small-vessel survey). Group sizes were of one or two individuals. Sightings were recorded during MISTCS, the Valiant Shield aerial survey, and the summer 2012 PIFSC small-vessel survey. Beaked whales were recorded in waters over bottom depths of <200 to 8,430 m and at distances of <1 to 344 km offshore.

***Ziphius cavirostris* (Cuvier's beaked whale).** There were three sightings of solitary Cuvier's beaked whales for a total of three individuals. One sighting was from the Valiant Shield aerial survey, while the other two were in the incidental sightings database. Sightings were made in waters <200 to 8,430 m in bottom depth and at distances of <1 to 106 km from shore (**Figure D-4**).

***Steno bredanensis* (rough-toothed dolphin).** There were four sightings of rough-toothed dolphins for a total of 25 animals (see **Figure D-5**). Sightings were at Aguijan, Saipan, off FDM, and south of Guam. Sightings are from the MISTCS cruise, Valiant Shield aerial survey, and incidental sightings database. Sightings were made in waters over bottom depths of 216 to 5,570 m and at distances of <1 to 174 km from the coast. Groups ranged in size from four to eight individuals.

***Tursiops truncatus* (bottlenose dolphin).** There were 20 sightings of bottlenose dolphins for a total of 146 individuals. Sightings were predominantly recorded for nearshore waters of Guam (particularly the west coast) and Aguijan, Saipan, and Tinian (**Figure D-6**). Records are from MISTCS, summer 2011–2013 PIFSC small-vessel surveys, the KB17 winter 2012 small-vessel survey, and the incidental sightings database. This species was sighted in waters with bottom depths <200 to 4,839 m and at distances <1 to 218 km from shore. Group sizes ranged from 1 to 14 individuals.

***Stenella attenuata* (pantropical spotted dolphin).** There were 46 sightings for a total of 1,450 pantropical spotted dolphins. Pantropical spotted dolphins were found in nearshore waters as well as deep waters of MIRC (**Figure D-7**). Sightings at the islands were concentrated on the leeward side (**Figure D-7**). Sightings were made during MISTCS, the Valiant Shield aerial survey, NMFS OES 10-04 shipboard survey, KB17 winter 2012 small-vessel survey, and summer 2011–2013 PIFSC small-vessel surveys. Sightings were made in waters with bottom depths of <200 to 5,406 m and at distances of 1 to 440 km from shore. Group sizes ranged from 2 to 200 individuals.

***Stenella longirostris* (spinner dolphin).** There were 123 sightings of spinner dolphins for a total of 4,140 individuals. Spinner dolphins were sighted around all the islands in the MIRC; in particular, around the islands of Guam, Saipan, Tinian, and Rota (see **Figure D-8**). Sightings were recorded on both the leeward (west) and windward (east) sides of the islands. There are locations along the northeast sides of both Saipan and Aguijan, where spinner dolphins are found reliably. Sightings were from the MISTCS cruise, from every small-vessel survey, the shore station survey, and the incidental sightings database. Sightings were made in waters with bottom

depths of < 200 to 1,441 m and at distances of close to shore to 33 km from the coastline. Group size ranged from 1 to 135 individuals.

***Stenella coeruleoalba* (striped dolphin).** There were 12 sightings of striped dolphins for a total of 267 individuals. Group sizes ranged from 6 to 50 individuals. Sightings primarily occurred throughout deep waters of the study area; there was at least one sighting over the Mariana Trench, southeast of Saipan (**Figure D-9**). Sightings were made during the MISTCS and NMFS OES 10-03 cruises. Sightings were made in waters with bottom depths of 2,430 to 7,970 m and at distances of 53 to 343 km from shore.

***Grampus griseus* (Risso's dolphin).** There was one sighting of Risso's dolphins, of three individuals, during the NMFS OES 10-03 shipboard survey. The sighting was at a distance of 89 km from shore located between Saipan and FDM, in waters with a bottom depth of 3,591 m (**Figure D-10**).

***Peponocephala electra* (melon-headed whale).** There were four melon-headed whale sightings for a total of 292 animals. Group sizes ranged from 4 to 135 individuals. Melon-headed whales were recorded off Guam (**Figure D-11**). Sightings were from MISTCS; NMFS OES 10-01 shipboard survey; KB17 winter 2012 small-vessel survey; and one record from the incidental sightings database. Melon-headed whales were sighted in waters with bottom depths of 296 to 2,901 m and at distances of <1 to 61 km from shore.

***Feresa attenuata* (pygmy killer whale).** There were three sightings of pygmy killer whales for a total of 20 individuals. Groups ranged in size from six to eight individuals. This species was observed during MISTCS and the summer 2011 and 2013 PIFSC small-vessel surveys. Pygmy killer whales were sighted off Guam and Saipan in waters with bottom depths from approximately 375 to 4,795 m and at distances of 1 to 105 km from shore (**Figure D-12**).

Pygmy killer whales are often confused with melon-headed whales and false killer whales (Jefferson et al. 2008). Therefore, identification to species might account for the low number of confirmed sightings.

***Pseudorca crassidens* (false killer whale).** There were 16 sightings for a total of 325 false killer whales. Group sizes ranged from 1 to 200 individuals. False killer whales were also recorded during the summer 2013 PIFSC small-vessel survey and in the incidental sightings database. This species was in waters with bottom depths of <200 to 7,793 m at distances from <1 to 359 km offshore (**Figure D-13**). Sightings were primarily off Guam and Rota. Several sightings were recorded over the Mariana Trench. There was also a sighting in deep waters west of the West Mariana Ridge.

***Orcinus orca* (killer whale).** There were six killer whale records in the incidental sightings database for a total of 26 individuals (Uyeyama 2014). These sightings were made off Guam and south of FDM (**Figure D-14**), in waters over bottom depths of <200 to 1,435 m and at distances of <1 km from the shore to 36 km offshore. Group sizes were three to six individuals. Notable is an account from 25 May 2010 that photo-documented a group of five killer whales feeding on an unidentified species of whale, approximately 20 miles south of FDM (Uyeyama 2014).

***Globicephala macrorhynchus* (short-finned pilot whale).** There were 39 short-finned pilot whale sightings for a total of 851 individuals. These sightings were reported primarily from the

west sides of Guam, Rota, Aguijan, Saipan, and Tinian (**Figure D-15**). There were also deep water sightings (**Figure D-15**). Sightings were recorded during MISTCS, the NMFS OES 10-03 cruise; summer 2011, 2012, and 2013 PIFSC small-vessel surveys; the KB17 winter small-vessel survey; the shore station survey; and the incidental sightings database. Sightings were made in waters over bottom depths of <200 to 4,409 m and at distances of <1 to 308 km from the shore. Some sightings were over the West Mariana Ridge, an area of seamounts (DoN 2007; Fulling et al. 2011). Groups ranged in size from 1 to 201 individuals.

3.2.2 Sea Turtle Species

***Chelonia mydas* (green turtle).** There were 64 sightings of 73 individual green turtles recorded. Group sizes ranged from 1 to 4 individuals. Sightings were from the KB08 and KB17 winter small-vessel surveys, PIFSC summer 2012 and 2013 small-vessel surveys, shore station survey, and from the incidental sightings database. Sightings were reported predominantly for nearshore waters of Guam, Rota, and Saipan (see **Figure D-16**). All sightings were made in waters with bottom depths between <200 and 1,273 m, at distances of <1 to 8 km from the shore.

***Eretmochelys imbricata* (hawksbill turtle).** There were two sightings of solitary hawksbill turtles. One sighting was during the MISTCS cruise, 85 km WSW off the island of Anatahan (north of FDM), in waters with a bottom depth of 2,766 m, while the other was during the summer 2012 PIFSC small-vessel survey in 10 m of water, 1 km west of Saipan (**Figure D-16**).

3.3 Miscellaneous Sighting Figures

Guam DAWR Sightings. Guam DAWR shared their compiled marine mammal sighting data with the U.S. Pacific Fleet; these data are displayed in the top inset map of **Figure D-17**. Refer to Uyeyama (2014) for more details on this dataset. Twelve species were included in the dataset: spinner dolphin, short-finned pilot whale, sperm whale, humpback whale, killer whale, common dolphin, blue whale, pantropical spotted dolphin, bottlenose dolphin, Cuvier's beaked whale, melon-headed whale, and false killer whale. All sightings were around Guam (predominantly on the west and north sides of the island), with the exception of a false killer sighting between the islands of Guam and Rota and a sighting at Rota for the humpback whale. There was one sighting of a single common dolphin (unidentified species—not distinguished as long-beaked [*Delphinus capensis*] or short-beaked [*Delphinus delphis*] common dolphin). The sighting was recorded at Galvez Bank off Guam on 8 July 1990 (Uyeyama 2014). The animal was in waters with a bottom depth of 42 m and at a distance of 35 km from shore. In tropical areas wherever common dolphins are routinely sighted, their occurrence is generally in upwelling-modified areas (e.g., eastern tropical Pacific Ocean – Au and Perryman 1985; western Atlantic Ocean – Jefferson et al. 2009; western tropical Indian Ocean – Ballance and Pitman 1998). Major upwelling areas are not known for the western tropical Pacific Ocean (e.g., DoN 2013) suggesting that common dolphins will not be found there.

Guam DAWR Strandings. Marine mammal stranding data were part of the data shared by Guam DAWR with the U.S. Navy (Uyeyama 2014). These data are displayed in the bottom inset map of **Figure D-18**. The data spanned a time period of 7 September 1962 to 12 June 2013. Since these data are so extensive but unpublished, Uyeyama (2014) considered these data to be an important contribution to occurrence records of marine mammals in the Marianas. Five species were included: spinner dolphin, sperm whale, false killer whale, Baird's beaked whale, and

bottlenose dolphin. The Baird's beaked whale record was considered to be a poaching case, as the animal had a 2.5-centimeter diameter piece of rebar in its head and had been impaled close to shore (Uyeyama 2014). All strandings were on Guam (predominantly on the west and north sides of the island, as with the vast majority of the sightings from the Guam DAWR dataset).

Incidental Sightings Excluding Guam DAWR. Sightings in the incidental sightings database that were provided to the U.S. Navy by sources other than Guam DAWR are plotted in **Figure D-19**. Refer to Uyeyama (2014) for more details on the sources of these data. Sightings included both marine mammals and sea turtles; those sightings identified to species were green turtle, humpback whale, killer whale, pantropical spotted dolphin, short-finned pilot whale, sperm whale, and spinner dolphin. Sighting locations included off Guam, Rota, Saipan, and FDM.

Farallon de Medinilla. Monitoring efforts by the U.S. Pacific Fleet at FDM are summarized by Uyeyama (2014) and provide most of the data for this area of the Mariana Islands. **Figure D-20** displays marine mammal and sea turtle sightings at FDM. Marine mammal sightings identified to species included spinner dolphin, humpback whale, sperm whale, pantropical spotted dolphin, and killer whale (**Figure D-20**). Humpback whale sightings were recorded during January through March.

Sea turtles were sighted at FDM, with some identified as green turtle. Due to strong current and tidal conditions, the beaches at FDM are highly unsuitable for nesting turtles (DoN 2013). Seagrasses and benthic algae are relatively sparse around the island and can probably support no more than a few green turtles at a time (DoN 2013).

Monitoring Question 2: *Are there patterns of distribution of marine mammal sightings during monitoring?*

Observed distribution of species sightings is a reflection of oceanography, resulting habitat associations, survey effort, and sea state conditions.

As summarized in DoN (2013) and Fulling et al. (2011), the Marianas lie within an oceanic province with generally very low levels of primary productivity. Strong interactions between the local oceanography and topography exist in the area. The Marianas region is comprised of a series of seamounts. Seamounts attract higher trophic-level marine species with enhanced production due to the formation of vortices capable of mixing nutrients to the surface and entraining phytoplankton in the overlying waters. In addition, the passage of the North Equatorial Current through the Mariana archipelago is capable of creating regions of enhanced turbulence. Passage of this current can initiate the formation of eddies on the lee side of the islands ("island effect"); these are capable of entraining phytoplankton and creating localized regions of enhanced primary production. In addition, passage of currents through a narrow channel (as found between the islands of Tinian and Saipan) can create localized zones of turbulent flow capable of mixing nutrients into the surface layer. Based on the distribution of sightings in **Figure 2** and **Appendix D**, seamounts, the lee of the islands, and the area between the islands of Tinian and Saipan, appear to be areas of sighting concentrations of marine mammals. The oceanic waters surrounding the Marianas do not contain a true continental shelf, and therefore no true shelf break, the region in which there is a sharp break in the slope of the island shelf (DoN 2013). Rather, the offshore bottom topography is steep and slopes rapidly reach the ocean basin floor (4,000 m) within tens of kilometers of the islands (DoN 2013). This

explains why deep-water cetaceans (e.g., beaked whales, sperm whale, pilot whales) are found close to shore in MIRC.

Close to shore, the PIFSC small-vessel surveys provide a multi-year picture of the distribution of marine mammals at Guam and the CNMI. Sightings close to the islands are concentrated in waters with bottom depths <500 m and within 20 km from shore (**Figure 2**). Spinner dolphins dominate sightings in nearshore waters. Spinner dolphins associate with shallow near-island and bank waters, with most sightings occurring within 1 km of shore, offshore at Marpi Reef or Rota Bank, and in water depths less than 300 m (Hill et al. 2014). Spinner dolphins appear to be found equally on both the lee (west) and windward (east) sides of the islands. Lagoons are high-usage habitat for resting by spinner dolphins; dolphins are reported in Saipan Lagoon at Saipan nearly every year (DoN 2013). Typically, these sightings are from the northern part of the lagoon, referred to as Tanapag Lagoon. High-use areas at Guam include Bile Bay, Tumon Bay, Double Reef, north Agat Bay, and off Merizo (Cocos Lagoon area) (DoN 2013).

The MISTCS cruise provides the best information on marine mammal occurrence in offshore, deep waters of the Marianas, even though the sea state conditions made collection of data challenging. Numerous cetacean sightings in offshore waters were distributed over or near steep bathymetric relief including the West Mariana Ridge, the Mariana Ridge, the steep slopes of the Mariana Trench, and several seamounts (see DoN 2007; Fulling et al. 2011). Sperm whales were documented near steep bathymetric relief. During the MISTCS cruise, a sperm whale was sighted off the western coast of Guam (DoN 2007; Fulling et al. 2011). In a 2012 survey, a single sperm whale was sighted close to the western coast of Guam (HDR 2012b). Additionally, Eldredge (2003) reported a sighting of a group of sperm whales including a newborn calf, made during June 2001 off the west coast of Guam (Eldredge 2003). Just over one quarter of the sightings (26%) were in or on the periphery of Agat Bay (**Figure D-2**), an area where the bathymetry drops to depths beyond 2,000 m very quickly, and closer to shore than any other area around Guam, Rota or Saipan.

Sei and Bryde's whales were near underwater ridges and in an area between the Chamorro seamounts and the start of the Caroline Ridge. Beaked whales occurred over the northern end of the West Mariana Ridge near a few unnamed seamounts; and there were several sightings of delphinids near slopes and seamounts. Pacific Islands Fisheries Science Center small-vessel surveys covered not only nearshore waters, but also deep water as far as 53 km offshore of Saipan and areas near seamounts, where marine mammals were also found. For example, pantropical spotted dolphins were recorded near Malakis Reef (i.e., Ruby Seamount).

Baleen whales were sighted in both nearshore and offshore waters of the Marianas. Humpback whales and one blue whale were sighted closer to shore than sightings of Bryde's and sei whales. As noted by Fulling et al. (2011), the occurrence of the sei whale was the first confirmation of the species this far south in the Pacific. Baleen whales were never visually detected during the PIFSC small-vessel surveys, although some nearshore sightings (in particular, of the humpback whale) are available from the incidental sightings database. Humpback whales in the incidental sightings database were recorded during January through March off FDM and Saipan. As part of the MISTCS cruise, a focal study of humpback whales was conducted 15 km off the northeast coast of Saipan. Humpback whale distribution in MIRC is similar to other locales during the breeding season, where individuals are typically found in insular shelf waters, but can also be found in deeper waters.

Section 4 Discussion

Sighting distributions presented in this report are generated by survey efforts that may be unevenly distributed due to variation in survey goals and design. As such, only limited assessments can be made about animal abundance and habitat use from this information. Interpretation of compiled data is therefore challenging, since results cannot be easily compared across different surveys. It should also be noted that some sighting data may be biased by poor sea state conditions, and mismatches between species' seasonal occurrences and spatial and temporal patterns of naval monitoring efforts. There are also differing degrees of experience for people reporting sightings that are included in this report. For example, NMFS-approved MMOs experienced in Pacific marine mammal and sea turtle identification were used during MISTCS, NMFS shipboard and small vessel surveys, and HDR-conducted small vessel and shore station surveys, while the incidental sightings database includes data from a diversity of sources that do not include information on experience of the person(s) reporting sightings. Monitoring surveys with similar temporal and spatial effort, and that follow standard line-transect methodology, will most likely yield the most reliable data for marine species abundance and density estimation (e.g., Kaschner et al. 2012).

Visual effort from small-vessels was primarily focused on leeward sides of Guam, Rota, Tinian, and Saipan, since windward areas of these islands typically have high sea states and are difficult to survey from small vessels. The majority of sightings (and effort) from small vessels occurred in waters with depths of <500 m, and within 20 km from shore (**Figure 2**). Large-vessel and aerial survey platforms were able to survey a much larger area, and together covered an area of approximately 585 square km, including portions of the Mariana Trench, over waters almost 11,000 m deep (see **Figure C-1**).

Underwater topography in the MIRC, as elsewhere, likely plays an important role in marine mammal distribution, and sightings of both baleen and toothed whales were associated with underwater features such as the Chamorro Seamounts (Fulling et al. 2011). Overall, the MIRC appears similar to other tropical areas, with mixed-species sightings of toothed whales indicating multi-species associations (Hill et al. 2014a), and cetacean migrations into the area for possible breeding (DoN 2007).

While numerous toothed whales species are well documented in the MIRC (Fulling et al. 2011; Hill et al. 2013 a,b,c; Hill et al. 2014 a,b,c), baleen whale sightings are relatively rare. All of the baleen whale sightings in this data summary occurred either during the MISTCS large-vessel survey or the Valiant Shield aerial survey, or were part of the incidental sightings database, which dates back almost 50 years (see **Figures D-17, D-18 and D-19**). Nearshore, small-vessel surveys appear to be ill-suited to detect baleen whales in the region, and may best be combined with other methods (e.g., PAM) in order to obtain more complete information about cetacean occurrence and distribution. In fact, efforts to combine these methods are already underway (Hill et al. 2014a). Although this marine species sightings summary is useful for determining overall species diversity in the MIRC, the incorporation of PAM, tagging, biopsy, and photo-identification data with these sightings data would provide a more complete picture of marine species habitat use, species distribution, stock structure, and movement patterns in the region.

Section 5 Acknowledgements

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APPENDIX A

List of MIRC Monitoring Efforts

Note: see Literature Cited (Section 6 in the main body of this report) for citations

Year	Survey Dates	Survey Title	Survey Platform	Survey Effort			Contract No.	Source
				Days	Hours	Trackline (km)		
2007	16 January-13 April	Mariana Islands Sea Turtle and Cetacean Survey (MISTCS)	Large vessel	72	666.2 (on)	11,486 (on)	Contract No. N68711-02-D-8043, Task Order 0036. SRS Parsons Joint Venture; Geo-Marine, Inc., Bio-Waves, Inc.	DoN 2007; Fulling et al. 2011
2007	13-17 August	Valiant Shield Aerial Survey (VS 07)	Aerial	5	10.6 (on)	2,188 (on)	Contract No. N62742-07-P-1903	Mobley 2007
2010	20 January-06 February	NMFS-PIFSC, R/V <i>Oscar Elton Sette</i> 10-01	Large Vessel	3 ¹	24 (on) ¹	451 (on) ¹	MOU between U.S. Navy and NMFS	NMFS-PIFSC 2010a; Oleson and Hill 2010
2010	09-18 February (Guam), 22 February-03 March (Saipan-Tinian-Aguijan)	Winter PIFSC Small-Vessel Survey	Small Vessel	16	96.1 (on)	1,265 (on)	MOU between U.S. Navy and NMFS	Oleson and Hill 2010; Ligon et al. 2011; Hill et al. 2013b
2010	20 March-12 April	NMFS-PIFSC, R/V <i>Oscar Elton Sette</i> 10-03	Large Vessel	20 ¹	83 (on) ¹	1,455 (on) ¹	MOU between U.S. Navy and NMFS	NMFS-PIFSC 2010b; Oleson and Hill 2010
2010	19 April-03 May	NMFS-PIFSC, R/V <i>Oscar Elton Sette</i> 10-04	Large Vessel	1 ^{1,2}	8.7 (on) ^{1,2}	1,367 (on) ^{1,2}	MOU between U.S. Navy and NMFS	NMFS-PIFSC 2010c; Oleson and Hill 2010
2011	17-23 February; 01-03 March	Guam Marine Species Monitoring Survey (KB08 Winter Small-Vessel Survey)	Small Vessel	10	71.7	1024.8	HDR, Contract No. N62470-10-D-3011, Task Order KB08	HDR 2011

Year	Survey Dates	Survey Title	Survey Platform	Survey Effort			Contract No.	Source
				Days	Hours	Trackline (km)		
2011	26 August-05 September (Guam); 07-12, 20-29 September (Saipan-Tinian-Aguijan); 14-19 September (Rota)	Summer PIFSC Small-Vessel Survey	Small Vessel	29	200.2 (on)	3,051 (on)	MOU between U.S. Navy and NMFS	Hill et al. 2012, 2013b
2012	15, 19-21 March (Guam); 23-29 March (Saipan)	Guam and Saipan Marine Species Monitoring Survey (KB17 Winter Small-Vessel Survey)	Small Vessel	10	80.3	664	HDR, Contract No. N62470-10-D-3011, Task Order KB17	HDR 2012b
2012	25-28 May, 26 June-03 July (Guam); 7-24 June (Saipan-Tinian-Aguijan); 28 May-04 June (Rota)	Summer PIFSC Small-Vessel Survey	Small Vessel	31	223.2 (on)	3,413 (on)	MOU between U.S. Navy and NMFS	Hill et al. 2013a,b
2013	11-20 May	Shore-Based Survey on Guam	Shore-Based	10	56 (on)	n/a	HDR, Contract No. N62470-10-D-3011, Task Order KB23	Deakos et al. 2014
2013	22 June-1 July (Guam); 4-10 July (Rota); 12-27 July (Saipan-Tinian-Aguijan)	Summer PIFSC Small-Vessel Survey	Small Vessel	30	216.7 (on)	3,208 (on)	MOU between U.S. Navy and NMFS	Hill et al. 2013c
1965-2013	n/a	Incidental MM/ST Sightings	Incidental Sightings	n/a	n/a	n/a	n/a	Uyeyama 2014

Notes: ¹ reflects actual effort within study area, since survey covered larger area that only in part included the study area; ² incomplete data set

Key: km = kilometer(s); MM = marine mammal; MOU = Memorandum of Understanding; n/a = not applicable; NMFS = National Marine Fisheries Service; NOAA = National Oceanic and Atmospheric Administration; PIFSC = Pacific Islands Fisheries Science Center; ST = sea turtle; U.S. = United States

APPENDIX B

Beaufort Sea State Scale

Beaufort Scale	Wind Speed		Descriptive Term	Effects Observed at Sea
	Km/hr	Knots		
0	Less than 1	Less than 1	Calm	Sea surface like a mirror, but not necessarily flat.
1	1 - 5	1 - 3	Light air	Ripples with the appearance of scales are formed, but without foam crests.
2	6 - 11	4 - 6	Light breeze	Small wavelets, still short but more pronounced. Crests do not break. When visibility good, horizon line always very clear.
3	12 - 19	7 - 10	Gentle breeze	Large wavelets. Crests begin to break. Foam of glassy appearance. Perhaps scattered whitecaps.
4	20 - 28	11 - 16	Moderate breeze	Small waves, becoming longer. Fairly frequent whitecaps.
5	29 - 38	17 - 21	Fresh breeze	Moderate waves, taking a more pronounced long form. Many whitecaps are formed. Chance of some spray.
6	39 - 49	22 - 27	Strong breeze	Large waves begin to form. The white foam crests are more extensive everywhere. Probably some spray.
7	50 - 61	28 - 33	Near gale	Sea heaps up and white foam from breaking waves begins to be blown in streaks along the direction of the wind.
8	62 - 74	34 - 40	Gale	Moderately high waves of greater length. Edges of crests begin to break into the spindrift. The foam is blown in well-marked streaks along the direction of the wind.
9	75 - 88	41 - 47	Strong gale	High waves. Dense streaks of foam along the direction of the wind. Crests of waves begin to topple, tumble and roll over. Spray may affect visibility.
10	89 - 102	48 - 55	Storm	Very high waves with long overhanging crests. Dense white streaks of foam. Surface of the sea takes a white appearance. The tumbling of the sea becomes heavy and shock-like. Visibility affected.
11	103 - 117	56 - 63	Violent storm	Exceptionally high waves. Sea completely covered with long white patches of foam. Visibility affected.
12	118 - 133	64 - 71	Hurricane	Air filled with foam and spray. Sea entirely white with foam. Visibility seriously impaired.

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APPENDIX C
Survey Trackline Maps

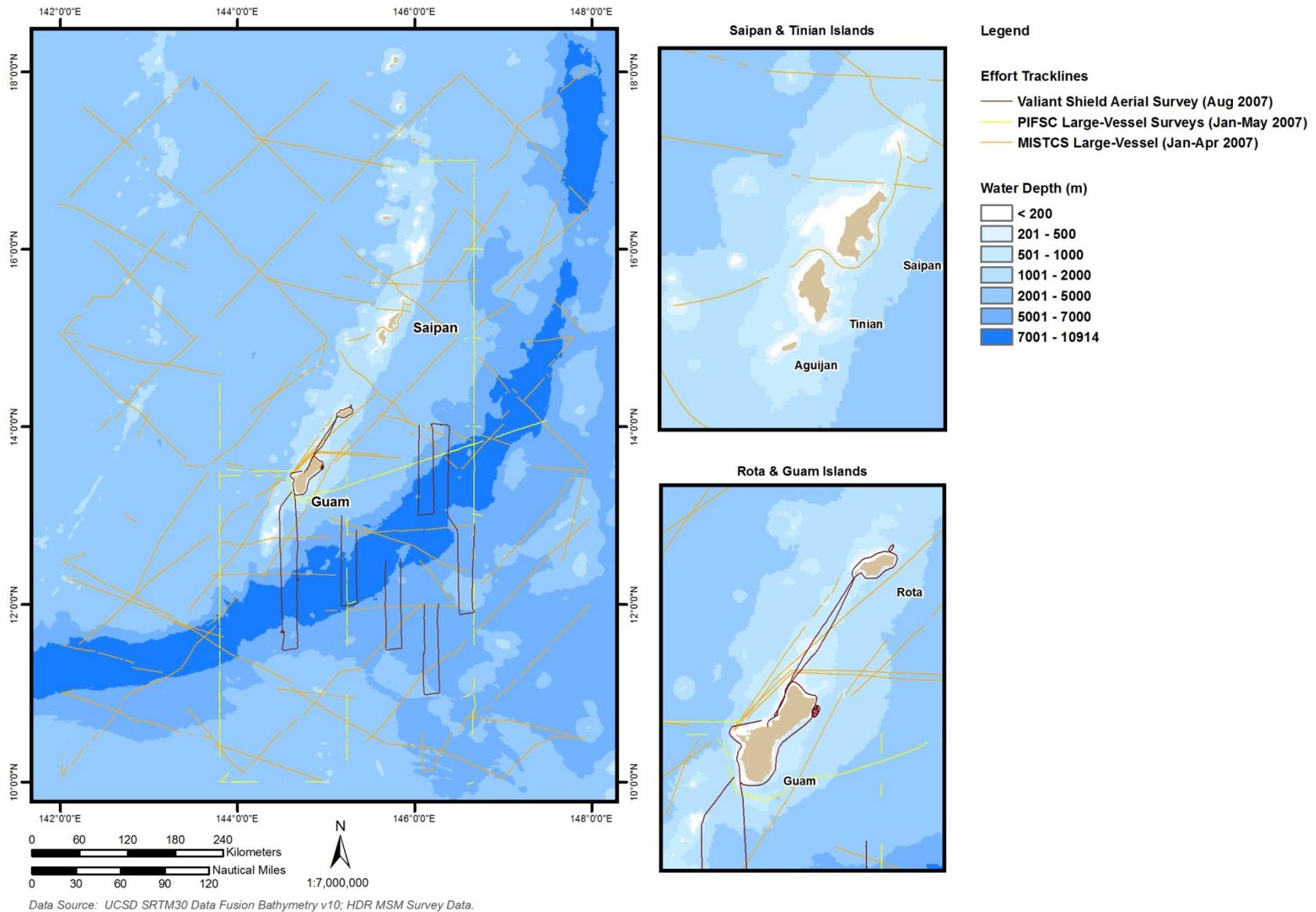


Figure C-1. Large-vessel and aerial survey tracklines.

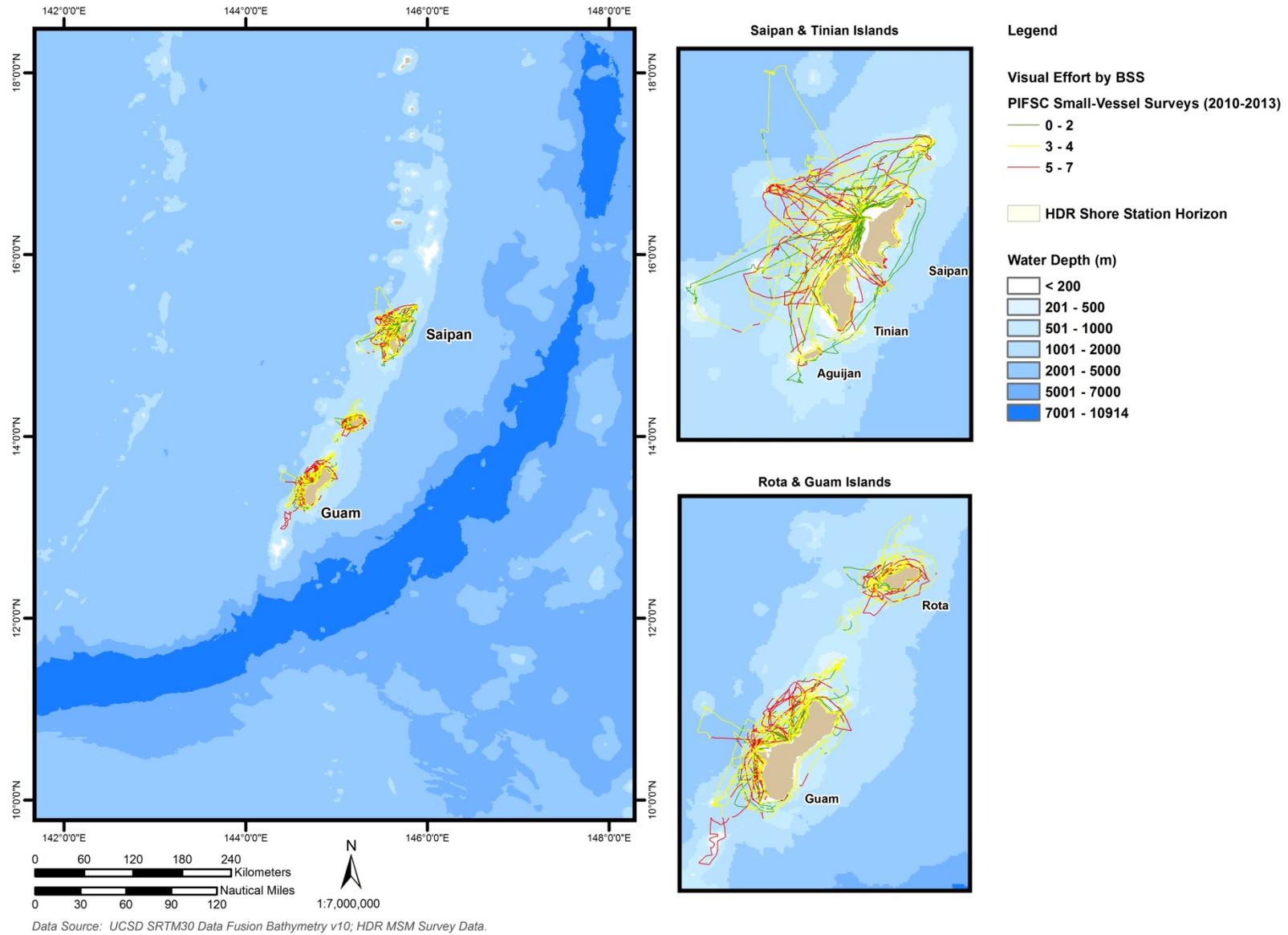


Figure C-2. PIFSC small-vessel survey tracklines.

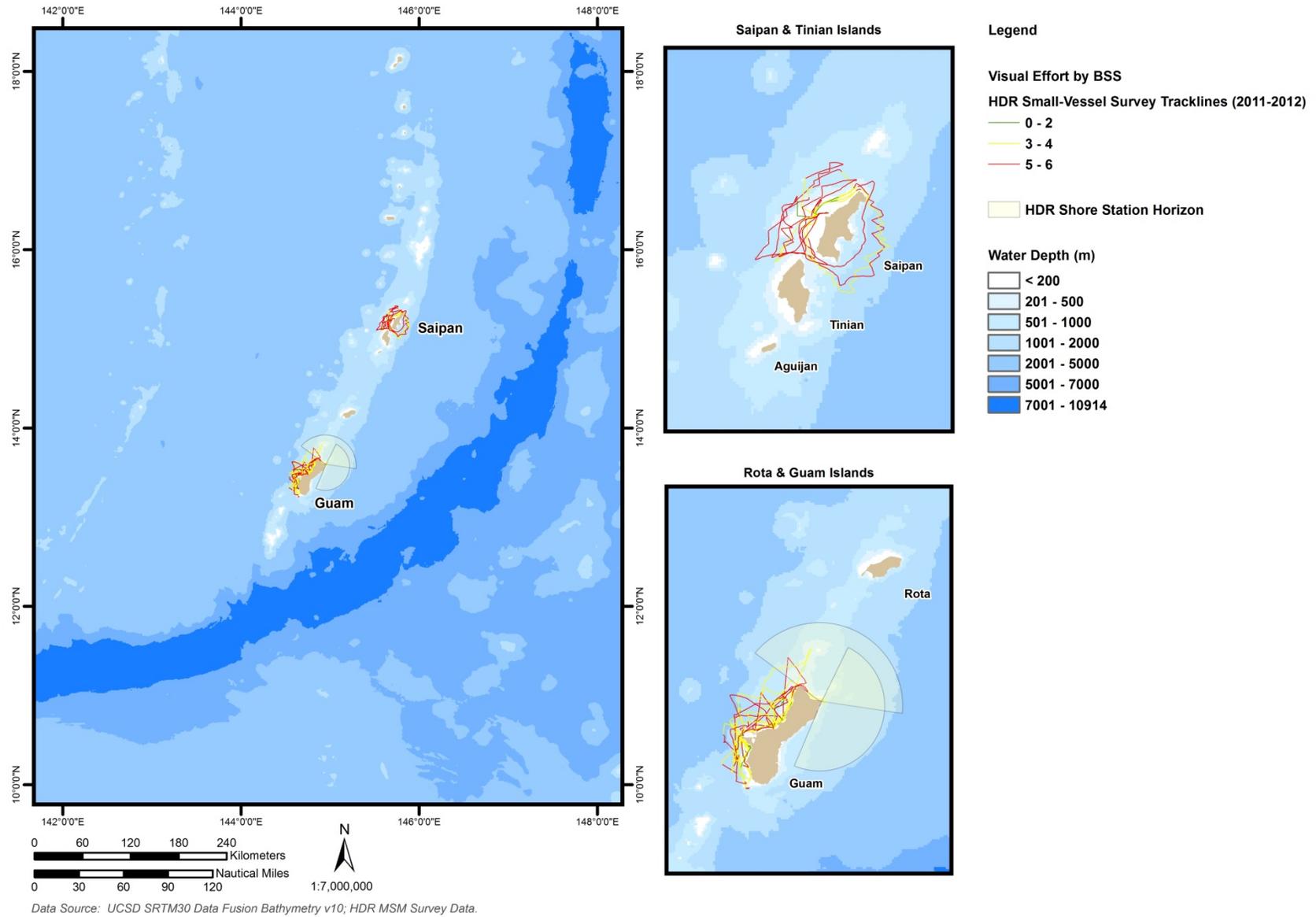


Figure C-3. HDR small-vessel survey tracklines and shore station horizon.

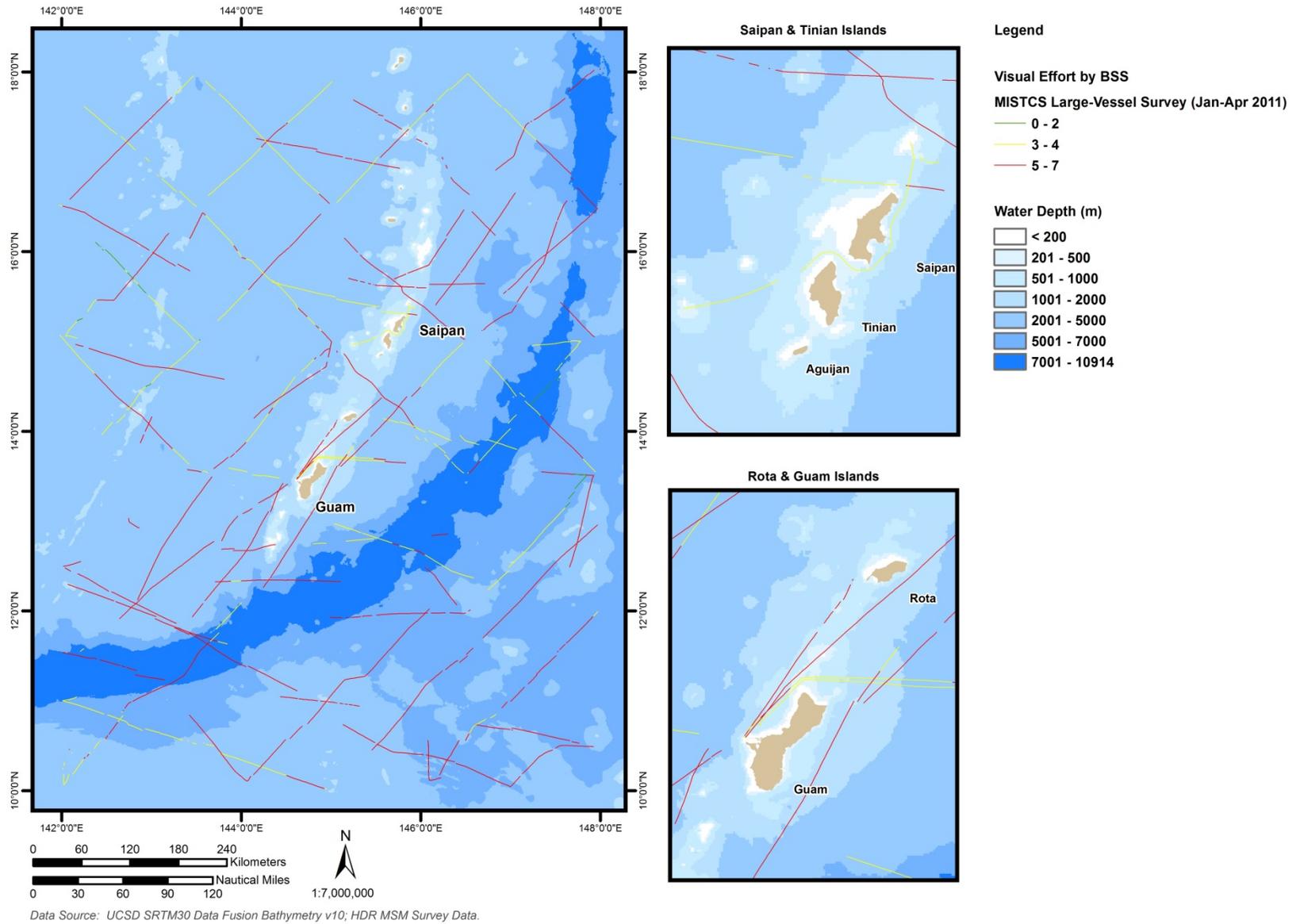


Figure C-4. MISTCS large-vessel survey tracklines.

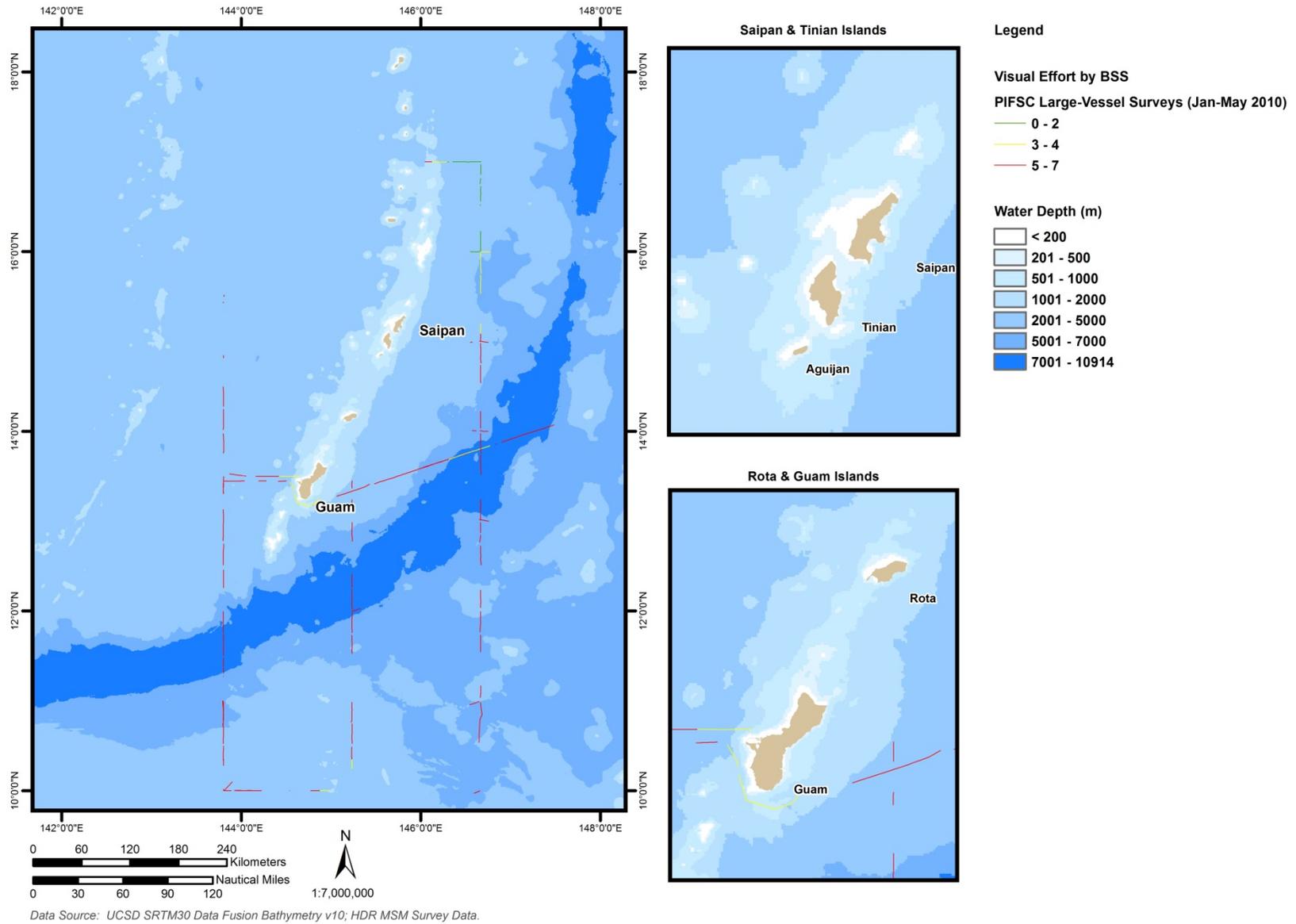


Figure C-5. PIFSC large-vessel survey tracklines.

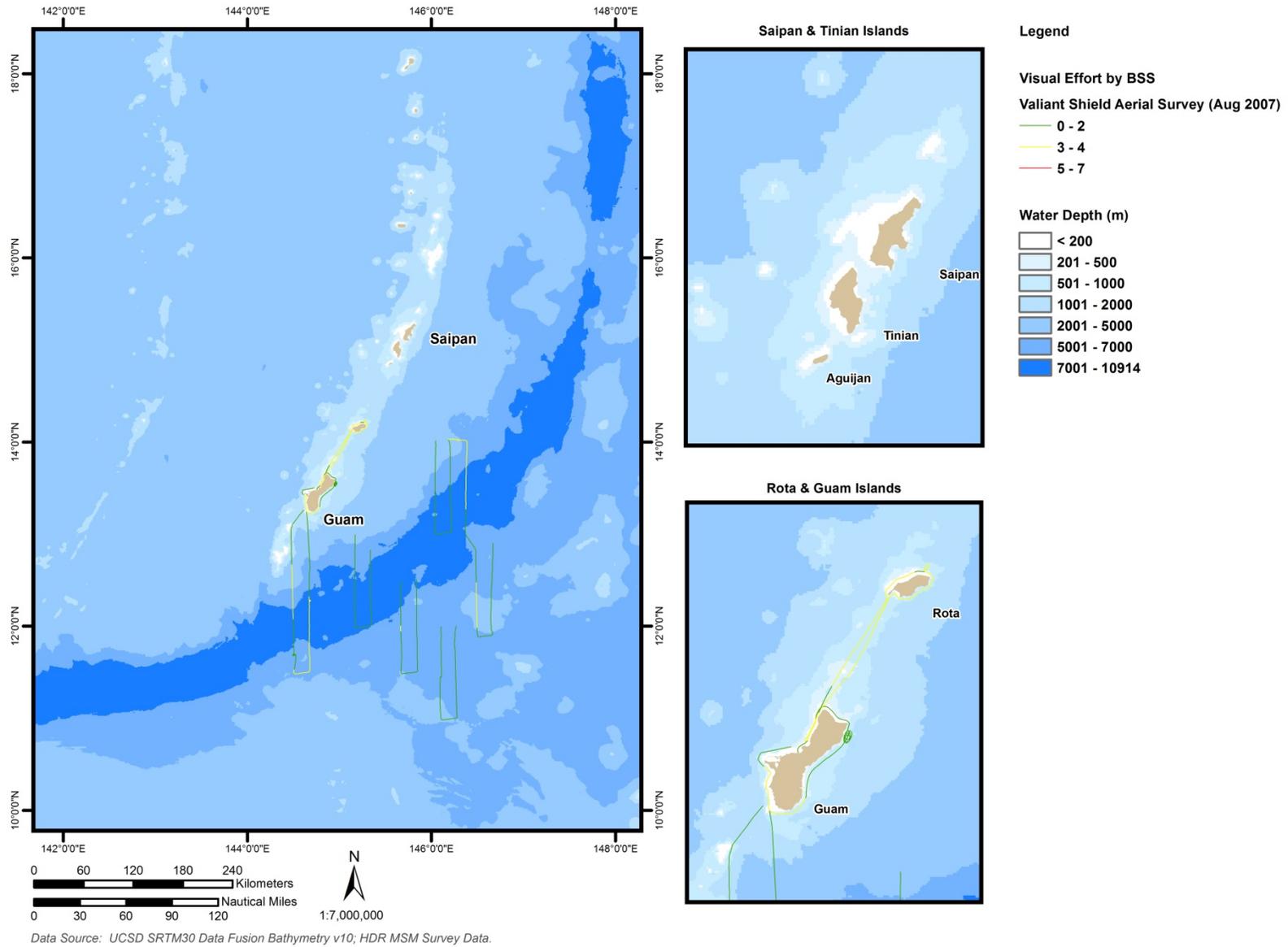


Figure C-6. Valiant Shield aerial survey tracklines.

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APPENDIX D

Species Sightings Maps

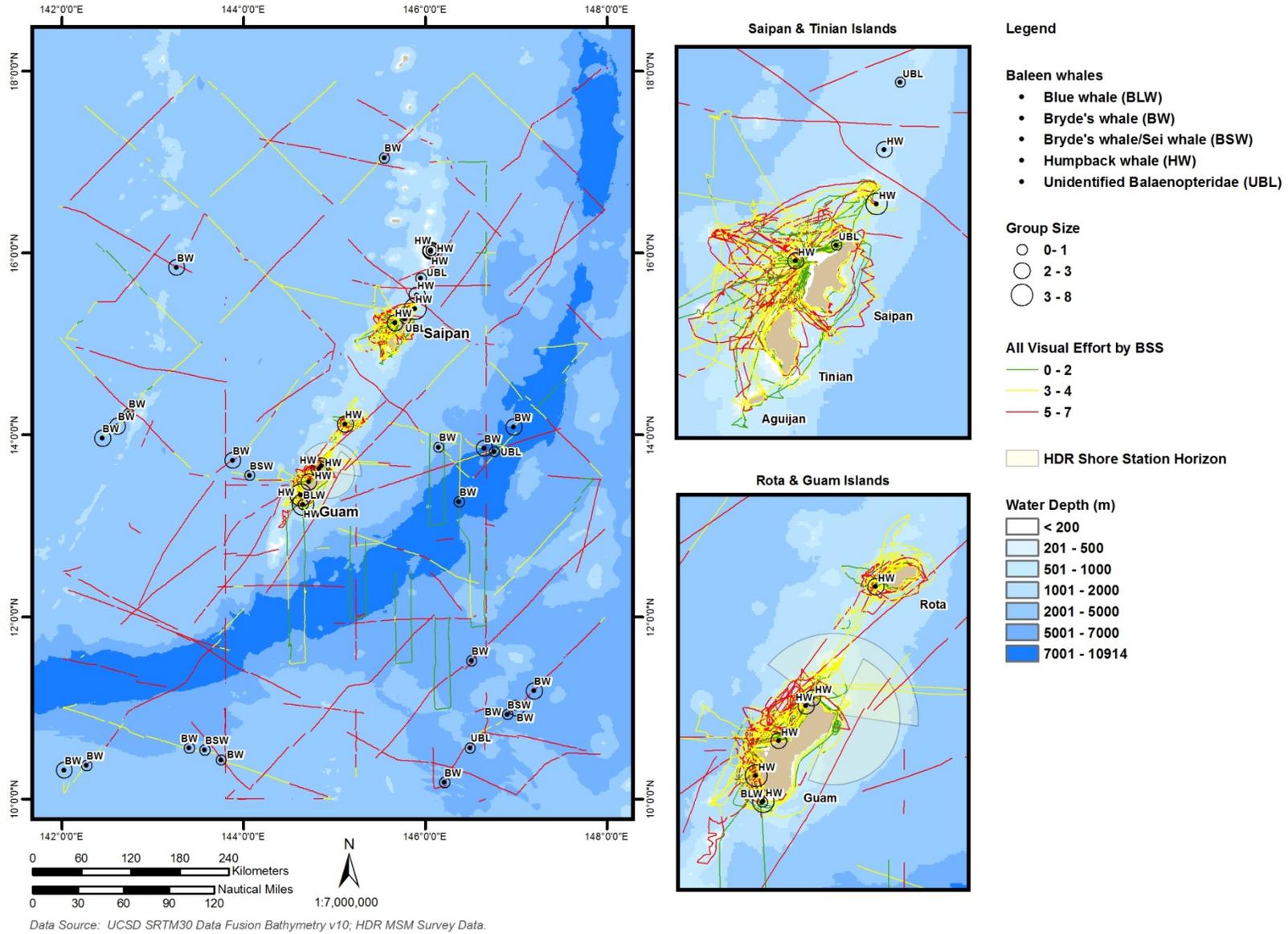


Figure D-1. Baleen whale sightings.

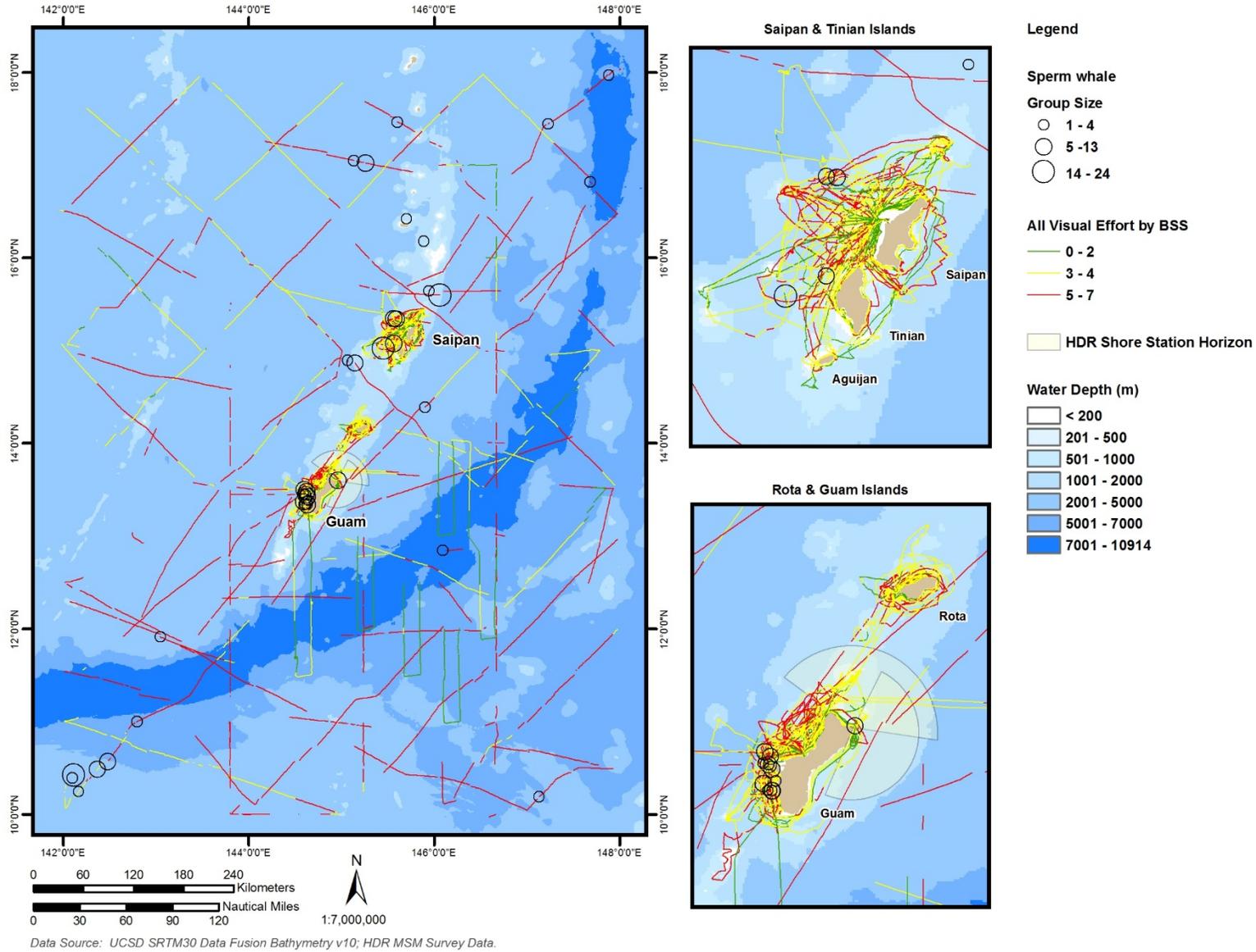


Figure D-2. Sperm whale (*Physeter macrocephalus*) sightings.

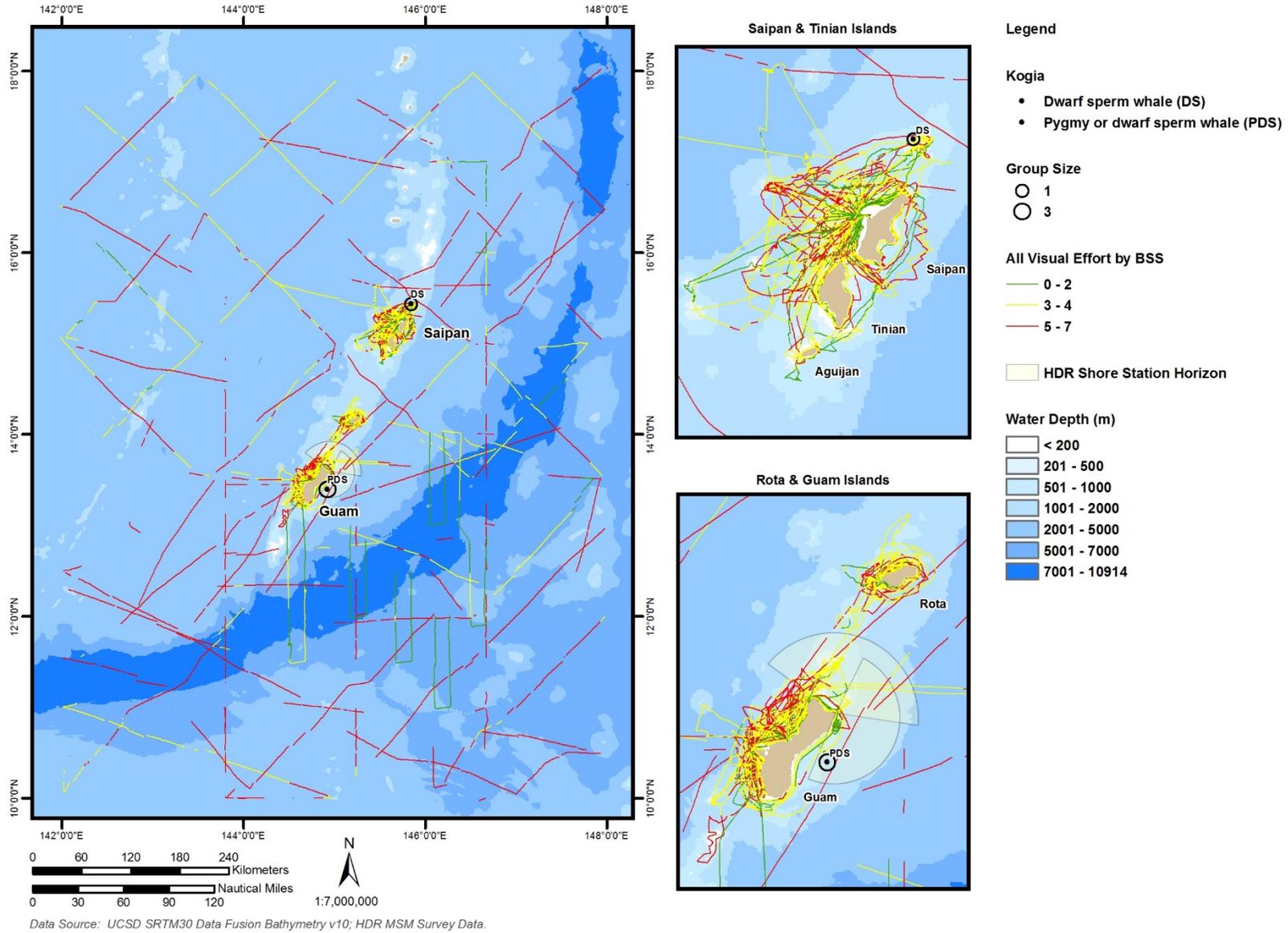


Figure D-3. *Kogia* sightings.

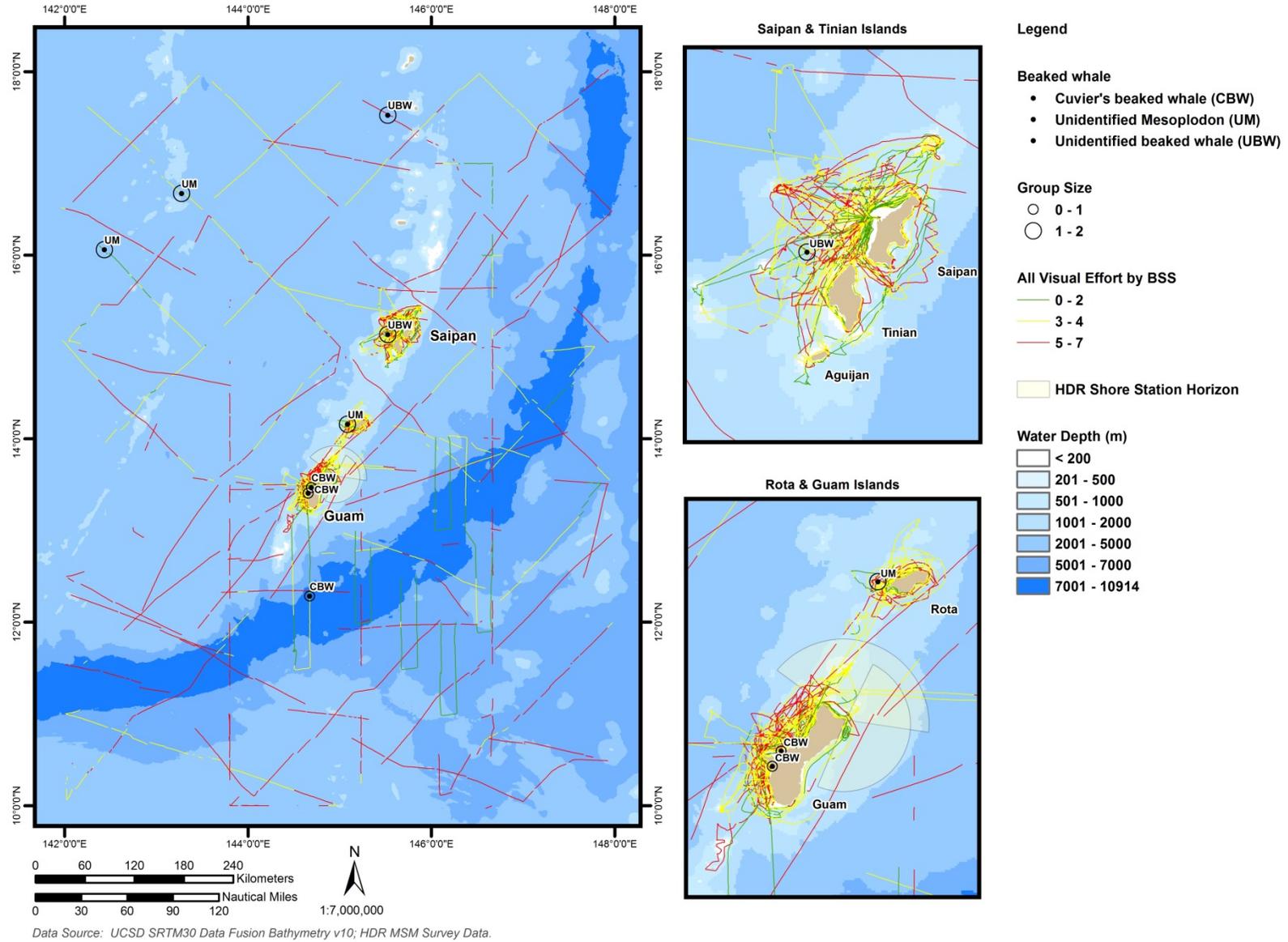


Figure D-4. Beaked whale sightings.

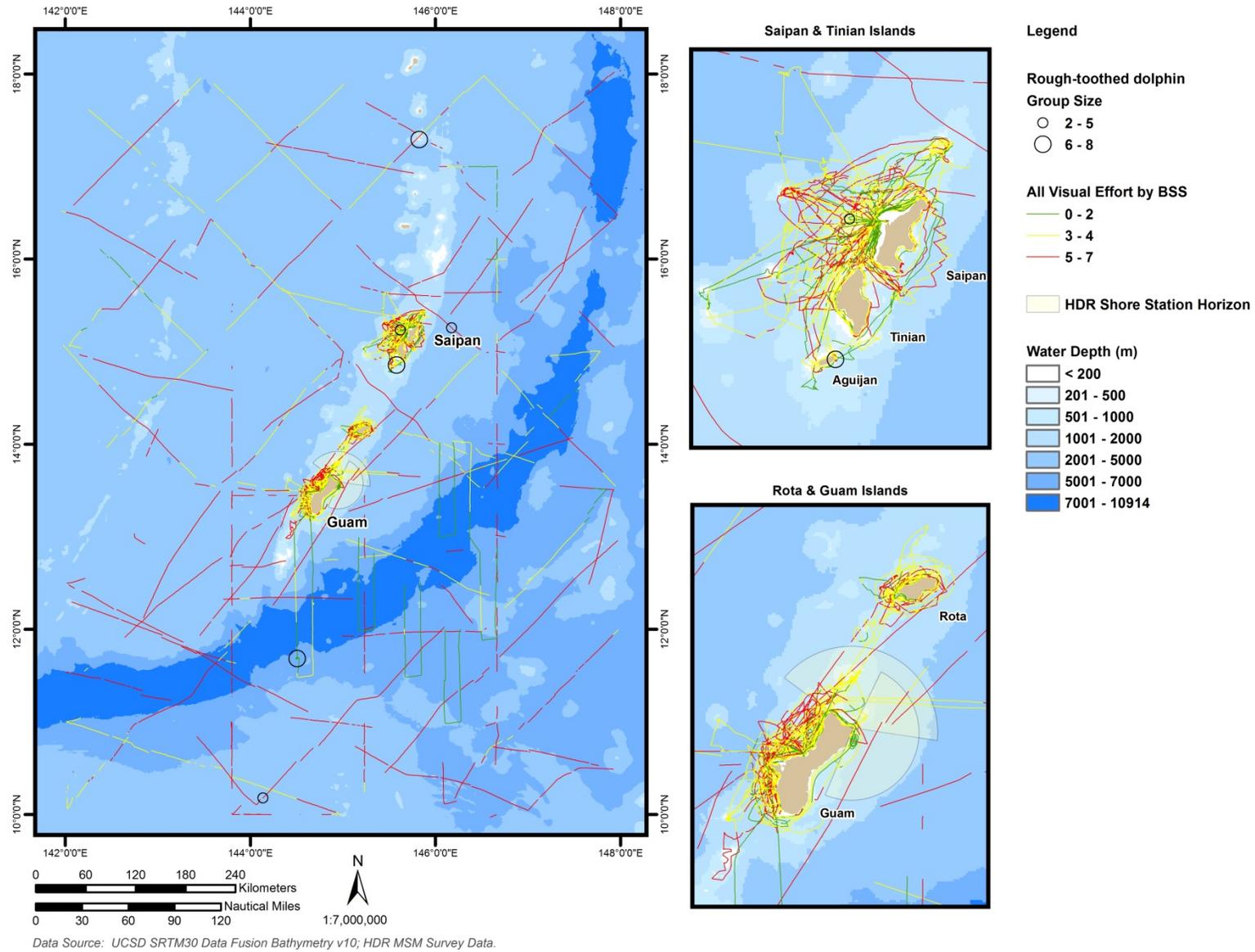


Figure D-5. Rough-toothed dolphin (*Steno bredanensis*) sightings.

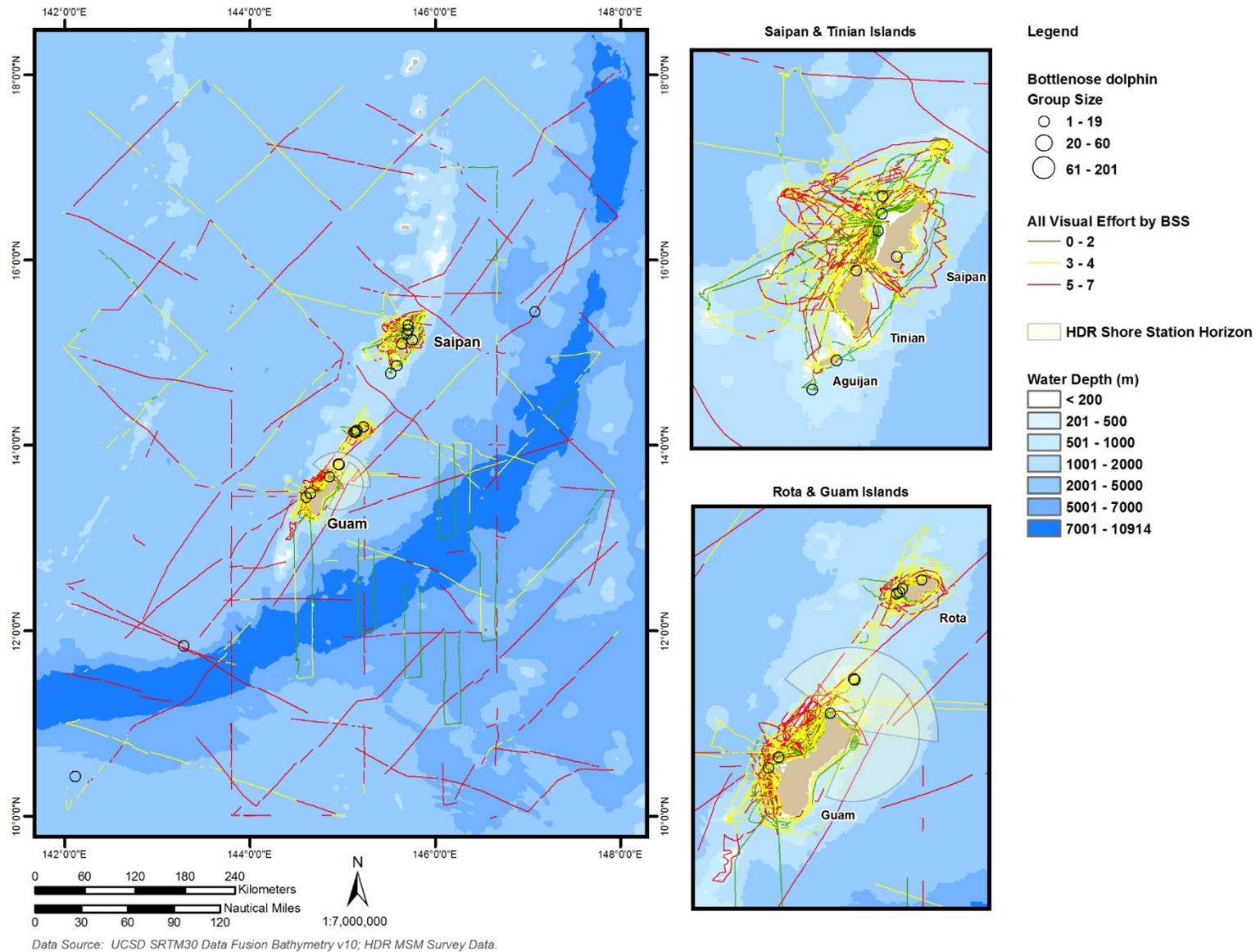


Figure D-6. Bottlenose dolphin (*Tursiops truncatus*) sightings.

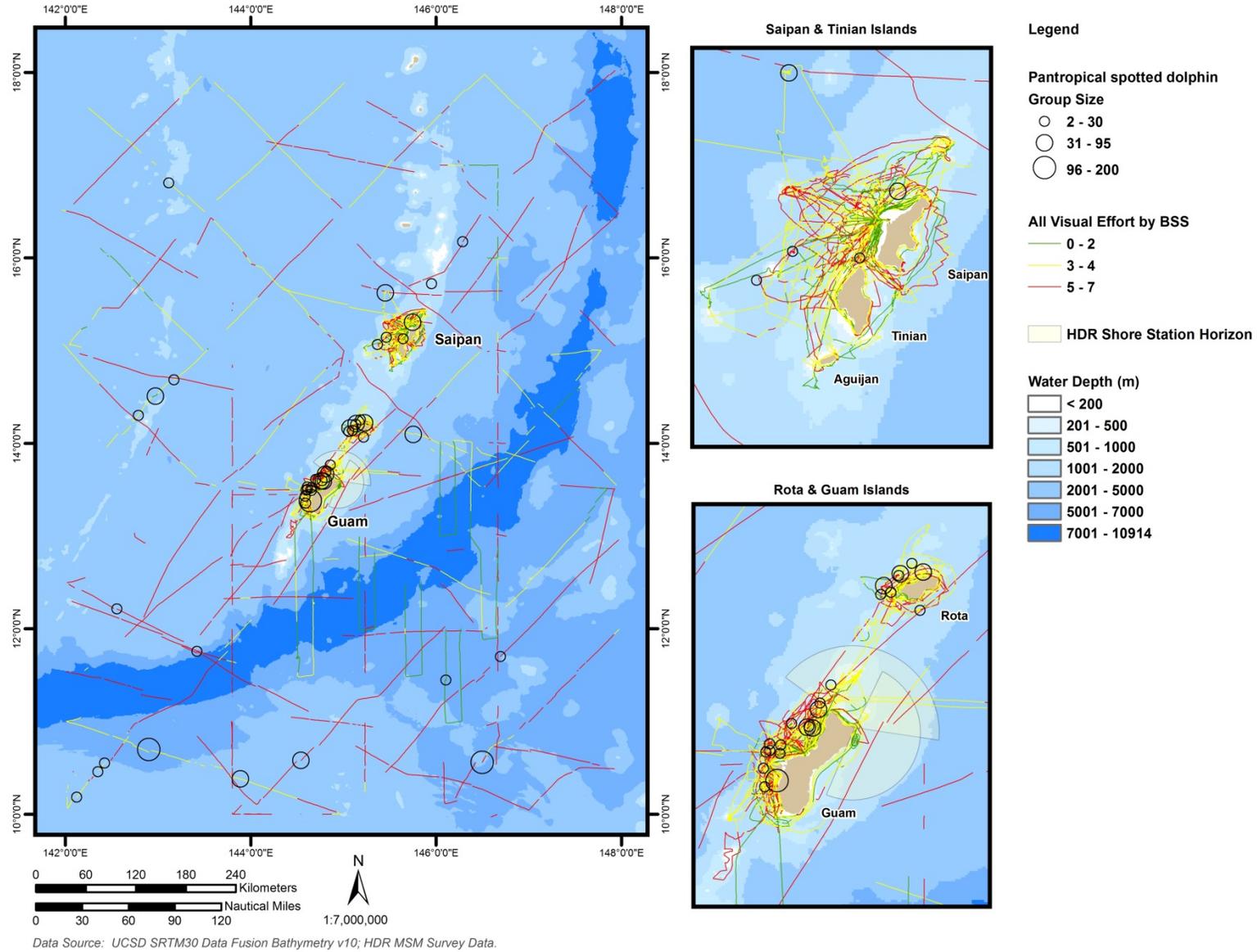


Figure D-7. Pantropical spotted dolphin (*Stenella attenuata*) sightings.

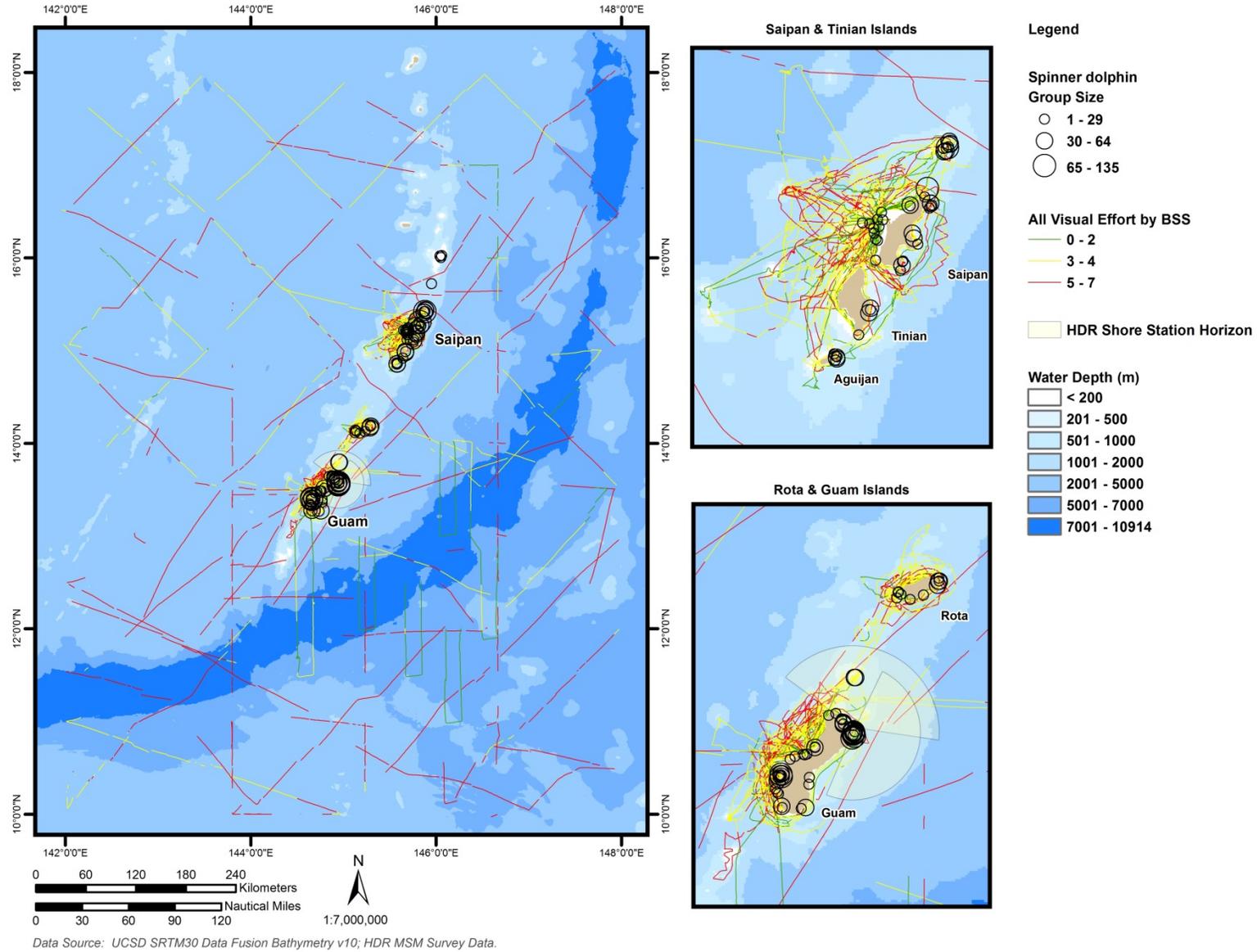


Figure D-8. Spinner dolphin (*Stenella longirostris*) sightings.

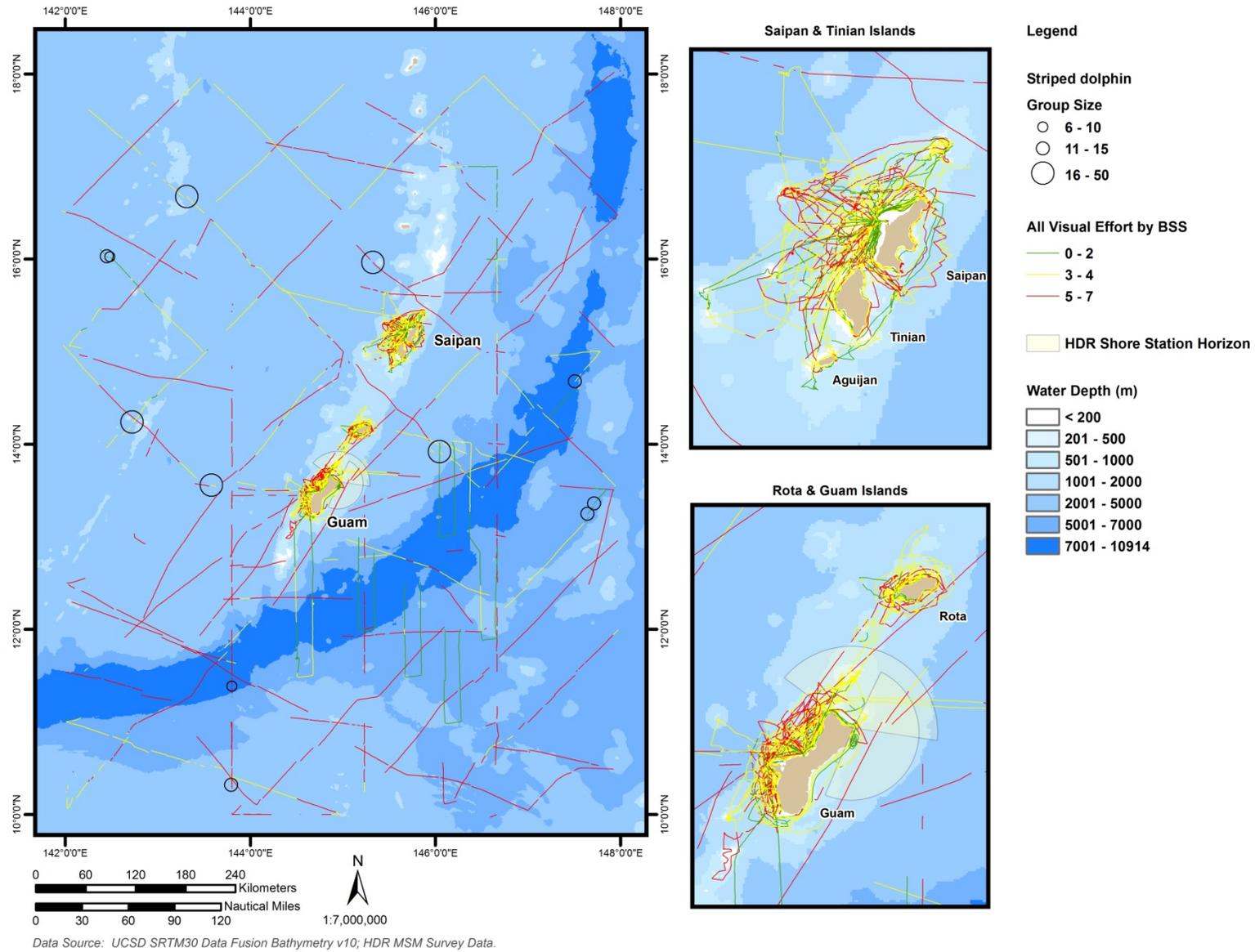


Figure D-9. Striped dolphin (*Stenella coeruleoalba*) sightings.

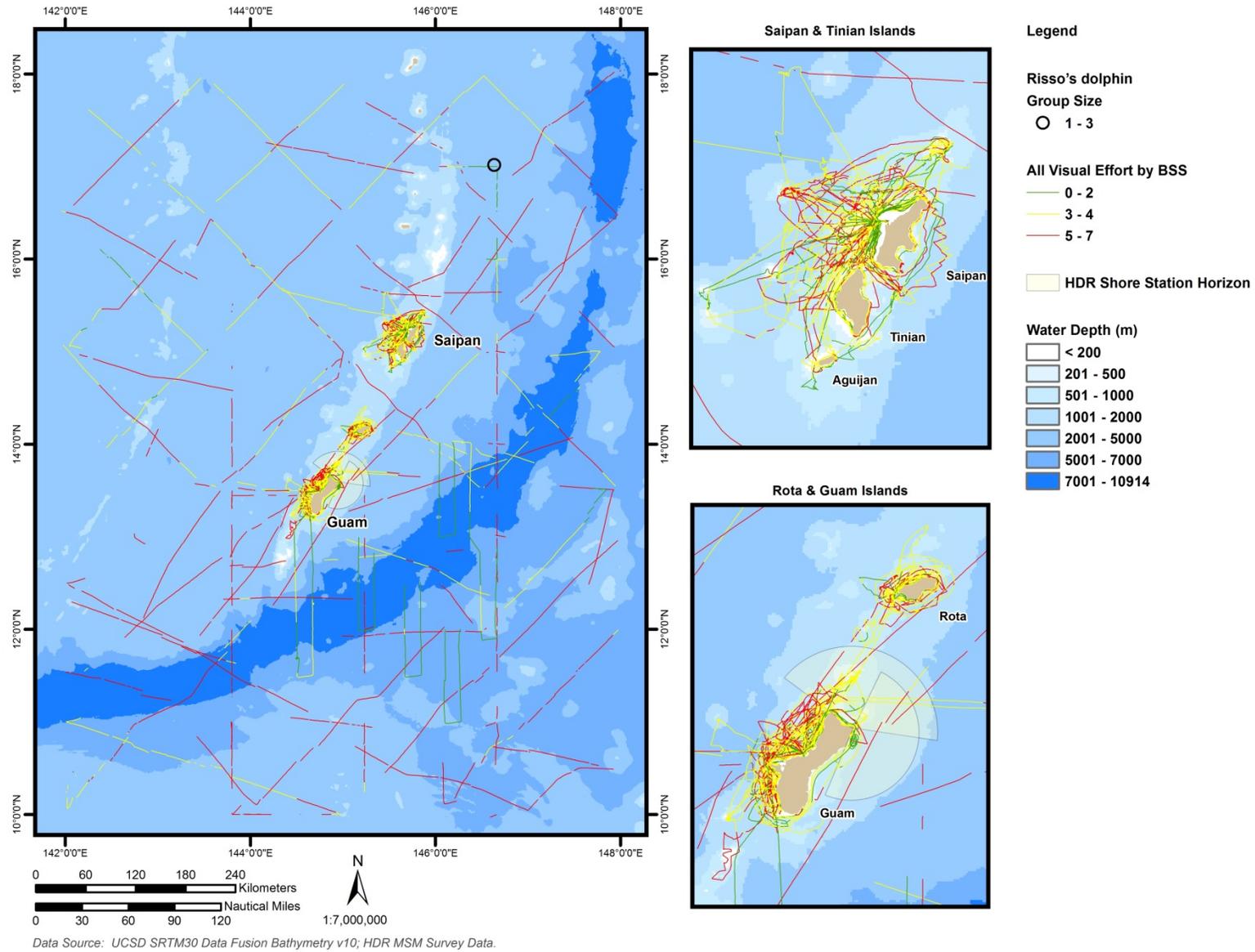


Figure D-10. Risso's dolphin (*Grampus griseus*) sightings.

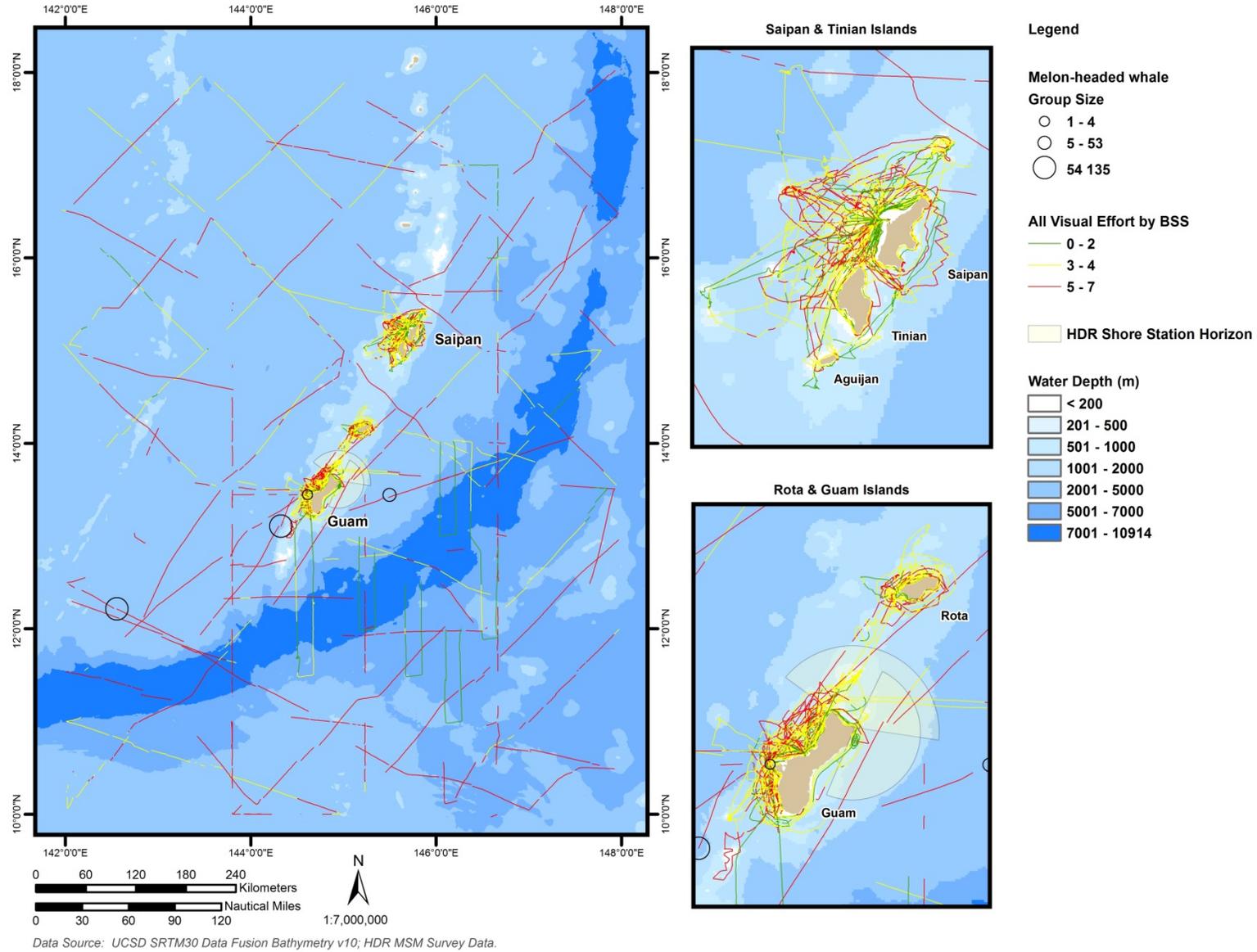


Figure D-11. Melon-headed whale (*Peponocephala electra*) sightings.

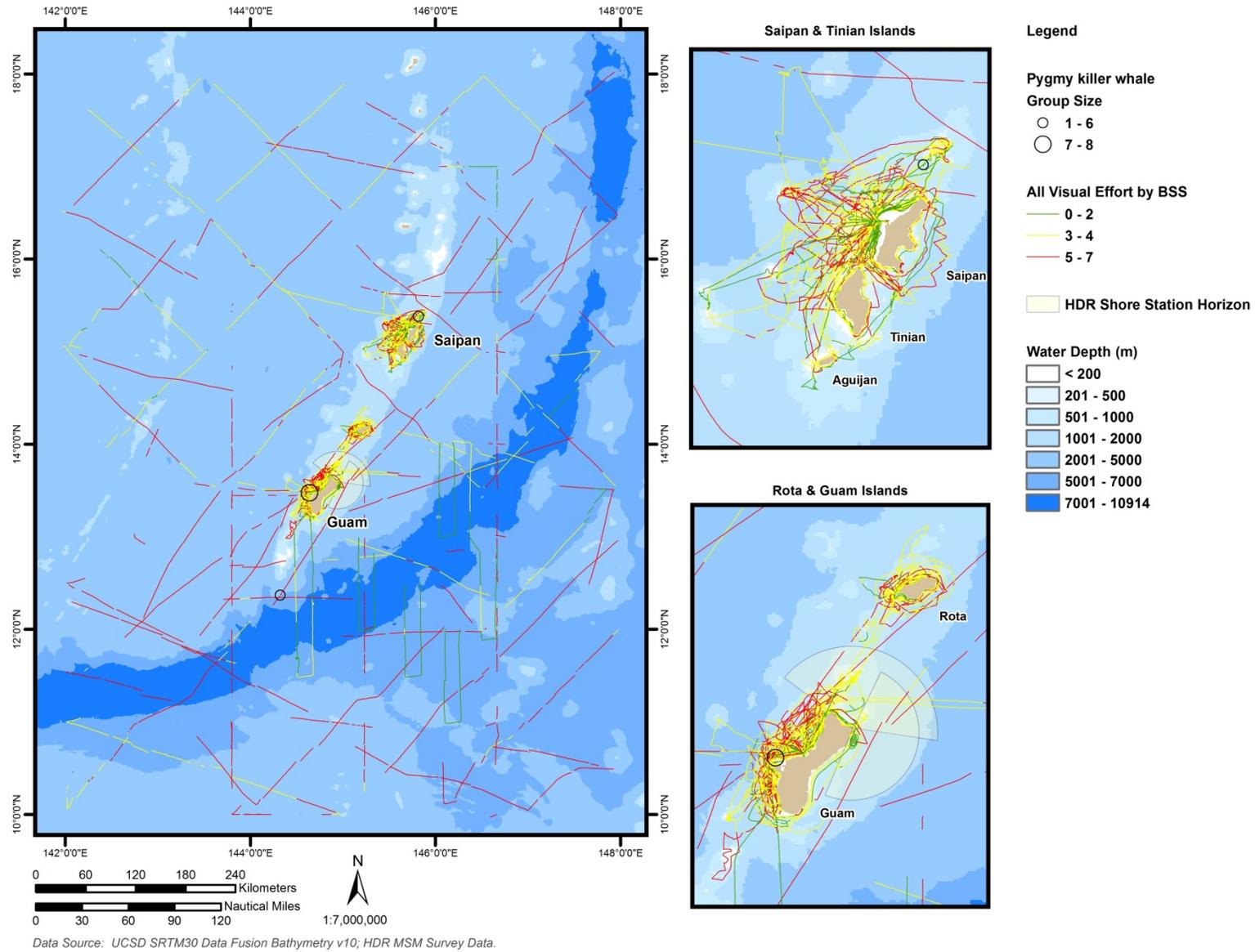


Figure D-12. Pygmy killer whale (*Feresa attenuata*) sightings.

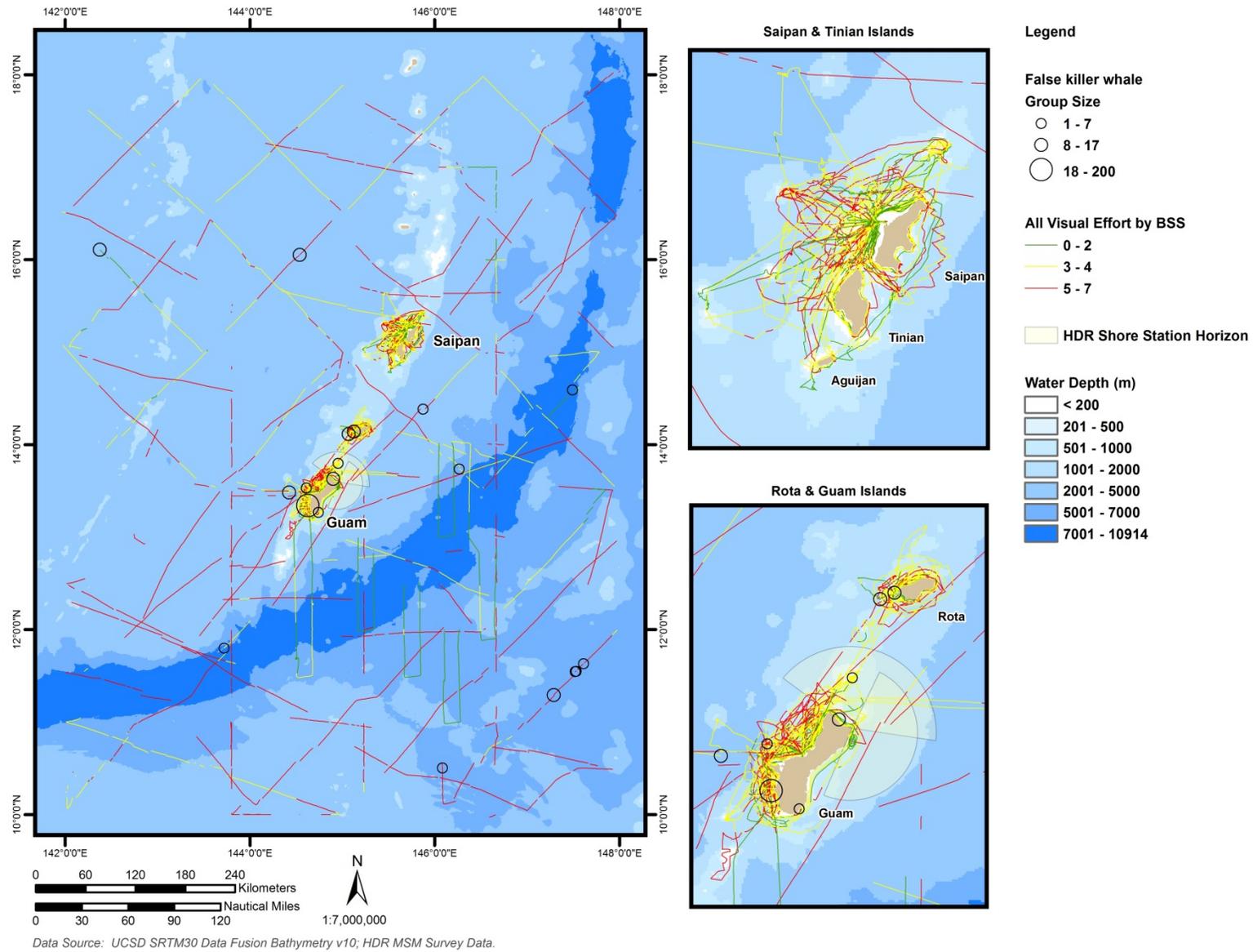


Figure D-13. False killer whale (*Pseudorca crassidens*) sightings.

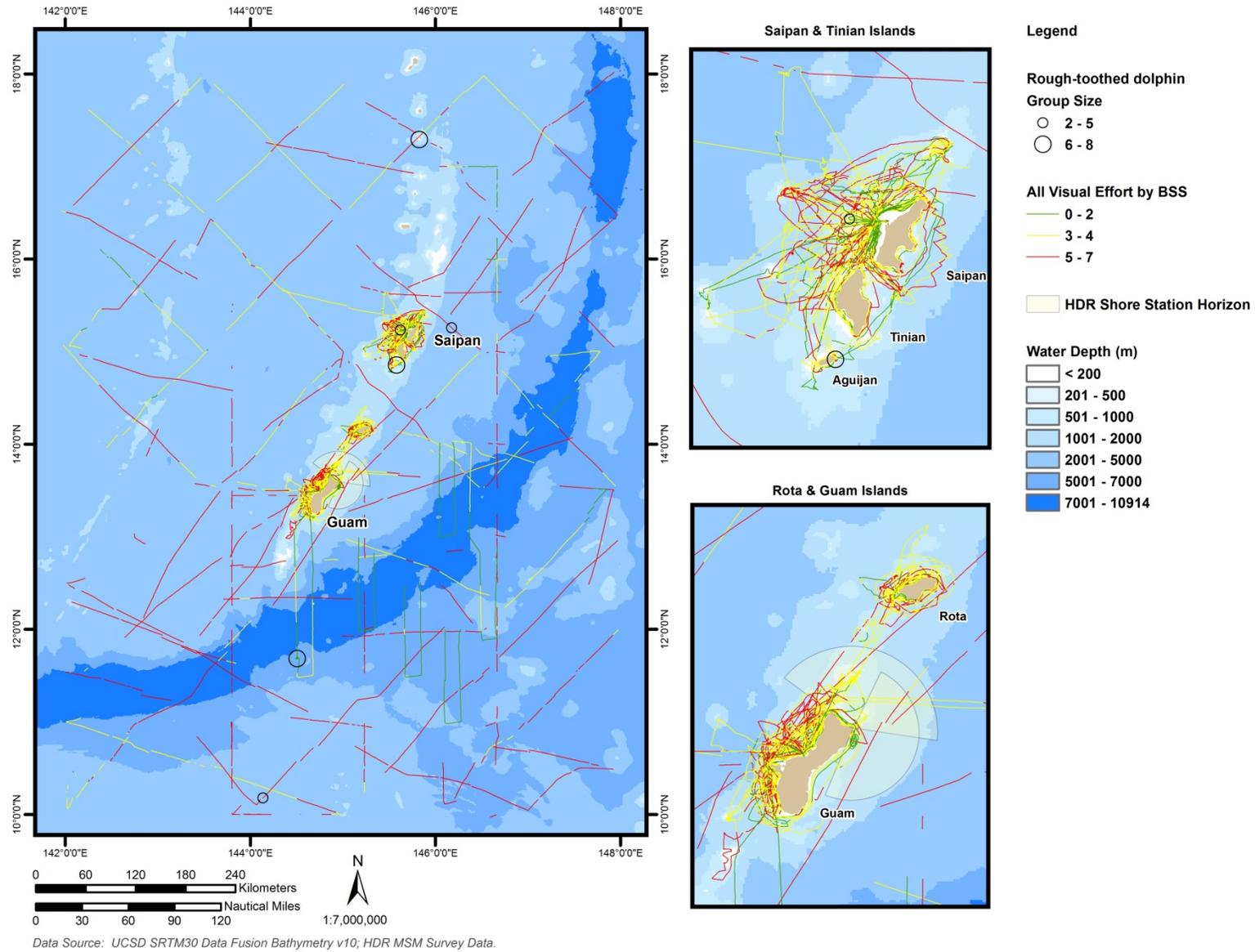


Figure D-14. Killer whale (*Orcinus orca*) sightings.

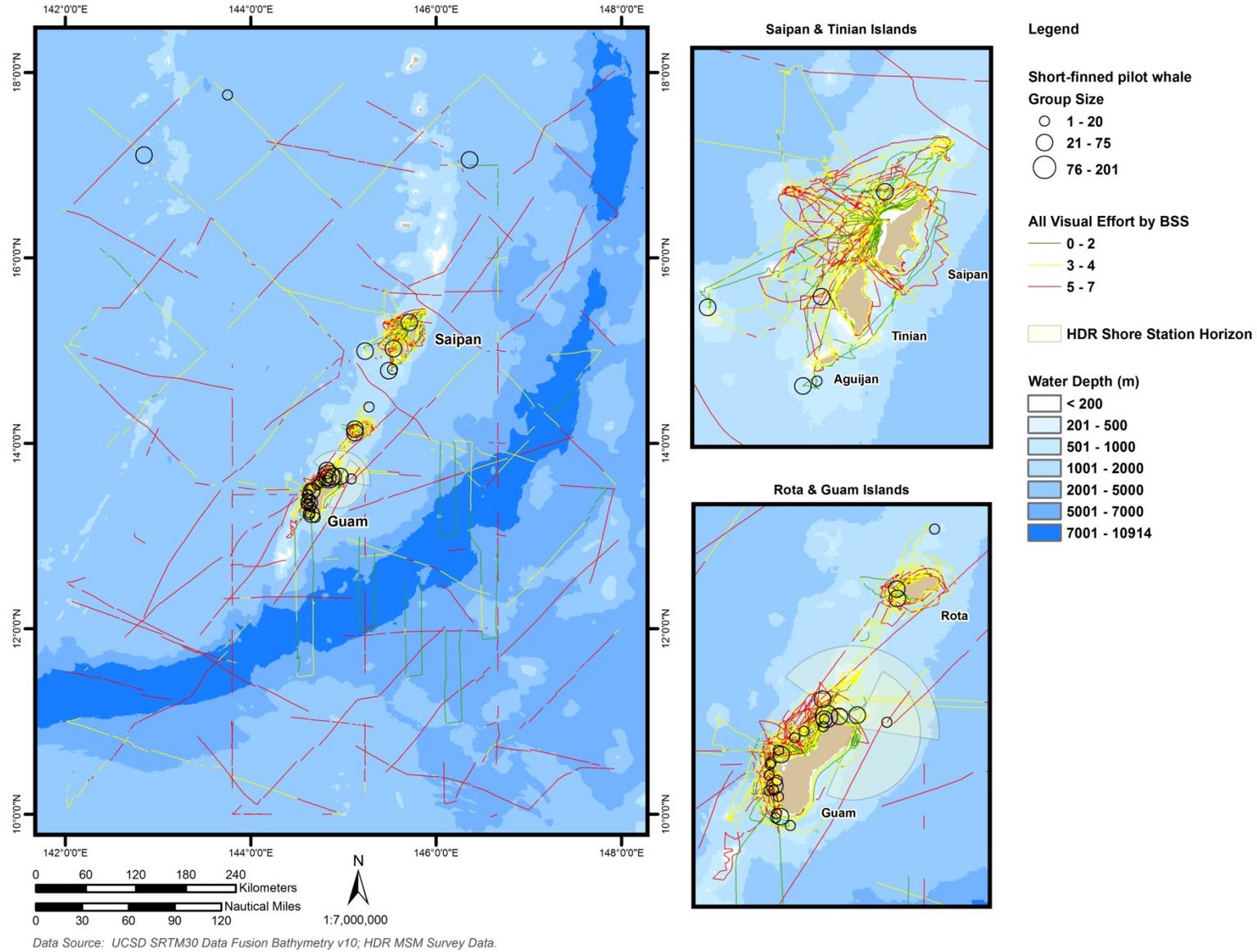


Figure D-15. Short-finned pilot whale (*Globicephala macrorhynchus*) sightings.

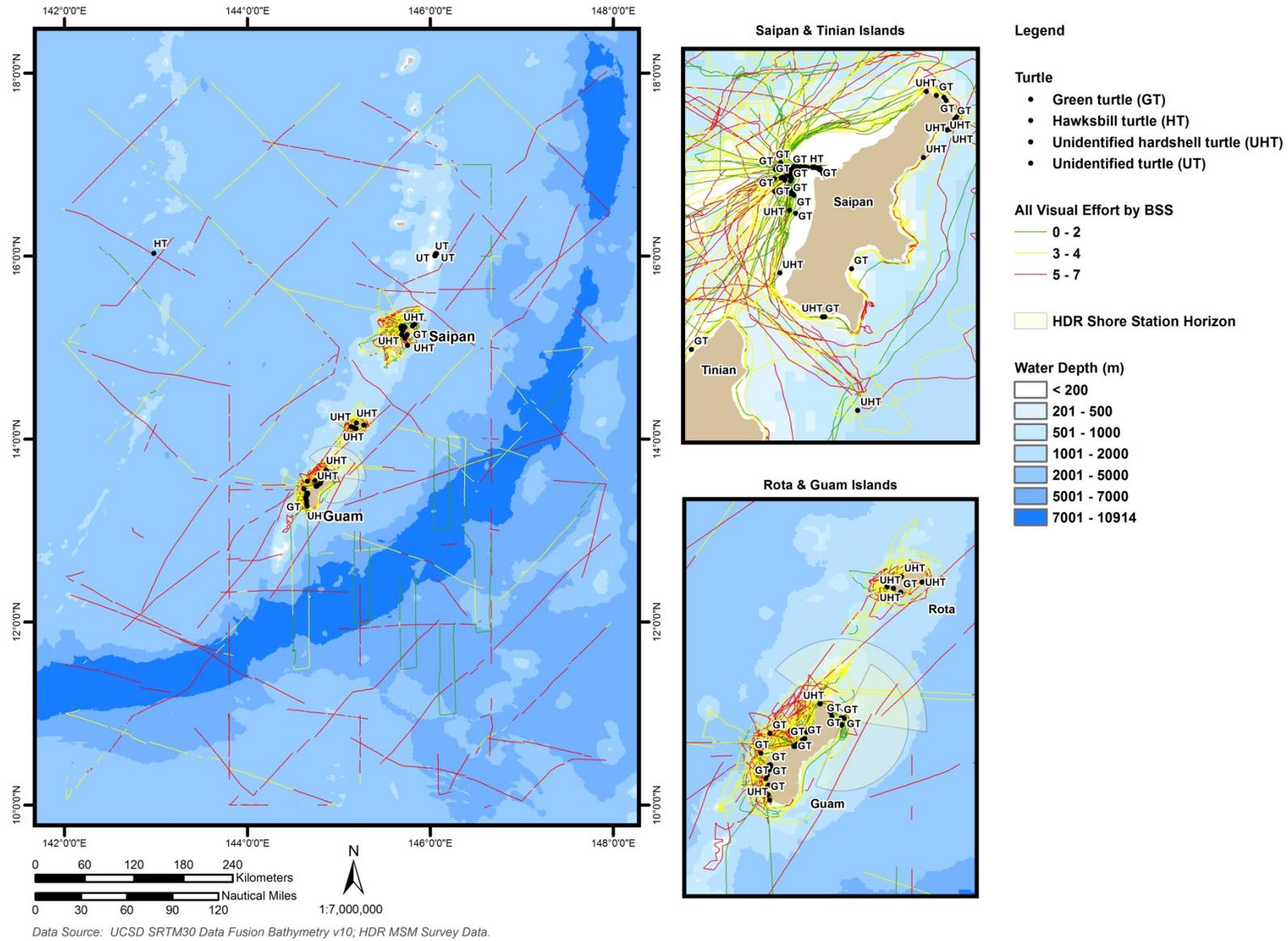


Figure D-16. Sea turtle sightings.

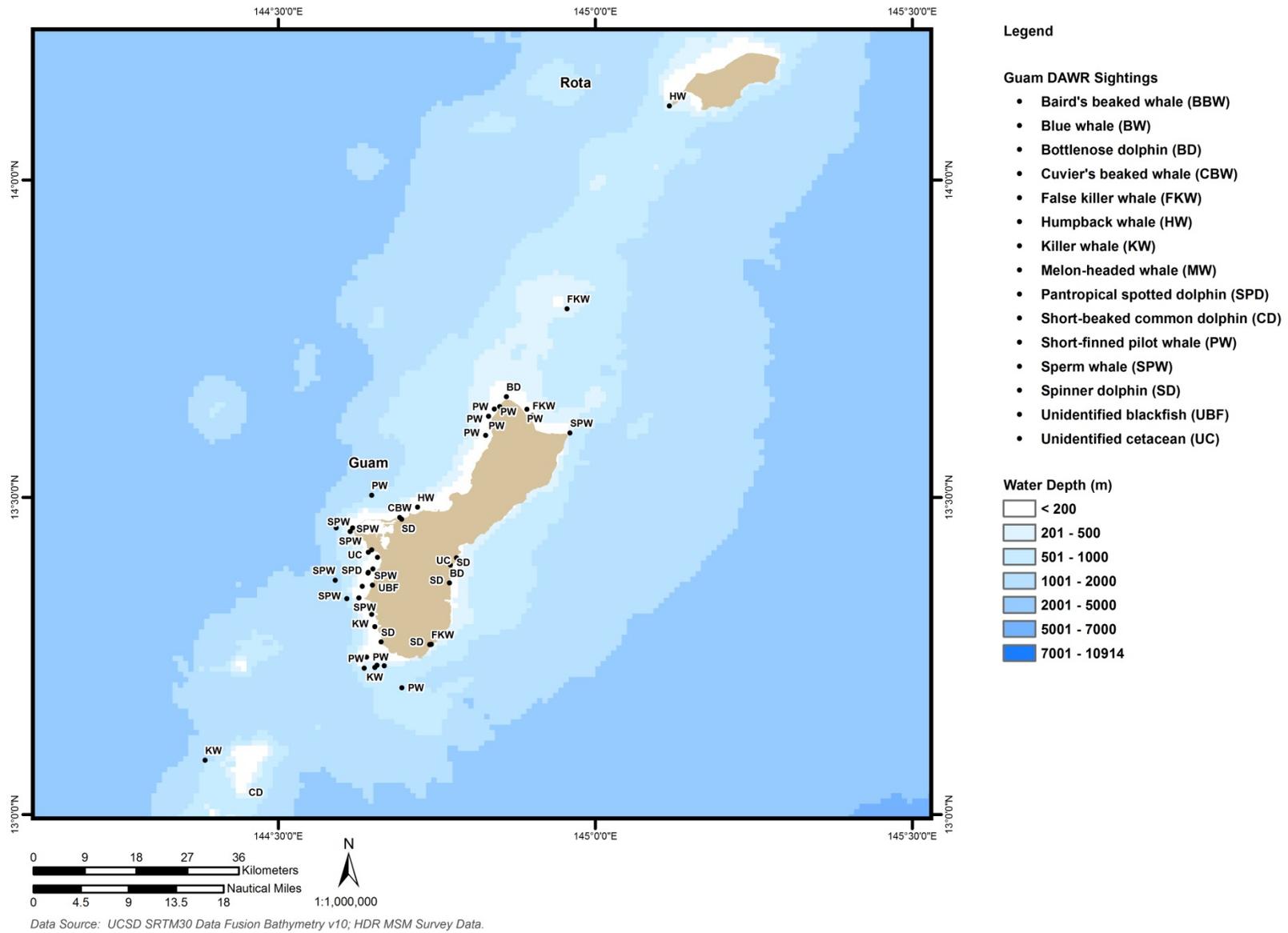


Figure D-17. Guam DAWR sightings.

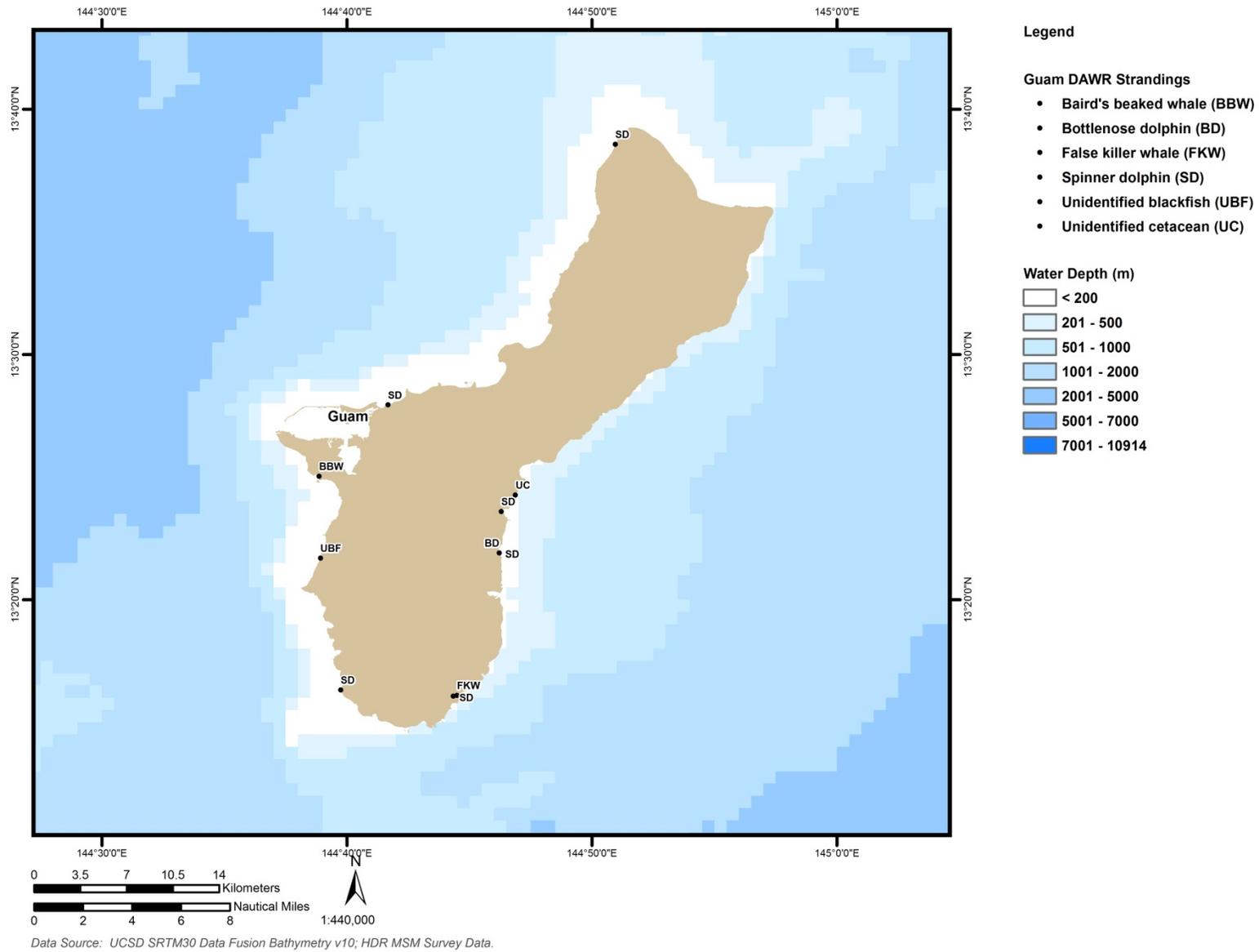


Figure D-18. Guam DAWR strandings.

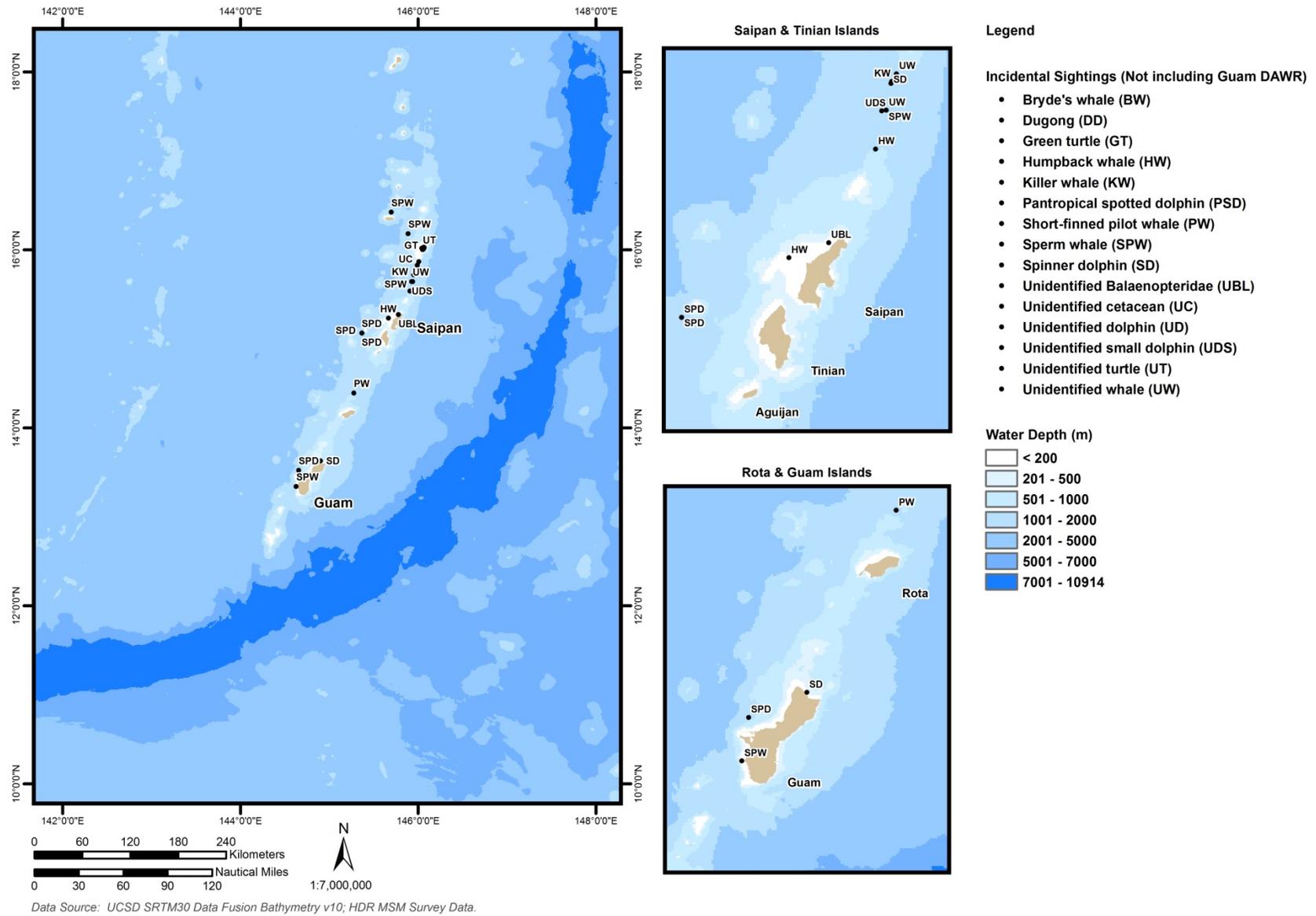


Figure D-19. Incidental sightings, not including Guam DAWR.

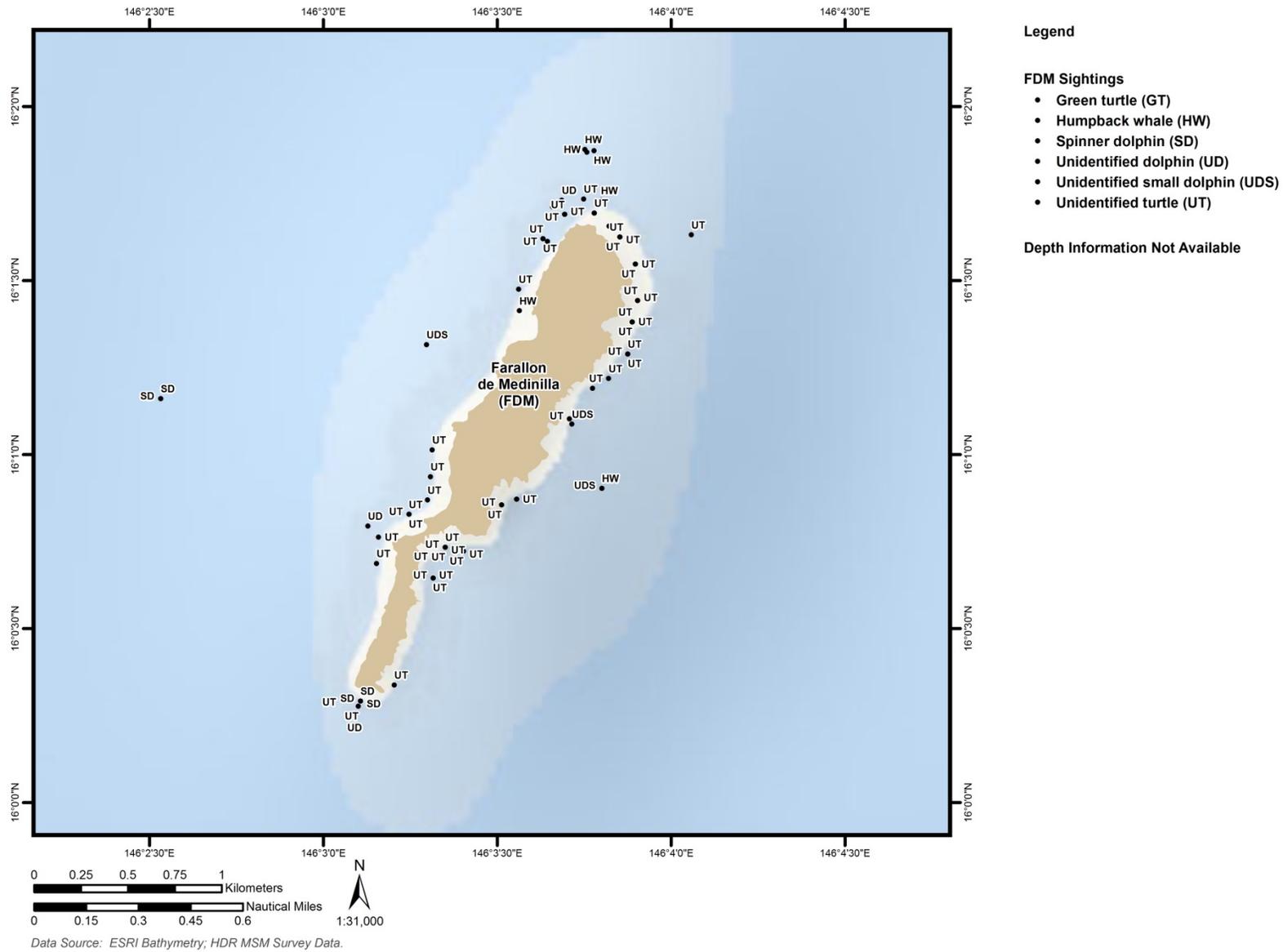


Figure D-20. Sightings at FDM.

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