Comprehensive
Exercise and Marine Species Monitoring Report

For the U.S. Navy's
Mariana Islands Range Complex
31 October 2014

THIS PAGE INTENTIONALLY LEFT BLANK

In Support Of
Letter of Authorization
Under The Marine Mammal Protection Act
For Incidental Harassment of Marine Mammals Resulting From
U.S. Navy Training and Testing Activities
In The Mariana Islands Range Complex

Comprehensive Exercise and Marine Species Monitoring Report For the U.S. Navy's Mariana Islands Range Complex

Prepared in Accordance With
50.C.F.R. §218.105(g)

Submitted By
Department of the Navy
Commander, United States Pacific Fleet
250 Makalapa Drive
Pearl Harbor, Hawaii 96860-3131

Submitted To
National Marine Fisheries Service
Office of Protected Resources
1315 East-West Highway
Silver Springs, Maryland 20910-3226

31 October 2014

Citation for this report is as follows:
Department of the Navy. 2014. Comprehensive Exercise and Marine Species Monitoring Report for The U.S. Navy's Mariana Islands Range Complex. Department of the Navy, Commander, U.S. Pacific Fleet, Pearl Harbor, Hawaii. 31 October 2014.

List of contributors (main document): Morgan W. Richie (Naval Facilities Engineering Command, Pacific), Julie A. Rivers (Commander, U.S. Pacific Fleet), and Robert K. Uyeyama (Naval Facilities Engineering Command, Pacific). Chapter 2: Steven E. Loeffler and Brett C. Boneau (Naval Mine and Anti-Submarine Warfare Command).

Cover photo: Sperm whale (*Physeter macrocephalus*) photographed during a small vessel survey in MIRC, 18 March 2012. Photo by Suzanne Yin taken under National Marine Fisheries Service permit 14451.

EXECUTIVE SUMMARY

This report summarizes the Commander, United States Pacific Fleet marine species monitoring under the Letters of Authorization (LOAs) received for at-sea training in the Mariana Islands Range Complex (MIRC) (NMFS 2010b; NMFS 2011; NMFS 2012). The period covered in detail by this report is from January 2010 to July 2014 and is based on annual monitoring and exercise reports submitted previously to the National Marine Fisheries Service (NMFS) in accordance with 50 Code of Federal Regulations (C.F.R.) §218.105(d) and 50 C.F.R. §218.105(f). This document is a comprehensive report summarizing the results of these reports, prepared in accordance with 50 C.F.R. §218.105(g). Monitoring activities that took place as early as 2007 in support of the Tactical Training Theater Assessment and Planning (TAP), Phase 1 EIS/OEIS for the MIRC are also presented to provide context for the development and implementation of the marine species monitoring program in the MIRC.

Overall, the Navy met or exceeded the monitoring requirements in each year's monitoring plan during the monitoring years summarized in this document, 2010-2014. A monitoring year in MIRC covers a 12-month period from 13 February in one year to 12 February in the following year, except for the first permit-covered yearly report (DoN 2011), which reported on monitoring beginning January 2010 that had been conducted in anticipation of the LOA. Mitigation measures agreed to under the LOA were applied effectively on Navy ships using mid-frequency active sonar (MFAS); there were 4 total mitigation events where active sonar was powered down or shut down due to the sighting of marine mammals or sea turtles during MTEs from 12 August 2010 to 15 July 2014. In addition, throughout the period covered by this report, existing data sets not collected during monitoring efforts have been analyzed when the anticipated results were likely to provide information which was relevant to Navy monitoring, such as acoustic recordings (towed array and moored devices) and genetic samples. Methodologies are continuing to evolve through lessons learned, Adaptive Management Review (AMR) with National Marine and Fisheries Service (NMFS), and input from the scientific community. In many cases, monitoring projects will continue into the future as analysis is ongoing and field efforts planned.

To make the progression of monitoring methods in MIRC easier to visualize and understand, a detailed timeline of monitoring events and administrative events is included in this report. Events are laid out in a graphical manner, and a corresponding table describing the events accompanies the graphical monitoring timeline.

MIRC, unlike other range complexes, is a region where only limited data from systematic surveys for marine mammals and sea turtles exists. Therefore during development of the first MIRC monitoring plan (DoN 2010b), NMFS recommended that the Navy focus the goals of the plan on augmenting the limited baseline distribution and abundance data for marine species in this region.

The initiation of monitoring described in the MIRC's first monitoring plan was comprised of passive acoustic monitoring, acoustic data analysis from a 2007 large vessel survey (Mariana Islands Sea Turtle and Cetacean Survey [MISTCS]), and visual surveys as the primary methods of data collection. Through the process of adaptive management review (AMR), the first MIRC monitoring plan was adjusted iteratively in 2012, 2013, and 2014 to add more emphasis on being guided by designation and implementation of scientific monitoring questions directed at these goals. The FY12 MIRC monitoring

plan first introduced five guiding monitoring questions specific to the monitoring needs of the MIRC, which have been retained through the most recent FY14-15 monitoring plan. The five questions are:

Question 1. What species of beaked whales and other odontocetes occur around Guam and Saipan?

Question 2. Are there locations of greater relative cetacean and/or sea turtle abundance around Guam and Saipan?

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

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

Question 5. What is the occurrence and habitat use of sea turtles in areas where the U.S. Navy conducts underwater detonations?

Although the disadvantages of mandated metrics of effort within a monitoring plan first surfaced in the course of monitoring in other range complexes, the 2012 MIRC monitoring plan update for FY13 and beyond was the first of any Navy range complex to remove numerical metrics of monitoring effort, replacing these with the goal of documenting progress made on each monitoring question as defined in the monitoring plan. This goal of structuring the annual reporting on such progress was achieved in the corresponding MIRC annual monitoring report submitted at the end of that monitoring year (DoN 2014). The subsequent MIRC monitoring plan for FY14-15 placed further emphasis on the goal of progress on monitoring questions by removing predetermined lists of specific monitoring projects and replacing these with a list of broad categories of monitoring methodologies that would be applied to meet this goal: acoustic methodologies, visual survey methodologies, population structure analyses, and mark-recapture analyses.

This change was made to optimally plan field projects and to facilitate dynamic response to development of new technologies, lessons learned, and evolving scientific needs to best address the monitoring questions. Methodologies are continuing to evolve through lessons learned, Adaptive Management Review (AMR) with National Marine and Fisheries Service (NMFS), and input from the scientific community. In many cases, monitoring projects will continue past the time of this report as analysis is ongoing and field efforts planned. Notable results, discussed in detail in Chapters 3 and 4, have contributed to our greater understanding of the five study questions first developed in the FY12 MIRC monitoring plan, and have made significant strides for developing previously-sparse baseline knowledge on marine species I the MIRC, as first conceptualized by NMFS and Navy during development of the first monitoring plan in 2010. Therefore these results provide the context for planning for monitoring for the next Phase of environmental planning and marine species monitoring for the Mariana Islands Training and Testing EIS/OEIS (MITT), and within the context of the further evolution of the ICMP and Strategic Planning Process, which will programmatically consider relative monitoring needs in the course of planning monitoring execution across all Navy fleet and SYSCOM range complexes.

TABLE OF CONTENTS

Executive Summary i
Table of Contents iii
List of Figures v
List of Tables vi
APPENDICES vii
List Of Acronyms viii
1 Introduction 1
1.1 Integrated Comprehensive Monitoring Program 3
1.2 Mariana Islands Range Complex Monitoring Goals 5
1.3 Five Monitoring Questions 5
1.4 Reference Resources 6
1.5 Monitoring Team and Performers 7
2 Mariana Islands Range Complex Major Training Exercise Summary (12 August 2010 to 15 July 2014) . 8
2.1 Composite Listing of MIRC Major Training Exercises 8
2.1.1 Composite Listing of MIRC Mitigation Events 8
2.1.2 Composite Listing of MIRC Marine Animal Sightings 9
2.2 Evaluation of Mitigation Effectiveness 9
3 Compliance Monitoring Summary 11
3.1 Overview (2010 to 2014) 11
3.1.1 Summary of Monitoring Plan Metrics 15
3.1.2 Monitoring goals and implementation 20
3.2 Chronological timeline of monitoring in Mariana Islands Range Complex 25
3.2.1 Lessons Learned and Evolution of Methodology 43
3.2.2 Monitoring Highlights 44
3.3 Projects and Methodologies 51
3.3.1 Passive Acoustic Monitoring 51
3.3.2 Systematic Visual Line Transect 55
3.3.3 Other Visual Survey, Satellite Tagging, Biopsy, Photo-ID 56
3.3.4 Sea Turtle Distribution and Density 60
4 Progress on Monitoring Questions and lessons learned 61

4.1 Progress on Monitoring Question 61
4.1.1 What species of beaked whales and other odontocetes occur around Guam and Saipan? 68
4.1.2 Are there locations of greater relative cetacean and/or sea turtle abundance around Guam and Saipan? 72
4.1.3 What is the baseline abundance and population structure of odontocetes which may be exposed to sonar and/or explosives in the nearshore areas of Guam, Saipan, Tinian, and Rota? 76
4.1.4 What is the seasonal occurrence of baleen whales around Guam, Saipan, Tinian, and Rota? 80
4.1.5 What is the occurrence and habitat use of sea turtles in areas where the U.S. Navy conducts underwater detonations? 83
5 Future Directions 86
5.1 Revision to the Compliance Monitoring Structure 86
5.1.1 Adaptive Management 86
5.1.2 Scientific Advisory Group Recommendations 86
5.1.3 Strategic Planning Process 89
5.2 Final Year Compliance Monitoring (February 2014 to February 2015) 89
6 References 92

LIST OF FIGURES

Figure 1. The MIRC Study Area (DoN 2010a) 2

Figure 2. Monitoring Timeline 27

Figure 3. Survey track line of MISTCS large vessel survey 45

Figure 4. Bryde's whale *(Balaenoptera edeni)* sighted from 2007 aerial survey (Mobley 2007) 46

Figure 5. Super-telephoto images (500mm with 1.4x teleconverter and body with APS-C sensor) providing shore-based species identification of pilot whales at a distance of 5 km 47

Figure 6. Killer whales engaged in hunting sighted incidentally during aerial transit between Saipan and Farallon de Medinilla on 10 May 2010 (Wenninger 2010; Uyeyama 2014) 48

Figure 7. Migration of tagged subadult hawksbill turtle from Tinian, CNMI to Guam 49

Figure 8. Map of MIRC EAR deployments. Yellow pushpins indicate EAR deployments 54

Figure 9. Survey vessel M/V Kahana during Leg 2 of MISTCS line transect survey, sighted from aerial survey to FDM, 18 February 2014 55

Figure 10. Melon-headed whales *(Peponocephala electra)* sighted from small vessel survey near Guam 15 March 2012 58

Figure 11. Comparison of shore station survey viewshed at Guam with survey effort track lines for small vessel surveys 59

Figure 12. Shore station marine mammal survey on Guam utilizing Big Eye binoculars, theodolite, super-telephoto photography, and hand-held binoculars. (Deakos et al. 2014) 59

Figure 13. Distribution of cetacean encounters and search effort across depth profiles (including resights) 69

Figure 14. Species discovery by distance of trackline surveyed by PIFSC small vessel surveys 2010-April 2014 70

Figure 15. All beaked whale sightings from MIRC monitoring 2007-2013 71

Figure 16. Satellite locations for deployed on false killer whales off Rota in 2013 74

Figure 17. Satellite locations for tags 128897 and 128898 deployed on bottlenose dolphins off Aguijan and Saipan, respectively in 2013 75

Figure 18. Navy underwater detonation and explosive ordnance areas, cetacean encounter locations and short-finned pilot whale satellite tag locations 78

Figure 19. Combined all survey effort and all cetacean and sea turtle sightings within the MIRC, 2007-2013 79

Figure 20. All baleen whale sightings from MIRC monitoring 2007-2013, and incidental sightings ... 82

Figure 21. Proportion of days with calls in relation to recording effort, by month with recording effort combined across years 83

Figure 22. All sea turtle sightings from MIRC monitoring, 2007-2013 85

Figure 23. Planned survey track for offshore acoustic glider survey, deployed 29 September 2014 . 91

LIST OF TABLES

Table 1. Mariana Islands Range Complex Major Training Exercise Summary 8

Table 2. Mariana Islands Range Complex Major Training Exercise Mitigation Events 8

Table 3. Mariana Islands Range Complex Sighted Marine Mammals and Sea Turtles 9

Table 4. First MIRC monitoring plan summary table (DoN 2010b). 16

Table 5. Updated MIRC Monitoring Plan summary (DoN 2012a) included as part of the 2012 MIRC annual report 17

Table 6. Updated MIRC Monitoring Plan summary included as part of the 2013 MIRC annual report (DoN 2013b) 18

Table 7. Updated MIRC Monitoring Plan FY14-FY15 summary included as part of the 2014 MIRC annual report (DoN 2014) 19

Table 8. FY10- Monitoring Goals and Implementation 20

Table 9. FY11-12 Monitoring Goals and Implementation 21

Table 10. FY13 Monitoring Goals and Implementation 22

Table 11. FY 14 Monitoring Goals and Implementation 23

Table 12. Description of Monitoring Efforts and Key Events Related to Monitoring. 30

Table 13. Marine mammal and sea turtle sightings from all MIRC monitoring and incidental sighting sources through 2013 50

Table 14. Acoustic datasets collected near Saipan and Tinian by PIFSC since 2010 52

Table 15. EAR deployments in the MIRC 53

Table 16. PIFSC Satellite tag deployment information and summary of depth and distance to shore for the Douglas ARGOS filtered tag locations by species and tag ID 56

Table 17. Progress made on FY10-FY14 Monitoring Plan Study Questions 62

APPENDICES

Appendix A. Summary Report: Compilation of Visual Survey Effort and Sightings for Marine Species Monitoring in the Mariana Islands Range Complex (HDR 2014)

Appendix B. Cetacean surveys in the waters of the southern Mariana Archipelago (February 2010–April 2014 (Hill et al. 2014)

Appendix C. Compilation of incidental marine mammal and sea turtle sightings in the Mariana Islands Range Complex (Uyeyama 2014)

Appendix D. Sea Turtle Tagging in the Mariana Islands Range Complex (MIRC): Annual Progress Report (Jones and Van Houtan 2014)

LIST OF ACRONYMS

AMR	Adaptive Management Review
CNMI	Commonwealth of the Northern Mariana Islands
COMPACFLT	Commander, U.S. Pacific Fleet
CPF	Commander, U.S. Pacific Fleet
DAWR	Division of Aquatic and Wildlife Resources (Guam Department of Agriculture)
DFW	Division of Fish and Wildlife (CNMI)
DON	Department of the Navy
EAR	Ecological Acoustic Recorder
EIS/OEIS	Environmental Impact Statement/Overseas Environmental Impact Statement
ESA	Endangered Species Act
FDM	Farallon de Medinilla
FR	Final Rule
FY	Fiscal Year
HARP	High Frequency Acoustic Recording Package
HIMB	Hawaii Institute for Marine Biology
ICMP	Integrated Comprehensive Monitoring Plan
kHz	kiloHertz
LoA	Letter of Authorization
m	meters
MFAS	Medium Frequency Active Sonar
MIRC	Mariana Islands Range Complex
MITT	Mariana Islands Testing and Training (EIS)
MISTCS	Mariana Islands Sea Turtle and Cetacean Survey
MMO	Marine Mammal Observer
MMPA	Marine Mammal Protection Act
MTE	Major Training Exercise
MTER	Major Training Exercise for Reporting (MTER). This wording was used in the MIRC LoA, and is equivalent to MTE.
NAVFAC PAC	Naval Facilities Engineering Command, Pacific
NEPA	National Environmental Policy Act
NMAWC	Naval Mine and Anti-Submarine Warfare Command
NMFS	National Marine Fisheries Service
NOAA	National Oceanographic and Atmospheric Administration
OBIS-SEAMAP	Ocean Biogeographic Information System Spatial Ecological Analysis of Megavertebrate Populations
OES	Oscar Elton Sette (NOAA large vessel survey)
ONR	Office of Naval Research
OPNAV N45	Chief of Naval Operations Energy and Environmental Readiness Division
OPR	Office of Protected Resources
OSI	Oceanwide Science Institute
OSU	Oregon State University
PAM	Passive Acoustic Monitoring
PIFSC	Pacific Islands Fisheries Science Center (NMFS)
rSAG	Regional Scientific Advisory Group
SAG	Scientific Advisory Group
SWFSC	Southwest Fisheries Science Center (NMFS)
UW	University of Washington
VS	Valiant Shield

1 INTRODUCTION

The United States (U.S.) Department of the Navy (Navy) developed Range Complex-specific Monitoring Plans under the Navy Monitoring Program to provide marine mammal and sea turtle monitoring as required under the Marine Mammal Protection Act (MMPA) of 1972 and the Endangered Species Act (ESA) of 1973. The Commander, U.S. Pacific Fleet (COMPACFLT) and Commander, U.S. Fleet Forces Command marine species monitoring programs are composed of a collection of "range-specific" monitoring plans each developed as part of the MMPA/ESA authorization process. The Fleets' individual plans establish specific monitoring requirements for each range complex based on a set of effort-based metrics.

This report summarizes the COMPACFLT marine species monitoring under the Letters of Authorization (LOAs) received for at-sea training in the Mariana Islands Range Complex (MIRC) (NMFS 2010b; NMFS 2011; NMFS 2012). The period covered in detail by this report is from January 2010 to July 2014, and is based on annual monitoring and exercise reports submitted previously to the National Marine Fisheries Service (NMFS) in accordance with 50 Code of Federal Regulations (C.F.R.) §218.105(d) and 50 C.F.R. §218.105(f). Monitoring activities that took place as early as 2007 are also presented to provide context for the development and implementation of the Tactical Training Theater Assessment and Planning (TAP), Phase 1 marine species monitoring program in the MIRC. This document is a comprehensive report summarizing the results of these reports, prepared in accordance with 50 C.F.R. §218.105(g).

There are five main sections within this report: Introduction, Exercise Report Summary, Compliance Monitoring Summary, Progress on Monitoring Questions, and Future Directions. Because no Research and Development (R&D) projects for marine species monitoring methodologies is conducted by the Navy in the MIRC, there is not a section titled Navy Basic and Applied Research included as part of this Comprehensive Report. However, monitoring activities that do overlap with traditional "demonstration and validation" of new technologies has been planned and was deployed in the field in late September 2014, and is described in 5.2, "Final Year Compliance Monitoring."

Chapter 2 "Exercise Report Summary" contains a composite listing and review of marine mammal sightings during major training events (MTEs) within the MIRC through 15 July 2014. Chapter 3 "Compliance Monitoring Summary" discusses annual monitoring plan goals and associated accomplishments described by the NMFS-authorized Mariana Islands Range Complex Monitoring Plans, as originally published in 2010 (DoN 2010b), and subsequently updated (DoN 2012a; DoN 2013b; DoN 2014). Also a comprehensive graphical timeline and table of all monitoring activities is presented, followed by an overview of monitoring methodologies including selected highlights. Chapter 4 "Progress on Monitoring Questions" discusses how various technologies and associated results contributed directly to the five MIRC-specific scientific monitoring questions introduced in the 2012 update of the monitoring plan (DoN 2012a). Finally, "Future Directions" describes the Navy's lessons learned and recommendations for follow-on monitoring.

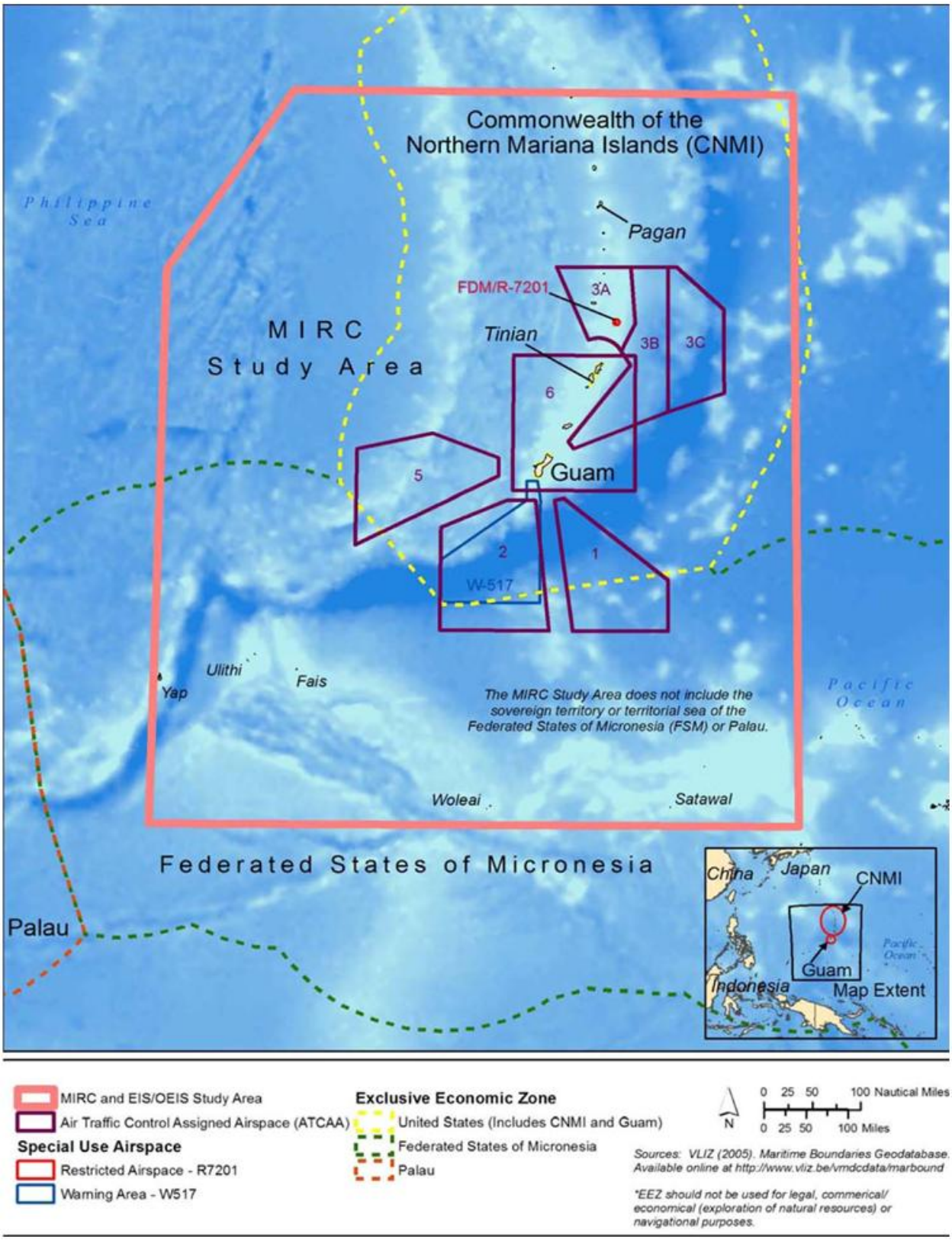


Figure 1. The MIRC Study Area (DoN 2010a)

1.1 Integrated Comprehensive Monitoring Program

Concurrent with implementation of the initial range-specific monitoring plans, the Navy developed the Integrated Comprehensive Monitoring Program (ICMP) which provides the overarching framework for coordination of the Navy's marine species monitoring (Department of the Navy [DoN] 2010c). It has been developed in direct response to permitting requirements for U.S. Navy ranges, which are established in the various MMPA Final Rules, ESA Consultations, Biological Opinions, and applicable regulations. As a framework document, the ICMP applies, by regulation, to those activities on ranges and in operating areas for which the U.S. Navy sought and received incidental take authorizations.

The ICMP is intended for use as a planning tool to focus Navy monitoring priorities pursuant to ESA and MMPA requirements. Top priority will always be given to satisfying the mandated legal requirements across all ranges. Once legal requirements are met, any additional monitoring-related research will be planned and prioritized using guidelines outlined by the ICMP, consistent with availability of both funding and scientific resources. As a planning tool, the ICMP is a "living document" and will be routinely updated, as needed.

The initial area of focus for continuing to improve U.S. Navy marine species monitoring in 2011/2012 was on development of a Strategic Plan to be incorporated as a major component of the ICMP to guide investments and help refine specific monitoring actions to more effectively, and to efficiently address ICMP goals and objectives. As the development of the Strategic Plan continued in 2013/2014, updating its description as a "Strategic Planning Process" became more accurate as an approach to decision making for the monitoring program, with guidelines and processes necessary to develop, evaluate, and fund individual projects based on objective scientific study questions This process uses an underlying framework designed around top-level program goals, a conceptual framework incorporating a progression of knowledge toward these goals, and consultation with the Scientific Advisory Group and other regional experts.

In TAP, Phase 2 marine species monitoring program for Navy range complexes, the Strategic Planning Process for Marine Species Monitoring will be used to: 1) set intermediate overarching scientific objectives; 2) develop individual monitoring project concepts; 3) Evaluate, prioritize, and select monitoring projects to fund or continue supporting for a given fiscal year; 4) Execute selected monitoring projects; 5) Report and Evaluate progress and results. This process will also address relative investments to different range complexes based on goals of the U.S. Navy marine species monitoring program across all range complexes, and monitoring would leverage multiple techniques for data acquisition and analysis when optimal. The Strategic Planning Process for Marine Species Monitoring is available on the U.S. Navy's monitoring website (http://www.navymarinespeciesmonitoring.us), and at http://www.nmfs.noaa.gov/pr/permits/incidental/military.htm.

The ICMP is evaluated through the Adaptive Management Review (AMR) process to: (1) assess progress, (2) provide a matrix of goals and objectives for the following year, and (3) make recommendations for refinement and analysis of the monitoring and mitigation techniques. This process includes conducting an annual AMR meeting at which the U.S. Navy and NMFS jointly consider the prior-year goals,

monitoring results, and related scientific advances to determine if modifications to monitoring plans are warranted to more effectively address program goals. Modifications to the ICMP that result from AMR discussions are incorporated into a revision to the ICMP and submitted to NMFS.

Under the ICMP, monitoring measures prescribed in range-specific monitoring plans and U.S. Navy-funded research relating to the effects of U.S. Navy training and testing activities on protected marine species should be designed to accomplish one or more of the following top level goals as prescribed in the current revision of the ICMP (Department of the Navy 2010b):

(a) An increase in our understanding of the likely occurrence of marine mammals and/or ESA-listed marine species in the vicinity of the action (i.e., presence, abundance, distribution, and/or density of species).

(b) An increase in our understanding of the nature, scope, or context of the likely exposure of marine mammals and/or ESA-listed species to any of the potential stressors associated with the action (e.g., sound, explosive detonation, or expended materials), through better understanding of one or more of the following: (1) the nature of the action and its surrounding environment (e.g., sound-source characterization, propagation, and ambient noise levels); (2) the affected species (e.g., life history or dive patterns); (3) the likely co-occurrence of marine mammals and/or ESA-listed marine species with the action (in whole or part); and/or (4) the likely biological or behavioral context of exposure to the stressor for the marine mammal and/or ESA listed marine species (e.g., age class of exposed animals or known pupping, calving, or feeding areas).

(c) An increase in our understanding of how individual marine mammals or ESA-listed marine animals respond (behaviorally or physiologically) to the specific stressors associated with the action (in specific contexts, where possible, e.g., at what distance or received level [RL]).

(d) An increase in our understanding of how anticipated individual responses, to individual stressors or anticipated combinations of stressors, may impact either: (1) the long-term fitness and survival of an individual, or (2) the population, species, or stock (e.g., through effects on annual rates of recruitment or survival).

(e) An increase in our understanding of the effectiveness of mitigation and monitoring measures, including increasing the probability of detecting marine mammals to better achieve the above goals (through improved technology or methodology), both generally and more specifically within the safety zone (thus allowing for more effective implementation of the mitigation). Improved detection technology will be rigorously and scientifically validated prior to being proposed for mitigation, and should meet practicality considerations (engineering, logistic, and fiscal).

(f) A better understanding and record of the manner in which the authorized entity complies with the MMPA incidental take authorization and ESA incidental take statement.

Chief of Naval Operations Energy and Environmental Readiness Division (OPNAV N45) is responsible for maintaining and updating the ICMP, as necessary, reflecting the results of regulatory agency rulemaking, AMRs, best available science, improved assessment methodologies, and more effective protective measures. This is done as part of the AMR process, in consultation with U.S. Navy technical experts, Fleet Commanders, and Echelon II Commands as appropriate.

1.2 Mariana Islands Range Complex Monitoring Goals

COMPACFLT's marine species monitoring program from 2010 to 2014 in the MIRC was designed to better understand the distribution and abundance of marine mammals and sea turtles in the Mariana Islands, as outlined in the 2010 MIRC monitoring plan (DoN 2010b). During earlier development of this plan, the original draft had outlined study questions that have been used in other range complex monitoring plans, directed at gathering data for determining potential effects from training. However NMFS suggested that although the Navy conducted a four month line-transect survey in 2007 (DoN 2007), the MIRC, unlike other range complexes, is a region where limited data from systematic surveys for marine mammals and sea turtles exists. Therefore as a result of Navy/NMFS discussions, the monitoring plan was refocused to distribution and abundance. Since that time, the MIRC monitoring plan was updated first in 2012, followed by smaller incremental updates in 2013 and 2014. The 2012 revision (DoN 2012a) introduced five scientific monitoring questions specific to the MIRC, which facilitated removal of quantitative metrics of effort, and introduction of monitoring projects utilizing additional monitoring methodologies. The 2013 MIRC monitoring plan (DoN 2013b) made an adjustment in listed projects related to tagging, and the update in 2014 (DoN 2014) removed lists of specifically named monitoring projects as goals, and replaced these with general categories of planned monitoring methodologies to be used as tools to answer each of the five MIRC monitoring questions. This sequence in the evolution of MIRC monitoring goals is described in more detail in Section 3.1.1 of this report, and a comparison of goals and accomplishments is described in Section 3.1.2.

1.3 Five Monitoring Questions

As described above in 1.2, the 2012 revision of the MIRC monitoring plan (DoN 2012a) provided five monitoring ("study") questions to guide the planning and evaluation of monitoring in the MIRC. These five questions are specific to the MIRC and different from those for other range complexes. These questions developed for the 2012 monitoring plan revision are still consistent with the focus of the original MIRC monitoring plan (DoN 2010b) with regard to investigating the distribution and abundance of marine mammals and sea turtles in the Mariana Islands. Two of the questions narrow the study question into water areas where training might occur. The five questions are:

Question 1. What species of beaked whales and other odontocetes occur around Guam and Saipan?

Question 2. Are there locations of greater relative cetacean and/or sea turtle abundance around Guam and Saipan?

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

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

Question 5. What is the occurrence and habitat use of sea turtles in areas where the U.S. Navy conducts underwater detonations?

The original 2010 MIRC monitoring plan (DoN 2010b) provided the initial guidance for COMPACFLT's process of selecting field methodologies that were funded to satisfy its monitoring requirements. The monitoring requirements (e.g., specific projects and metrics) in the plan were specifically designed to enable unambiguous evaluation of compliance with the Letter of Authorization (LoA) through the statement of a required quantitative metric of effort for every item in a required list of specified monitoring projects. These monitoring projects and metrics are described in Table 4 in Section 3.1.1. Section 3.1.1 also describes the updates to the MIRC monitoring plan made through the AMR process that implemented these study questions, implementing a progressively stronger emphasis on focusing the monitoring program on making progress on these questions, thereby also achieving a deeper iterative integration into the ICMP through its adaptation of a newly defined Strategic Planning Process.

1.4 Reference Resources

The reference resources listed below are located within the "Reading Room" page of the Navy's marine species monitoring website at the following URL: http://www.navymarinespeciesmonitoring.us/reading-room/. To view content specific to MIRC at the above website, expand "Pacific Monitoring Reports," and within that section, expand "Mariana Islands Range Complex (MIRC)." Most of the below resources are also available at the NOAA webpage at the following URL: http://www.nmfs.noaa.gov/pr/permits/incidental/military.htm.

Annual monitoring and exercise reports:

2011 Mariana Islands Range Complex Annual Monitoring Report
http://www.navymarinespeciesmonitoring.us/index.php/download_file/view/206/

2012 Mariana Islands Range Complex Annual Monitoring Report
http://www.navymarinespeciesmonitoring.us/index.php/download_file/view/204/

2013 Mariana Islands Range Complex Annual Monitoring Report
http://www.navymarinespeciesmonitoring.us/index.php/download_file/view/339/

2014 Mariana Islands Range Complex Annual Monitoring Report
http://www.navymarinespeciesmonitoring.us/index.php/download_file/view/763/

Other files:

Integrated Comprehensive Monitoring Program Charter (December 2010)
http://www.navymarinespeciesmonitoring.us/index.php/download_file/view/83/

Scientific Advisory Group Recommendations Report (May 2011)
http://www.navymarinespeciesmonitoring.us/index.php/download_file/view/86/

1.5 Monitoring Team and Performers

The Commander, U.S. Pacific Fleet MIRC monitoring team is comprised of non-Navy civilian, academic, and contractor scientists along with participation by Navy marine species technical experts.

Passive Acoustic Monitoring and acoustic analyses: HDR (Mark Deakos, Michael F. Richlen); Hawaii Institute for Marine Biology (Whitlow W.L. Au); Oceanwide Science Institute (Marc O. Lammers, Lisa M. Munger); Biowaves (Thomas F. Norris, Julie Oswald, Tina Yack, Elizabeth Ferguson, Cory Hom-Weaver, Kerry Dunleavy, Shannon Coates, Talia Dominello); NMFS PIFSC (Erin M. Oleson); University of Washington (Neil M. Bogue, James C. Luby) and Oregon State University (Holger Klinck, David K. Mellinger, Haru Matsumoto).

Systematic aerial visual line transect surveys: Marine Mammal Research Consultants (Joseph R. Mobley, Jr., Lori Mazzuca, and Amanda Cummins); SRS Parsons Joint Venture/GeoMarine/Biowaves (Gregory Fulling, Jim Cotton, Richard Rowlett, Cornelia Oedekoven, Beth Phillips, Juan Carlos Salinas, Adam Ü, Chris Cutler, Mike Force, Candice Hall, Mark Deakos, Jamie Gove, Thomas F. Norris, Alyson Azzara, Laura Morse, and Julie A. Rivers); and NMFS PIFSC for the Oscar Elton Sette cruises.

Small vessel survey: HDR (Greg Fulling, Annie Douglas, Kristen Ampela, Suzanne Yin, Jennifer Brown, Desray Reeb, Phil Thorson, Mark Deakos, and Paula Von Weller); NAVFAC Pacific (Robert K. Uyeyama, Sean F. Hanser, Jessica M. Aschettino); NMFS PIFSC (Marie C. Hill, Allan Ligon, Mark Deakos, Adam Ü, Erin M. Oleson, Erik Norris, Daniel L. Webster, Rachel Karasik, Ali Bayless, Aliza Milette-Winfree, and Andrea Bendlin).

Marine mammal tissue genetic analysis: NMFS SWFSC and PISFC (Karen K. Martien, Marie C. Hill, Amy M. Van Cise, Kelly M. Robertson, Samuel M. Woodman, Louella Dollar, Victoria L. Pease, and Erin M. Oleson).

The pilot shore station survey was conducted by HDR (Mark Deakos, Michael F. Richlen) with NAVFAC Pacific (Robert K. Uyeyama, Jessica M. Aschettino).

Sea turtle tagging was conducted by NMFS PIFSC Marine Turtle Assessment Group (Kyle Van Houten and T. Todd Jones)

The data management process including production of the MIRC survey atlas was conducted by HDR (Kristen Ampela, Mark Deakos, John Chadbourne, Dagmar Fertl, Jennifer Latusek-Nabholz, and Dana Spontak), and the compilation of incidental sightings was performed by NAVFAC Pacific (Robert K. Uyeyama). The annual monitoring reports in the years 2011–2013 were prepared by COMPACFLT (Julie A. Rivers), and in 2014 was prepared for COMPACFLT by HDR (Kristen Ampela and Mark Deakos) and NAVFAC Pacific (Robert K. Uyeyama). The annual exercise reports 2011-2014 were prepared by COMPACFLT (Roy Sokolowski) and NMAWC (Steven Loeffler).

2 Mariana Islands Range Complex Major Training Exercise Summary (12 August 2010 to 15 July 2014)

2.1 Composite Listing of MIRC Major Training Exercises

There were 2 individual MTEs that took place in the MIRC from 12 August 2010 to 15 July 2014. These MTEs are summarized in Table 1 below.

Table 1. Mariana Islands Range Complex Major Training Exercise Summary

Exercise Type	12 Aug 2010 – 15 Feb 2011	16 Feb 2011 – 15 Feb 2012	16 Feb 2012 – 15 Feb 2013	16 Feb 2013 – 15 Feb 2014	16 Feb 2014 – 15 Jul 2014	Reporting Period Total
Joint Multi-Strike Group Exercise	1	0	1	0	0	2
Total	1	0	1	0	0	2

2.1.1 Composite Listing of MIRC Mitigation Events

There were 4 total mitigation events where active sonar was powered down or shut down due to the sighting of marine mammals or sea turtles during MTEs from 12 August 2010 to 15 July 2014. These mitigation events are summarized in Table 2. All of these sightings were observed within 4,000 yards of the Navy unit; one was observed by an aircraft, and one was an acoustic detection. The Navy's unclassified annual exercise reports from 2010 through 2014 contain tables listing all marine mammals sighted during that reporting year and the range of the sighting.

Table 2. Mariana Islands Range Complex Major Training Exercise Mitigation Events

Marine Animal Species	Range of Detection (Yards, <200, 200-500, 500-1,000, 1,000-2,000, >2,000)	Mitigation Measure Implemented	Un-required Mitigation (Yes/No)
12 August 2010 – 15 February 2011			
Generic	Acoustic detection	Sonar shut down	Yes
Whale	<200	Sonar shut down	No
Whale	200-500	Sonar shut down	No
Whale	>2,000	Sonar shut down/maneuvered	Yes
16 February 2011 – 15 February 2012			
No mitigation events during this period			
16 February 2012 – 15 February 2013			
No mitigation events during this period			
16 February 2013 – 15 February 2014			
No mitigation events during this period			
16 February 2014 – 15 July 2014			
No mitigation events during this period			

2.1.2 Composite Listing of MIRC Marine Animal Sightings

There were 11 reported sightings of an estimated 47 marine mammals during MTEs in the MIRC from 12 August 2010 to 15 July 2014. These sightings are summarized in Table 3.

Table 3. Mariana Islands Range Complex Sighted Marine Mammals and Sea Turtles

Marine Animal Types	12 Aug 2010 – 15 Feb 2011	16 Feb 2011 – 15 Feb 2012	16 Feb 2012 – 15 Feb 2013	16 Feb 2013 – 15 Feb 2014	16 Feb 2014 – 15 Jul 2014	Reporting Period Total
Estimated Number of Animals Sighted While Sonar Active						
Dolphin	0	0	0	0	0	0
Whale	4	0	0	0	0	4
Pinniped	0	0	0	0	0	0
Turtle	0	0	0	0	0	0
Generic	1	0	0	0	0	1
Subtotal while Active	5	0	0	0	0	5
Estimated Number of Animals Sighted While Sonar Passive						
Dolphin	25	0	8	0	0	33
Whale	9	0	0	0	0	9
Pinniped	0	0	0	0	0	0
Turtle	0	0	0	0	0	0
Generic	0	0	0	0	0	0
Subtotal while Passive	34	0	8	0	0	42
Total	**39**	**0**	**8**	**0**	**0**	**47**

2.2 Evaluation of Mitigation Effectiveness

During the 2 MTEs in the MIRC from 12 August 2010 to 15 July 2014 (Table 1), prescribed NMFS mitigation zones were effectively applied in cases of observation of marine mammals and sea turtles within the applicable zone. The three categories of mitigation measures (Personnel Training, Lookout and Watchstander Responsibility, and Operating Procedures) outlined in the MIRC Final Environmental Impact Statement/Overseas Environmental Impact Statement of May 2010 and approved by NMFS in subsequent LOAs were effective in appropriately mitigating exposure of sighted marine mammals and sea turtles to sonar. During the entire reporting period, there were zero instances, out of 11 sightings, where a ship or aircraft neglected to mitigate adequately for a marine mammal sighted by the watchstander team within 1,000 yards. Fleet commanders, aircrews, and ship watch teams continue to improve individual awareness, mitigation execution, and reporting practices. This improvement can be attributed to pre-exercise planning practices, mandatory Marine Species Awareness Training, adherence to required MFAS mitigation zones, and application of lessons learned in marine animal sighting and reporting.

For deep diving animals observed during any MTEs, if exposure did occur, the Navy assesses that these animals would not be exposed to significant levels for long periods based on the moving nature of hull-mounted MFAS use, and even less from less-frequent and lower-power aviation-deployed MFAS systems (dipping sonar, sonobuoys). During a 1-hour dive by a beaked whale or sperm whale (*Physeter*

macrocephalus), a MFAS ship moving at a nominal speed of 10 knots could transit up to 10 nautical miles (nm) from its original location, well beyond ranges predicted to have significant exposures.

Table 2 lists the 4 mitigation events where sonar was active and ships took action to reduce or eliminate inadvertent exposure of marine mammals and sea turtles to sonar. With or without mitigation, given the rapid relative motion of ships maneuvering at sea and the independent marine mammal movement, the time any given animal would be exposed to MFAS from surface ships is likely to be limited. Of the 4 total mitigations listed in Table 2 above, 2 were conducted in excess of mandated safety zones where ships powered down or shut down sonar at ranges beyond what was required. No specific cause to over-mitigating has been determined; however, Navy is taking a pro-active role in improved training on mitigation procedures. In support of the 2 MTEs during the reporting period, the Navy conducted over 3,495 hours of Marine Species Awareness Training for 1,498 Navy personnel prior to the beginning of these exercises. While at sea, when accounting for the entire bridge watch team, the Navy spent over 29,258 hours of surface and aerial visual observation toward the detection of marine mammals and sea turtles. Additionally, over 883 hours were spent documenting and reporting marine animal sightings and mitigation events.

3 COMPLIANCE MONITORING SUMMARY

The objective of this chapter is to summarize annual requirements of the MMPA LOA monitoring program in the MIRC in the years 2010–2014, including goals, accomplishments, and methods. The incremental improvements in the MIRC monitoring program through adjustment of the goals, and the associated annual accomplishments will be described through these years.

The chapter is structured with the following sections:

- **3.1 Overview (2010 to 2014):** Describes the evolution of overall MIRC monitoring plan goals.
    - **3.1.1 Summary of Monitoring Plan Metrics**: Illustrates the changes in 3.1 with summary tables of annual monitoring goals for each time update of the monitoring plan.
    - **3.1.2 Monitoring goals and implementation:** Describes monitoring accomplishments directly in comparison to the goals listed in 3.1.1.
- **3.2 Chronological timeline of monitoring in Mariana Islands Range Complex:** Concise summary of the entire MIRC monitoring program 2010–2014 at a glance with: 1) a graphical timeline of events, accompanied by 2) a table summarizing all monitoring events shown in the timeline.
    - **3.2.1 Lessons Learned and** Evolution of Methodology: Describes the process through which changes in specific monitoring projects were developed through a process of integrating new knowledge and lessons learned.
    - **3.2.2 Monitoring Highlights:** Noteworthy monitoring results are given, providing an overview of key events and results.
- **3.3 Projects and methodologies:** The following sections briefly describe the projects given in the tables above in 3.1.1 and 3.1.2, and are broadly organized by the following general methodologies.
    - **3.3.1 Passive Acoustic Monitoring**
    - **3.3.2 Systematic Visual Line Transect**
    - **3.3.3 Other Visual Survey, Satellite Tagging, Biopsy, Photo-ID**
    - **3.3.4 Sea Turtle Distribution and Density**

Further detailed results with respect to monitoring plan questions are described in Chapter 4 Progress on Monitoring Questions.

3.1 OVERVIEW (2010 TO 2014)

2010 Monitoring Plan. MIRC, unlike other range complexes, is a region where only limited knowledge of presence and occurrence from systematic surveys for marine mammals and sea turtles exists. Therefore during development of the first MIRC monitoring plan (DoN 2010b), NMFS recommended that the Navy focus on goals with a different emphasis than those posed by the study questions that had been developed for other range complex monitoring plans. This was because those questions from other ranges were directed at gathering data for determining potential effects from training activities in waters where marine mammal occurrence data was well established in the literature, in contrast to the waters of the MIRC. Therefore the finalized monitoring plan that initiated MMPA LOA monitoring

requirements for the MIRC (DoN 2010b) was focused instead upon augmenting the limited baseline distribution and abundance data for this region, as were all subsequent iterations of the plan.

The planned monitoring projects were organized by fiscal year (FY). As a result of the above emphasis on collecting baseline data, the first MIRC monitoring plan (DoN 2010b) began with planning FY10 to be comprised of passive acoustic monitoring, archival acoustic data analysis from a 2007 large vessel survey, and various visual surveys as the primary methods of data collection (Table 4). Each monitoring project, when applicable, was also accompanied by numerical metrics of planned effort, following the format of existing monitoring plans of other range complexes. Specifically, the plan stated that in FY11 a total of *"four devices"* were to be deployed for passive acoustic monitoring, and *"45 days"* of visual survey completed. Monitoring plans were annually submitted for NMFS review as a component of the MIRC annual monitoring reports in April of each year, and any updates to the plan were applied at the time of this submission.

2012 Monitoring Plan Update. Through the process of annual adaptive management review (AMR), the MIRC monitoring plan continued to be incrementally updated. The first major change was to designate scientific monitoring questions as goals, with later updates gradually adding increasing emphasis on the monitoring program being guided by these goals. Results from any new projects arising from any updates to the monitoring plan made in a given calendar year could not be available until at least two calendar years later due to the funding cycle of the federal fiscal year. For example, the second MIRC annual report was submitted to NMFS in April 2012 (DoN 2012b), and contained the first update for the monitoring plan (DoN 2012a). Because FY12 was already well in progress by this time, all monitoring projects for FY12 had already been programmed for funding, or already funded. Therefore the monitoring plan update contained no substantial changes for the then-current FY12, and all monitoring plan updates for new projects were applied only to FY13 and beyond. Results of these new projects initiated in FY13 could therefore be reported in the April 2014 MIRC annual report at the earliest, two years after the monitoring plan update submitted in April 2012.

This April 2012 MIRC monitoring plan update (DoN 2012a) first introduced five guiding monitoring questions specific to the MIRC (see Section 1.3) that have remained unchanged since that time. Table 5 summarizes the monitoring goals that accompanied this 2012 update, which listed specific projects by methodology, as well as quantitative metrics of effort (i.e., "45 days" for visual survey and "4 devices" for PAM). Concurrently during this period, the disadvantages of specifying mandated metrics of effort within a monitoring plan were becoming apparent at other range complexes. The lesson learned was that if monitoring was evaluated by effort quantity, unambiguously expending that specified level of effort could be interpreted as the primary regulatory requirement with a higher relative priority compared to achieving cumulative progress in scientific monitoring knowledge. Although this issue first surfaced at other range complexes, the updated FY12 MIRC monitoring plan was the first of any Navy range complex to implement the removal of quantitative metrics of monitoring effort, and to replace these with the qualitative requirement to report on progress made on each monitoring question defined in the monitoring plan. This goal of re-structuring the annual monitoring reporting (of C.F.R. §218.105(d)) to document such progress was achieved in the corresponding MIRC annual monitoring report submitted at the end of that monitoring year (DoN 2014).

The project descriptions for both categories of passive acoustic monitoring and visual survey were modified with new projects reflecting lessons learned, and lacked numerical metrics (Table 5). Visual surveys could be conducted at any time of year to capture seasonal data, and the option of utilizing a shore station was added due to lessons learned regarding the difficulty encountered in effectively surveying the windward waters of the islands with a small vessel.

Also alternate approaches to acoustic work were implemented. The use of a dipping hydrophone during marine mammal sightings by the vessel survey was added to the plan. One of the difficulties with PAM data analysis in the MIRC has long been the lack of prototype recordings from the Marianas where the species identification has been visually validated, in particular for species which may have variable acoustic characteristics in different water areas. Making recordings during visual sightings in the MIRC has the potential to eventually provide more return on investment by incrementally adding to the important library of acoustic samples. Therefore these techniques were added to the category of "acoustic monitoring" (Table 5).

The adjustments above were intended to better address the newly defined monitoring questions introduced in the 2012 monitoring plan update. At the same time, the introduction of the study questions required adding projects utilizing methodologies in addition to those listed (i.e., passive acoustic monitoring and visual survey) in the original 2010 plan. Therefore, as shown in the left column of Table 5, new monitoring projects were added within four new categories of methodologies: 1) Biopsy, 2) satellite-tagging, 3) Photo-ID and mark-recapture abundance estimates, and 4) sea turtle detection and analysis.

2013 Monitoring Plan Update. Due to lessons learned during the course of MIRC monitoring in FY12 and early FY13, adjustments were made via the 2013 update to the monitoring plan (Table 6) submitted as part of the 2013 annual monitoring report (DoN 2013b, p10). In the 2012 update, the purchase of biopsy supplies had been listed for FY13 onwards, but the biopsy performer, NMFS PIFSC, informed the Navy that it had sufficient biopsy supplies available in inventory for that year, but could benefit from the funding of genetic analysis of tissue samples obtained from biopsies collected in the MIRC to better address the monitoring question regarding odontocete population structure. Therefore for biopsy category, the purchasing component was removed for FY13 and replaced with processing and analysis; the goals for FY14 and FY15 were also redefined in order to remain flexible to facilitate a combination of purchase and analysis depending on emerging needs for optimal outcomes in biopsy-based monitoring tasks. For the satellite tagging category, support for deployment of tags was appended in addition to purchase of tags and analysis of tag data. With regard to the photo-ID category, analysis had been planned to begin in FY15, but the performer NMFS PIFSC informed the Navy that sufficient numbers of photographs had already been collected that processing work could most efficiently begin a year earlier. Therefore support for beginning the long term work of processing the photographs for incorporation into catalogs was added for FY14. Finally, as described in Section 3.3.1.1, the use of moored passive acoustic devices had been in progress since late FY10, but at this point in time the Navy had been re-evaluating this methodology due to emergent issues including device failures and technical challenges with analysis algorithms. Further investment in continuing this program seemed a suboptimal application of monitoring resources while questions still remained regarding both the hardware and

data analysis. Therefore deployment of further PAM devices was removed from the plan for FY13, with data analysis continuing in order to provide a solution for the ongoing acoustic data analysis from previous deployments. The dipping hydrophone technique during visual survey had been added in the 2012 update and was retained in the 2013 update. Also, through the partnership established with PIFSC, the opportunity became available to fund analysis of existing archived data from alternate autonomous acoustic devices that had been deployed by PIFSC further offshore. Finally, validation of new glider technologies that had the potential to make recordings significantly farther offshore within the MIRC, with device characteristics that could better detect and classify beaked whales and baleen whales, was initiated. Therefore FY14 was planned with the goal of deploying an unspecified acoustic device, collecting recordings during visual survey, and analyzing archived existing data, with the latter two planned to continue for FY15.

2014 Monitoring Plan Update. The subsequent MIRC monitoring plan update for FY14-15 (submitted with the April 2014 annual report [Don 2014]) placed further emphasis on the goal of making progress on monitoring questions. In all of the monitoring plans up to this point, specific monitoring projects had been listed according to monitoring methodology. However, another lesson learned from FY13 monitoring in the MIRC was that listing specific projects made planning less flexible to address emergent needs or opportunities. Already, specific projects had been modified to enable optimal monitoring in the 2012 and 2013 update, including: changing the specific biopsy techniques supported, adjusting the schedule for photo-ID tasks, adaptively adding a new passive acoustic methodology (dipping hydrophone), adjusting the schedule of existing PAM deployments and analysis, adding even making the new PAM deployment unspecified. While NMFS OPR had agreed to the removal of quantitative effort metrics and using a new focus on study questions (as implemented in the 2012 monitoring plan update) during the NMFS-Navy Adaptive Management meeting in October 2012, by 2014 it was clear that the process of incremental adjustments to the monitoring plan could be further improved.

With these lessons learned, development began on the 2014 update to the MIRC monitoring plan. The new plan, submitted as part of the April 2014 annual monitoring report (DoN 2014), directly integrated the five MIRC monitoring plan questions as a major component of the summary table of planned monitoring methods by incorporating these as rows (Table 6). Additionally the practice of predicting specific projects years in advance was removed; the list of such specific and predetermined monitoring projects was replaced with a list of general monitoring methodologies that could be applied to address each monitoring question, e.g., acoustic methodologies, visual survey methodologies, population structure analyses, and mark-recapture analyses. This change was made to optimally plan field projects and to facilitate the ability to dynamically respond to development of new technologies, lessons learned, and evolving scientific needs to best address the monitoring questions, without the need to annually modify the monitoring plan for small adjustments. In this way through actively applying learned experiences from the iterations of MIRC monitoring in the past five years, the Navy is planning for a thoughtfully considered and scientifically-sound basis to transition into an improved and effective TAP Phase II monitoring program for the MITT that may serve as a model for other range complexes or even other permitees.

3.1.1 Summary of Monitoring Plan Metrics

The incremental development of the MIRC monitoring plan described above in the overview of Section 3.1 is illustrated below in the summary tables of monitoring goals from each iteration of the monitoring plan. The years include the first year of 2010 (Table 4), as well as the years 2012, 2013, and 2014 when it was updated (Table 5, Table 6, Table 7, respectively). These monitoring plans were prepared for NMFS review as a component of the MIRC annual monitoring reports submitted in April of each year.

Table 4. First MIRC monitoring plan summary table (DoN 2010b).

	FY10	ADAPTIVE MANAGEMENT REVIEW (AMR)	FY11	AMR	FY12	AMR	FY13	AMR	FY14	AMR	FY15
Passive Acoustic Monitoring			Deploy four passive acoustic monitoring devices around the Mariana Islands that are capable of gathering data throughout the year.		Continue recording from PAM devices and begin data analysis.		Continue recording from PAM devices and conduct data analysis.		Continue recording from PAM devices and conduct data analysis.		Continue recording from PAM devices and conduct data analysis.
Acoustic Data Analysis			Analyze existing acoustic data set which was collected during Navy's 2007 MISTCS survey.								
Visual Surveys	- Small boat surveys around Guam, Tinian and Saipan. - Visual observations using marine species observers aboard NMFS/PIFSC oceanographic survey in the Region, as well as during transits between Hawaii and Guam.		Conduct summer and winter visual surveys using a small boat and/or airplane around Guam, Tinian, Rota and Saipan in cooperation with NMFS and/or DAWR. Visual surveys would integrate methods such as photo ID that provide data that can be used for distribution and abundance. 45 days total.		Conduct summer and winter visual surveys using a small boat and/or airplane around Guam, Tinian, Rota and Saipan in cooperation with NMFS and/or DAWR. Visual surveys would integrate methods such as photo ID that provide data that can be used for distribution and abundance. 45 days total.		Conduct summer and winter visual surveys using a small boat and/or airplane around Guam, Tinian, Rota and Saipan in cooperation with NMFS and/or DAWR. Visual surveys would integrate methods such as photo ID that provide data that can be used for distribution and abundance. 45 days total.		Conduct summer and winter visual surveys using a small boat and/or airplane around Guam, Tinian, Rota and Saipan in cooperation with NMFS and/or DAWR. Visual surveys would integrate methods such as photo ID that provide data that can be used for distribution and abundance. 45 days total.		Conduct summer and winter visual surveys using a small boat and/or airplane around Guam, Tinian, Rota and Saipan in cooperation with NMFS and/or DAWR. Visual surveys would integrate methods such as photo ID that provide data that can be used for distribution and abundance. 45 days total.

Table 5. Updated MIRC Monitoring Plan summary (DoN 2012a) included as part of the 2012 MIRC annual report

Quantitative effort-based metrics were removed in years FY13 and beyond; additional methodologies introduced to better answer new monitoring questions.

	FY10		FY11		FY12		FY13		FY14		FY15
Passive Acoustic Monitoring		ADAPTIVE MANAGEMENT REVIEW (AMR)	Deploy four passive acoustic monitoring devices around the Mariana Islands that are capable of gathering data throughout the year. Analyze existing acoustic data set which was collected during Navy's 2007 MISTCS survey.	AMR	Deploy four passive acoustic monitoring devices around the Mariana Islands that are capable of gathering data throughout the year. Analyze data from 4 PAM devices deployed in FY12	AMR	- Deploy PAM devices in the Mariana Islands that are capable of gathering data throughout the year. - Opportunistically collect acoustic recordings with a dipping hydrophone during visual survey effort. - Analyze data from PAM devices	AMR	- Deploy PAM devices in the Mariana Islands that are capable of gathering data throughout the year. - Opportunistically collect acoustic recordings with a dipping hydrophone during visual survey effort. - Analyze data from PAM devices	AMR	Opportunistically collect acoustic recordings with a dipping hydrophone during visual survey effort.
Visual Surveys	- Small boat surveys around Guam, Tinian and Saipan. - Visual observations using marine species observers aboard NMFS/PIFSC oceanographic survey in the Region, as well as during transits between Hawaii and Guam.		Conduct summer and winter visual surveys using a small boat and/or airplane around Guam, Tinian, Rota and Saipan in cooperation with NMFS and/or DAWR. Visual surveys would integrate methods such as photo ID that provide data that can be used for distribution and abundance. 45 days total.		Conduct summer and winter visual surveys using a small boat and/or airplane around Guam, Tinian, Rota and Saipan in cooperation with NMFS and/or DAWR. Visual surveys would integrate methods such as photo ID that provide data that can be used for distribution and abundance. 45 days total.		Conduct non-random, non-systematic visual survey or shore based surveys at any time of the year.		Conduct non-random, non-systematic visual survey or shore-based surveys at any time of the year.		Conduct non–random, non-systematic visual survey or shore-based surveys at any time of the year.
Biopsy							Purchase biopsy supplies to support biopsy attempts. Archive (preserve, extract DNA, sex) biopsy samples.		Purchase biopsy supplies to support biopsy attempts. Archive (preserve, extract DNA, sex) biopsy samples.		Purchase biopsy supplies to support biopsy attempts. Archive (preserve, extract DNA, sex) biopsy samples.
Satellite tagging							- Purchase satellite tags to support tagging attempts during visual surveys. - Analyze data from satellite tags.		- Purchase satellite tags to support tagging attempts during visual surveys. - Analyze data from satellite tags.		- Purchase satellite tags to support tagging attempts during visual surveys. - Analyze data from satellite tags.
Photo-ID and mark-recapture abundance estimates											Mark-recapture abundance estimate analysis for species with the highest likelihood of generating a statistically significant result.
Sea turtle distribution and density							Either line transect diving surveys or sea turtle tags along with analysis		Either line transect diving surveys or sea turtle tags along with analysis		Either line transect diving surveys or sea turtle tags along with analysis

Table 6. Updated MIRC Monitoring Plan summary included as part of the 2013 MIRC annual report (DoN 2013b)

	FY10		FY11		FY12		FY13		FY14		FY15
Passive Acoustic Monitoring		ADAPTIVE MANAGEMENT REVIEW (AMR)	Deploy four passive acoustic monitoring devices around the Mariana Islands that are capable of gathering data throughout the year. Analyze existing acoustic data set which was collected during Navy's 2007 MISTCS survey.	AMR	Deploy four passive acoustic monitoring devices around the Mariana Islands that are capable of gathering data throughout the year. Analyze data from 4 PAM devices deployed in FY12	AMR	-Opportunistically collect acoustic recordings with a dipping hydrophone during visual survey effort. - Analyze acoustic data	AMR	- Collect acoustic data using PAM devices - Opportunistically collect acoustic recordings with a dipping hydrophone during visual survey effort. - Analyze data from PAM devices	AMR	- Opportunistically collect acoustic recordings with a dipping hydrophone during visual survey effort. - Continue to analyze and remaining acoustic data
Visual Surveys	- Small boat surveys around Guam, Tinian and Saipan. - Visual observations using marine species observers aboard NMFS/PIFSC oceanographic survey in the Region, as well as during transits between Hawaii and Guam.		Conduct summer and winter visual surveys using a small boat and/or airplane around Guam, Tinian, Rota and Saipan in cooperation with NMFS and/or DAWR. Visual surveys would integrate methods such as photo ID that provide data that can be used for distribution and abun-dance. 45 days total.		Conduct summer and winter visual surveys using a small boat and/or airplane around Guam, Tinian, Rota and Saipan in cooperation with NMFS and/or DAWR. Visual surveys would integrate methods such as photo ID that provide data that can be used for distribution and abundance. 45 days total.		Conduct non-random, non-systematic visual survey or shore based surveys at any time of the year.		Conduct non-random, non-systematic visual survey or shore-based surveys at any time of the year.		Conduct non–random, non-systematic visual survey or shore-based surveys at any time of the year.
Biopsy							Archive (preserve, extract DNA, sex) biopsy samples.		Combination of purchasing biopsy supplies, collecting biopsy samples, archiving them and analyzing them.		Combination of purchasing biopsy supplies, collecting biopsy samples, archiving them and analyzing them.
Satellite tagging							Purchase, deploy tags and analyze satellite tag data		Purchase, deploy tags[1] and analyze satellite tag data		Purchase , deploy tags[1] and analyze satellite tag data
Photo-ID and mark-recapture abundance estimates									Continue to catalog photographs obtained during visual surveys		Continue to catalog photographs obtained during visual surveys and/or conduct meta-analysis of survey data which may include mark-recapture abundance estimates or other analyses likely to result in significant results
Sea turtle distribution and density							Either line transect diving surveys or sea turtle tags along with analysis		Either line transect diving surveys or sea turtle tags along with analysis		Either line transect diving surveys or sea turtle tags along with analysis

[1] Typo corrected. This table in the 2013 monitoring plan update omitted the word "tags" in the FY14 and FY15 cells and read: "Purchase, deploy and analyze satellite tag data".

Table 7. Updated MIRC Monitoring Plan FY14-FY15 summary included as part of the 2014 MIRC annual report (DoN 2014)

Years FY14 and FY15 were updated to organize goals by monitoring questions (see rows), and the goals listed for each question were specified by general methodology rather than specific project, to facilitate dynamic responses to development of new technologies, lessons learned, and evolving scientific needs to best address the monitoring questions.

Monitoring Plan Questions		Implementation goals		
		FY14		FY15
1. What species of beaked whales and other odontocetes occur around Guam and Saipan?	ADAPTIVE MANAGEMENT REVIEW (AMR)	-Continue acoustic methodologies *(may include analysis of previously collected moored PAM datasets, deployment of autonomous devices in offshore waters, and opportunistic dipping hydrophone recordings)* -Continue visual methodologies *(may include small boat surveys, shore-based surveys, satellite tagging)*	AMR	-Continue acoustic methodologies *(may include deployment of autonomous devices in offshore waters, however analysis of previously collected PAM data sets is likely to be prioritized over deployment of additional devices. Continue opportunistic dipping hydrophone recordings)* -Continue visual methodologies *(may include small boat surveys, shore-based surveys, satellite tagging)*
2. Are there locations of greater cetacean and/or sea turtle relative abundance around Guam and Saipan?		-Continue acoustic methodologies *(may include analysis of previously collected moored PAM datasets, deployment of offshore autonomous devices, and opportunistic dipping hydrophone recordings)* -Continue visual methodologies in multiple locations *(may include small boat surveys, shore-based surveys, diver surveys, satellite tagging)*		-Continue acoustic methodologies *(may include continued analysis of additional PAM datasets, or applying new analysis methods to previously-analyzed datasets; and/or deployment of offshore autonomous devices; and/or and opportunistic dipping hydrophone recordings)* -Continue visual methodologies in multiple locations *(may include small boat surveys, diver surveys, satellite tagging)*
3. What is the baseline abundance and population structure of odontocetes which may be exposed to sonar and/or explosives in the nearshore areas of Guam, Saipan, Tinian, and Rota?		-Continue population structure analyses *(may include collection and analysis of tissue samples)* - Continue mark-recapture photo ID collection and analysis		-Continue population structure analyses *(may include collection and analysis of tissue samples)* - Continue mark-recapture photo ID collection and analysis - Consider additional acoustic analysis methodologies of collected PAM datasets that may provide progress on this question
4. What is the seasonal occurrence of baleen whales around Guam, Saipan, Tinian, and Rota?		-Continue acoustic methodologies *(may include analysis of previously collected moored PAM datasets, deployment of offshore autonomous devices, and opportunistic dipping hydrophone recordings)* -Continue visual methodologies *(may include small boat and shore surveys, and opportunistic satellite tagging)* -Consider other methodologies		-Continue acoustic methodologies *(may include analysis of previously collected moored PAM datasets, deployment of offshore autonomous devices, and opportunistic dipping hydrophone recordings)* -Continue visual methodologies *(may include small boat and shore surveys, and opportunistic satellite tagging)*
5. What is the occurrence and habitat use of sea turtles in areas where the Navy conducts underwater detonations?		-Continue visual methodologies *(may include continued turtle observation on cetacean visual surveys, continued dedicated turtle survey; tagging and/or diver surveys)*		-Continue visual methodologies *(may include continued turtle observation on cetacean visual surveys, continued dedicated turtle survey; tagging and/or diver surveys)*

3.1.2 Monitoring goals and implementation

The tables below (Table 8; Table 9; Table 10; Table 11) describe the Navy's annual monitoring accomplishments in the MIRC as compared to the monitoring goals. The monitoring goals listed in these tables are sourced from the most recently updated monitoring plan for the applicable year from Section 3.1.1, above. Although the MIRC annual report was due and submitted April in every calendar year (DoN 2011, 2012b, 2013b, 2014), with descriptions of effort through mid-February of that year, the tables given below list monitoring accomplished through the entire fiscal year of that year. For example the end date for FY11 is 30 September 2012. For this reason the tables below do not exactly correspond to similar tables of accomplishments presented in the annual reports.

Table 8. FY10- Monitoring Goals and Implementation

Monitoring goals from 2010 MIRC Monitoring Plan (DoN 2010b)

Field Method	Monitoring Goal FY10	Total Accomplished Jan 2010-FY10
Visual Surveys	- Small boat surveys around Guam, Tinian and Saipan.	Small boat surveys around Guam, Tinian, and Saipan 9 Feb – 3 March 2010.
	- Visual observations using marine species observers aboard NMFS/PIFSC oceanographic survey in the Region, as well as during transits between Hawaii and Guam.	Visual observations using marine mammal observers aboard the following three NMFS PIFSC surveys aboard the large vessel Oscar Elton Sette (OES): - Cetacean visual and acoustic observations on the high-seas survey between Honolulu and Guam, 20 January – 6 February 2010 - Cetacean visual observations during daylight hours during the oceanography survey along the 144°W meridian between 11°N and 23°N, March 20 - April 11, 2010 - Cetacean visual and acoustic observations on the high-seas survey between Guam ,and Honolulu, 19 April – 3 May 2010

Table 9. FY11-12 Monitoring Goals and Implementation

Monitoring goals from 2010 MIRC Monitoring Plan (DoN 2010b)

Field Method	Monitoring Goal FY11-12	Total Accomplished FY11	Total Accomplished FY12
Passive Acoustic Monitoring	Deploy four passive acoustic monitoring devices around the Mariana Islands that are capable of gathering data throughout the year. - After FY11: Continue recording from PAM devices and begin data analysis.	Deployed four passive acoustic monitoring devices (Ecological Acoustic Recorders [EARs]) around Guam, Saipan and Tinian in September 2011 (i.e., late in FY10).	One-year deployments accomplished by recovering, servicing, and redeploying for a second 6 month deployment in April 2012.
Acoustic Data Analysis	Analyze existing acoustic data set which was collected during Navy's 2007 MISTCS survey.	Analyzed existing acoustic data set from 2007 MISTCS survey.	Additionally the report was updated in FY12-13 when new analysis methodologies for estimating sperm whale detection functions had matured and became available.
Visual Surveys	Conduct summer and winter visual surveys using a small boat and/or airplane around Guam, Tinian, Rota and Saipan in cooperation with NMFS and/or DAWR. Visual surveys would integrate methods such as photo ID that provide data that can be used for distribution and abundance. 45 days total.	. 49 field days of summer and winter visual surveys using a small boat around Guam, Saipan, Tinian, Rota, and Aguijan. 12,612 photographs were collected for use in photographic identification studies. . Cooperation by local observers from PIRO-Guam, PIFSC-Guam, HDR-Guam, CNMI-DFW, CNMI-CRM, CNMI-DEQ, and CNMI-PSS. - (15 days) HDR 17 Feb – 3 March 2011 off Guam - (11 days) PIFSC 26 Aug-5 Sept 2011 off Guam - (23 days) PIFSC 7-29 Sept 2011 off Saipan, Tinian, Rota, Aguijan	54 field days of summer and winter visual surveys using a small boat around Guam, Saipan, Tinian, Rota, and Aguijan. 12,895 photographs were collected for use in photographic identification studies. Cooperation by local observers from PIFSC-Guam, PIRO-Guam, CNMI-DRW, CNMI-PIRO, CNMI-CRM, and CNMI-PSS. - (15 days) HDR 15-29 March 2012 off Guam and Saipan - (12 days) PIFSC 25- 28 May and 26 June – 3 July 2012 off Guam - (27 days) 29 May -24 June 2012 off Saipan, Tinian, Rota, Aguijan

Table 10. FY13 Monitoring Goals and Implementation

Monitoring goals from 2012 update to MIRC Monitoring Plan (DoN 2012b)

Field Method	Monitoring Goal FY13	Total Accomplished FY13
Passive Acoustic Monitoring (PAM)	-Deploy PAM devices in the Mariana Islands that are capable of gathering data throughout the year.	The second deployment of EARs was recovered in January 2013; one of the four devices was lost and not recovered. Devices were not redeployed at this time as to await data analysis results to inform selection of future methods.
	Opportunistically collect acoustic recordings with a dipping hydrophone during visual survey effort.	Opportunistically collected acoustic recordings with a dipping hydrophone during visual survey effort (PIFSC); also performed in HDR March 2012 and PIFSC May-June 2012 surveys in FY12.
	Analyze data from PAM devices	Derived strategy for PAM data analysis; acoustic data analysis in progress.
Visual Surveys	Conduct non-random, non-systematic visual survey or shore based surveys at any time of the year.	HDR spring shore-based visual surveys on Guam 11-20 May 2013. PIFSC summer visual surveys using a small boat around Guam, Saipan, Tinian, Rota, and Aguijan 22 June – 27 July, 2013.
Biopsy	Purchase biopsy supplies to support biopsy attempts. Archive (preserve, extract DNA, sex) biopsy samples.	NMFS already had enough biopsy supplies, so through adaptive management the Navy funded collection of biopsy samples during visual surveys and analysis of archived samples. Accordingly, the 2013 update to the monitoring plan (DoN 2013b p10) revised this requirement for FY13 to: "Archive (preserve, extract DNA, sex) biopsy samples." Navy funded collection of biopsy samples during visual surveys and analysis of archived samples.
Satellite Tagging	Purchase satellite tags to support tagging attempts during visual surveys. Analyze data from satellite tags.	Satellite tags were purchased were used during summer survey. Analysis began after this survey.
Photo-ID and mark-recapture abundance estimates	(none in FY13)	Funded NMFS to catalog all photos collected from 2010 to present. Catalogs have been created for the three most commonly observed species.
Sea Turtle Distribution and Density	Either line transect diving surveys or sea turtle tags along with analysis	PIFSC sea turtle tagging project at Guam and Tinian funded and field effort started with successful tags deployed during field effort 15-21 August 2013.

Table 11. FY 14 Monitoring Goals and Implementation

Monitoring goals from 2013 update to MIRC Monitoring Plan Update (DoN 2013b, p10)

Field Method	Monitoring Goal FY14	Total Accomplished FY14
Passive Acoustic Monitoring (PAM)	Collect acoustic data using PAM devices	Two high frequency autonomous deep diving acoustic gliders deployed for 30-day survey in late September 2014 offshore of Guam and Saipan (HDR/OSU/UW).
	Opportunistically collect acoustic recordings with a dipping hydrophone during visual survey effort.	Opportunistic collected acoustic recordings collected during visual survey effort
	Analyze data from PAM devices	Acoustic data analyzed from seven EARs (three off Guam, two off Saipan, and two off Tinian) deployed in 2011 and 2012; further analysis in progress
		Preliminary analysis of acoustic data from 2 PIFSC-deployed HARPs off Saipan and Tinian; further analysis in progress
		Completed final report for analysis of sperm whale (*Physeter macrocephalus*) towed array acoustic data from MISTCS large vessel survey (2007)
Visual Surveys	Conduct non-random, non-systematic visual survey or shore-based surveys at any time of the year.	Completed final report for shore-based visual surveys on Guam during May 2013
		Completed final report for PIFSC small-vessel visual surveys around Guam, Tinian, Rota, Aguijan and Saipan during June–July 2014
		PIFSC small-vessel visual surveys around Guam, Tinian, Rota, Aguijan and Saipan during 11-27 April 2014.
		PIFSC small-vessel visual surveys around Guam, Tinian, Rota, Aguijan and Saipan during 15 May—20 June 2014
		Completed final summary report compiling analysis from all PIFSC surveys (and some HDR survey data) during 2010—April 2014, including analysis from biopsy, satellite tagging, and photo-ID/mark-recapture analysis.
Biopsy	Combination of purchasing biopsy supplies, collecting biopsy samples, archiving them and analyzing them.	Seventy-six biopsy samples were collected from eight cetacean species and eight sloughed skin samples from sperm whales. Six biopsy samples were obtained, four from green (*Chelonia mydas*) and two from hawksbill (*Eretmochelys imbricata*) sea turtles. Analysis of tissue samples funded, including stable-isotope analysis on the turtle samples. Biopsy analysis completed for 2010—April 2014 (see bottom cell for under visual survey, above in this table column)

Field Method	Monitoring Goal FY14	Total Accomplished FY14
Satellite Tagging	Purchase , deploy tags and analyze satellite tag data	Ten satellite tags deployed on four species of cetaceans, with analysis funded. Satellite tag analysis completed for 2010—April 2014 (see bottom cell for completed report under visual survey, above in this table column)
Photo-ID and mark-recapture abundance estimates	Continue to catalog photographs obtained during visual surveys	Cataloged all photos collected from 2010 to April 2014. First analysis completed (see bottom cell under visual survey, above in this table column). Catalogs have been created for the three most commonly observed species—spinner dolphins (*Stenella longirostris*), short-finned pilot whales (*Globicephala macrorhynchus*), common bottlenose dolphins (*Tursiops truncatus*). Discovery curves and abundance estimates are being updated for the 2013 season.
Sea Turtle Distribution and Density	Either line transect diving surveys or sea turtle tags along with analysis	6 satellite tags deployed on green and hawksbill sea turtles off Tinian; attempts were made at Cocos, Guam but turtles eluded capture and no tags were deployed. Analysis to be available for FY15 reporting period. Most satellite tag tracks have been analyzed but some tags are still transmitting and providing data. Line transect dive surveys also occurred off Tinian. New survey in 2014 succeeded in tagging turtles in Apra Harbor, Guam; analysis is in progress. Additionally, line transect surveys were conducted by divers off Tinian and will be repeated in 2015.

3.2 Chronological timeline of monitoring in Mariana Islands Range Complex

The central focus of this report is the 5-year monitoring period commencing in January 2010, but it is important to consider monitoring activities performed in 2007 prior to the official start of Phase 1 MMPA LOA marine species monitoring. Taking into account the monitoring activities of 2007 provides the appropriate context for the development of the original MIRC Monitoring Plan (DoN 2010b). Before 2007, available literature on marine mammal presence around the Mariana Islands was largely data-deficient and not based on any dedicated marine mammal field studies (e.g., see Eldredge 1991; Eldredge 2003). This state of knowledge serves as the baseline for measuring the progress made since the monitoring program was initiated in 2010.

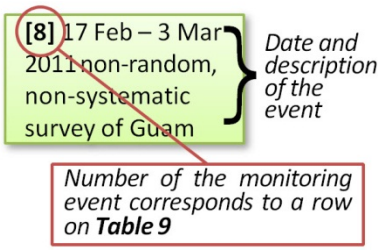
A graphical timeline that is a graphic representation for understanding the progression of monitoring events is provided immediately below in Figure 2. Accompanying this graphic timeline is Table 12, which provides detail to the numbered monitoring events from the timeline graphic such that there is a row on the table for every green box on the timeline. See Box 1 for a key to reading the timeline.

At the time of writing this report, all five years of monitoring and associated reporting for MMPA LOA compliance have not been completed. The graphical monitoring timeline (Figure 2) and Table 12 contain monitoring efforts that are completed, efforts that are ongoing, and efforts that are planned for later in the fifth monitoring year and beyond.

Box 1. Key to the Monitoring Timeline (Figure 2)

General Layout

- Time proceeds from left to right. The calendar years are labeled at the top of the page with the first and last months of the year labeled in the blue box.
- The black horizontal lines are timelines for types of monitoring activities. On the first page of the graphical timeline (2007-2009), there are three types: vessel surveys (top line), acoustic surveys (second line from the top), and aerial surveys (bottom line). On the second and third pages (2010-2015), there are five types: vessel or shore-based visual surveys (top line); acoustic surveys (second line from top); biopsy sampling (third line from top); Photo-identification (fourth line from top), and tagging (bottom line). On the third page (2013-2015), listed below the bottom line are activities that do not correspond to the above categories. The vertical lines along these black horizontal timelines correspond with the end of one calendar year and the beginning of the next calendar year.
- The background gray shaded areas signify the "monitoring year," which is a 12-month period within which the monitoring activities encompassed in that period are reported.. These monitoring years are labeled by yellow boxes and black arrows at the bottom of the page.
- Green boxes signify individual monitoring efforts. There is a numbered row in Table 12 for every green box on the monitoring timeline. The figure to the left explains how to interpret the text and numbers in the green boxes. Green boxes are placed relative to the horizontal black lines during the general span of time during the year when the event took place. The amount of text dictated the size of boxes, so the actual span of time covered by monitoring activities is not accurately represented.



  - Red vertical lines connect multiple activities that were integrated within the same field project.
  - Purple circles with black arrows highlight significant monitoring events. The arrows direct your attention to monitoring effort during which the significant event took place.
- Small orange boxes at the top (above the calendar years) with numbers preceded by the letter "E" (E1, E2, E3, etc.) represent other events related to the monitoring program, and correspond to similarly numbered rows in Table 12 that describe the event.
- Blue boxes signify a monitoring effort not funded through Navy funding, but provided as context for later green squares where Navy subsequently funded analyses of these data.

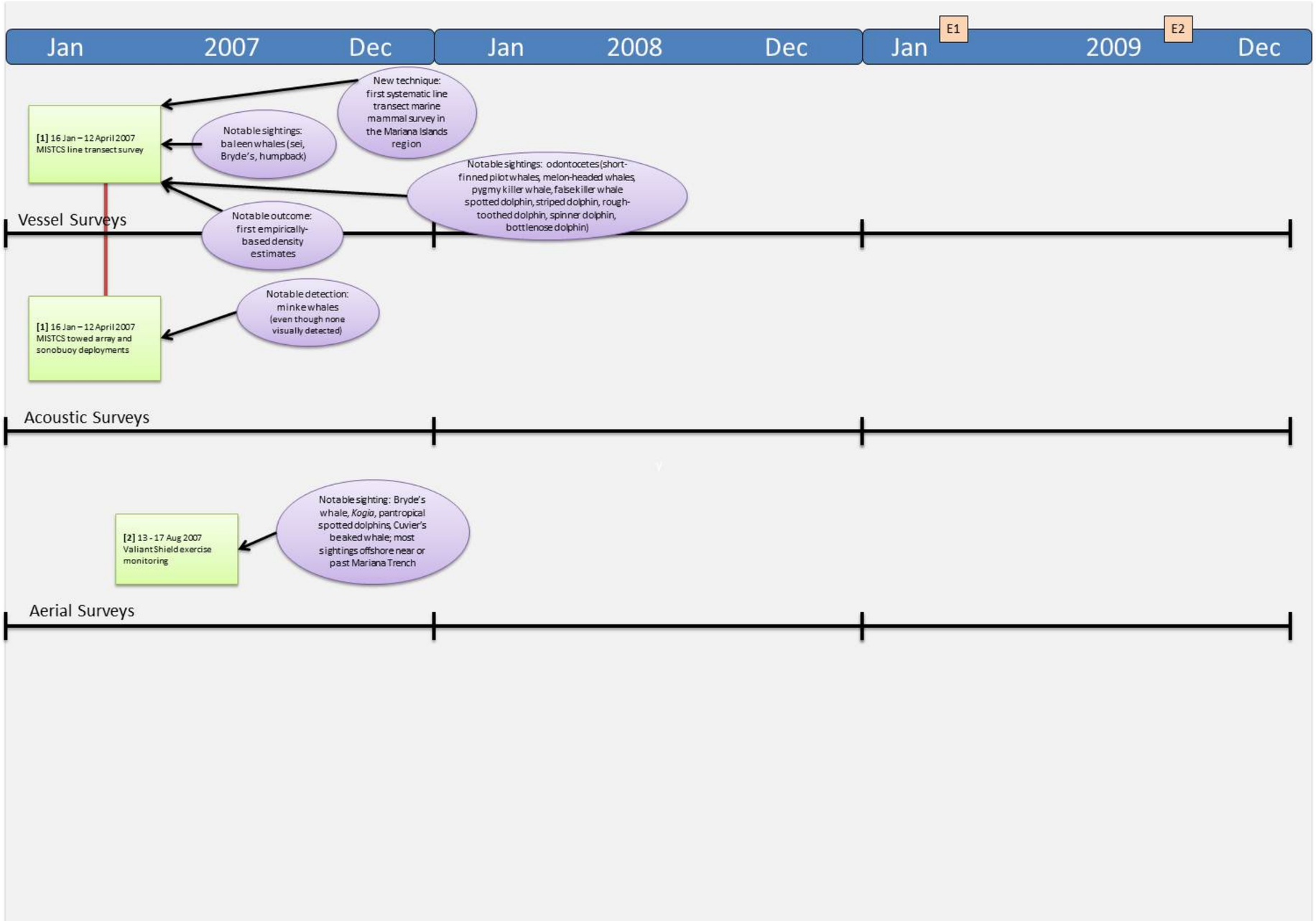


Figure 2. Monitoring Timeline

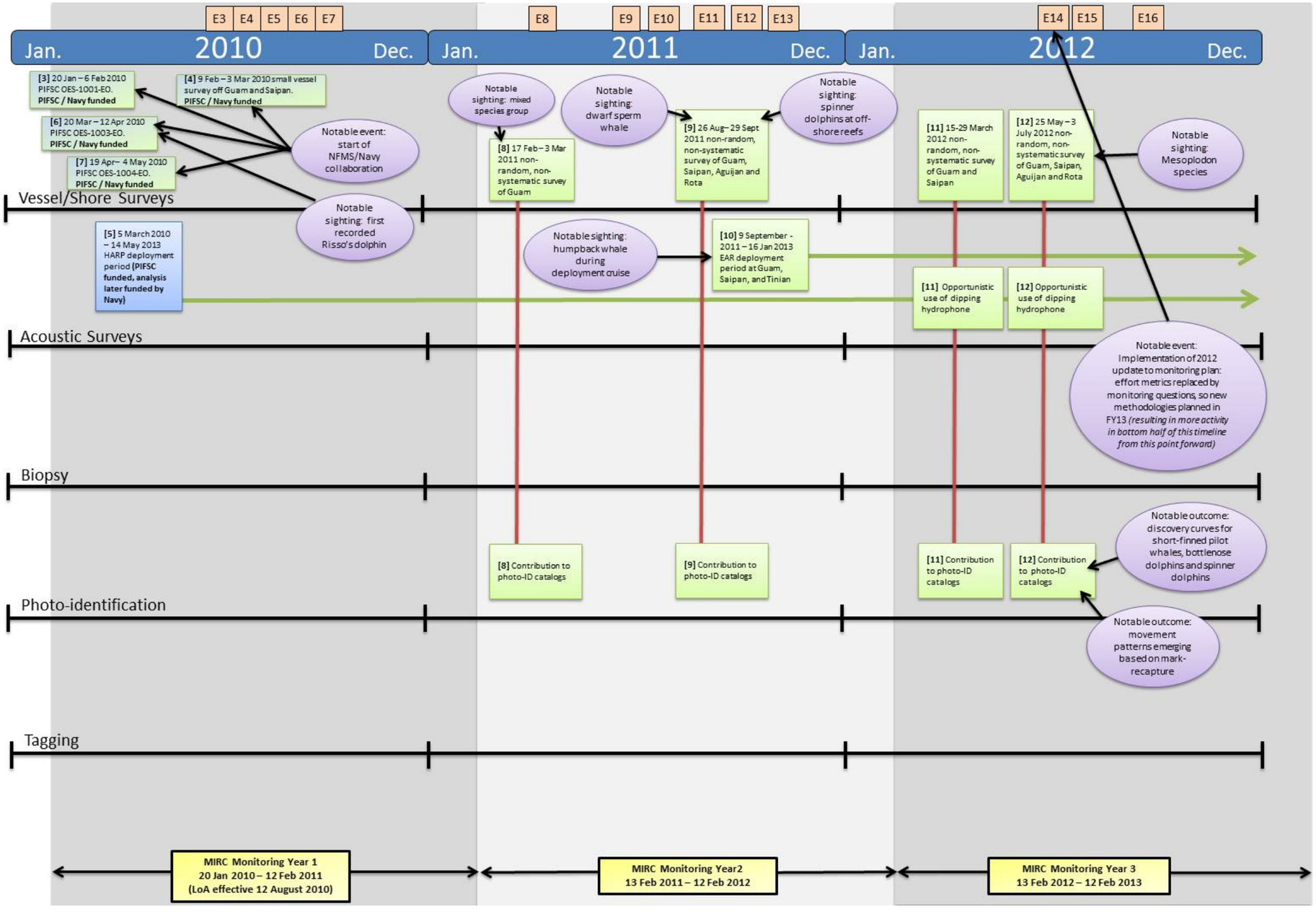


Figure 2 Monitoring Timeline (continued)

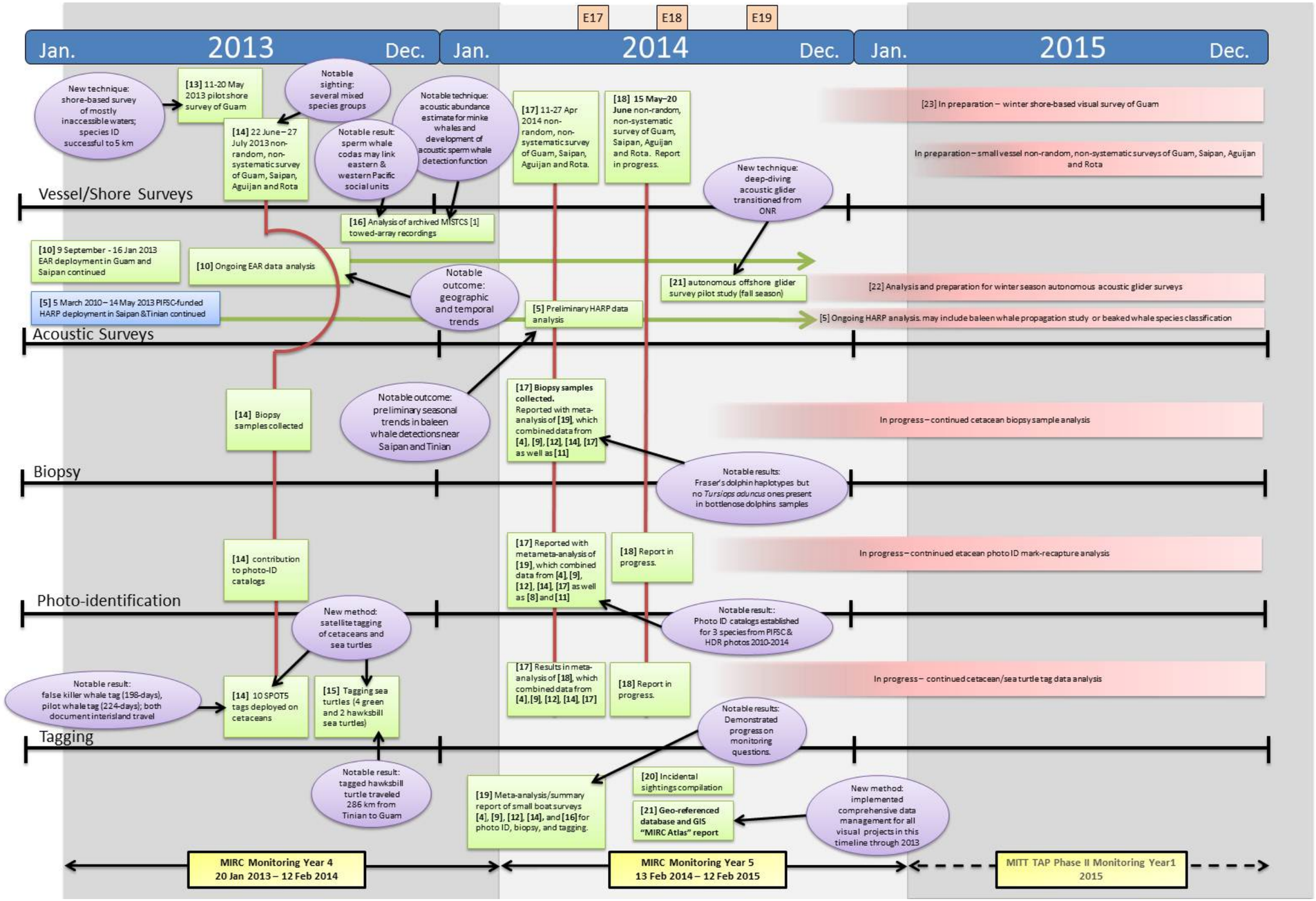


Figure 2 Monitoring Timeline (continue

Table 12. Description of Monitoring Efforts and Key Events Related to Monitoring.

Row numbers correspond to Green Monitoring Boxes and Orange Event boxes of the timeline graphic in Figure 2.

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/ Conclusions/Sightings (citations at top)
1	16 Jan – 12 April 2007 **(MISTCS)**	Mariana Islands Range Complex (entire)	• Baseline occurrence of sea turtles and cetaceans • Density estimates	• Visual line-transect (large vessel) • Towed acoustic array • Sonobuoys	• Sei whale • Bryde's whale • Sei or Bryde's whale • Balaenoptera spp. • Humpback whale • Sperm whale • Minke whale • Short-finned pilot whale • Melon-headed whale • Pygmy killer whale • False killer whale • Pantropical spotted dolphin • Striped dolphin • Spinner dolphin • Rough-toothed dolphin • Bottlenose dolphin • Mesoplodon spp. • Ziphiid whale • Unid. small delphinid • Unid. medium delphinid • Unid. large delphinid • Unid. dolphin • Unid. small whale • Unid. large whale • Unid. whale • Unid. cetacean • Hawksbill sea turtle	*DoN 2007; Fulling et al. 2011* • First estimated densities for sperm whale, sei whale, Bryde's whale, false killer whale, short-finned pilot whale, melon-headed whale, pygmy killer whale, pantropical spotted dolphin, striped dolphin, pacific bottlenose dolphin, spinner dolphin, and rough-toothed dolphin in the Mariana Islands Range Complex. • First verified record of minke whales in MIRC • Sei whales sighted when not expected to occur below 20°N • Abundance estimates for minke whales based on acoustic detections • Minke whales found on the east side of the archipelago but not the west • Sperm whale codas may link eastern and western social units
2	13-17 Aug 2007	Guam and Rota coastlines;	• Valiant Shield exercise monitoring for impacts	• Visual line transect survey (aerial)	• Bryde's whale • Pygmy or dwarf sperm whale • Spotted dolphin	*Mobley 2007* • No evidence of impacts, unusual behaviors, or stranding was observed

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/ Conclusions/Sightings (citations at top)
		southeast of Guam and Rota			• Rough-toothed dolphin • Cuvier's beaked whale • Unidentified dolphin • Unidentified turtle	
E1	**19-20 February 2009 – OPNAV N45 Marine Mammal Monitoring Workshop, R. David Thomas Executive Conference Center, Duke University, Durham, North Carolina**					
E2	**October 2009 – Adaptive Management Meeting, NMFS & Navy, Arlington, Virginia**					
3	20 Jan – 6 Feb 2010 (PIFSC OES-1001-EO)	Transit from Hawaii to Guam via Wake Island	• Baseline occurrence, abundance, population structure, change in relative abundance of prey species, oceanographic data	• Visual line transect survey (large vessel) • Photo-identification	• Sei whale or Bryde's whale • Unidentified small whale • Unidentified rorqual • Sperm whale • Striped dolphin • Unidentified small dolphin • Sei whale • False killer whale • Unidentified medium dolphin • Mesoplodon species • Melon-headed whale • Unidentified dolphin • Minke whale • Humpback whale • Fin whale	*PIFSC 2010a; Oleson & Hill 2010* • First dedicated marine mammal survey effort since 2007 • Leveraged platform of opportunity for cost-effective survey effort
4	9 Feb – 3 March 2010	Guam, Tinian, Saipan	• Occurrence of nearshore cetaceans	• Small vessel visual survey (non-random non-systematic) • Photo-identification • Analysis of biopsy samples	• Spinner dolphin • Sperm whale • Pantropical spotted dolphin • Unidentified medium dolphin	*Ligon et al. 2011; Oleson & Hill 2010* • Sperm whale fluke identification photos • Spinner dolphins regularly encountered at Agat Bay (popular for dolphin watching tourism) • Winter months described as "windy season" resulting in unfavorable survey conditions however pre-storm doldrums

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/ Conclusions/Sightings (citations at top)
						could provide windows of opportunity • Anecdotal reports from fishing and tourism offered some potential insight to presence of various species, including humpbacks
5	5 March 2010 – 14 May 2013 [Device deployments were funded entirely by PIFSC; dates reflect deployment dates, not Navy-funded analysis dates.]	Saipan, Tinian	• PIFSC long-term data set for baseline occurrence and relative seasonal abundance • Navy-funded analysis to contribute to monitoring questions[2]	• Navy-funded analysis of archived acoustic recordings from moored passive acoustic monitoring using High-frequency Acoustic Recording Packages (HARPs).	• Fin whale • Blue whale • Humpback whale • Minke whale • Unidentified whale • Cuvier's' beaked whale • Blainville's beaked whale • Unidentified beaked whale	*Oleson 2014* • Detections indicate that beaked whales occur year-round at both sites at Saipan and Tinian • Preliminary results of baleen whale seasonality at each island • Analysis is on-going and final report in progress.
6	20 March – 12 April 2010 (PIFSC-OES-1003-RD)	Guam and the southern portion of the Northern Mariana Islands	• Baseline occurrence, oceanographic data	• Visual line transect survey (large vessel)	• Unidentified small dolphin • Unidentified dolphin • Unidentified medium dolphin • Risso's dolphin • Short-finned pilot whale • Striped dolphin	PIFSC 2010b; Oleson & Hill 2010 • Sighting of Risso's dolphins
7	19 April – 4 May 2010	Transit from Hawaii to Guam	• Baseline occurrence, abundance, population structure, change in relative abundance of prey species,	• Visual line transect survey (large vessel) • Photo-identification	• Pantropical spotted dolphin • Unidentified dolphin • Sei whale or Bryde's whale • Unidentified rorqual • False killer whale	PIFSC 2010c; Oleson & Hill 2010 • Minke whales detected acoustically but not visually • Sperm whales detected visually and acoustically

[2] What species of beaked whales and other odontocetes occur around Guam and Saipan? What is the seasonal occurrence of baleen whales around Guam, Saipan, Tinian, and Rota?

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/ Conclusions/Sightings (citations at top)
			oceanographic data		• Unidentified dolphin • Melon-headed whale • Sperm whale • Short-finned pilot whale • Unidentified large whale • Spinner dolphin • Minke whale	
E3	**17-18 June 2010 – Marine Species Monitoring Contract Kickoff and Coordination Meeting, Navy and HDR|EOC, Marriott Hotel, San Diego, California**					
E4	**28 June 2010 – Programmatic Biological Opinion for U.S. Navy Training and Testing in MIRC from June 2010 to June 2015 issued**					
E5	**3 August 2010 – Final Rule published in the Federal Register on the taking of marine mammals in the MIRC.** **Beginning of MIRC monitoring program in support of the MIRC EIS.**					
E6	**19 October 2010 – Navy Marine Species Monitoring Review Meeting, NMFS, Navy, HDR|EOC, Contractors, & Marine Scientists, Arlington, Virginia**					
E7	**20 October 2010 – Adaptive Management Meeting, NMFS & Navy, Arlington, Virginia**					
8	17 Feb – 3 March 2011	Guam	• Baseline occurrence •	• Small vessel visual survey (non-random, non-systematic) • Photo-identification	• Spinner dolphin • Short-finned pilot whale • Bottlenose dolphin • Unidentified small dolphin • Green sea turtle	*HDR 2011* • Sea conditions not conducive to line-transect. Windward side of the island not accessible due to sea conditions. • Mixed group of bottlenose dolphins and pilot whales sighted • In-water sea turtle sightings
E8	**1-2 March 2011 – Scientific Advisory Group Meeting, HDR|EOC Offices, San Diego, California**					
E9	**8-9 June 2011 - Marine Mammal Monitoring Workshop, public meeting, Arlington, Virginia**					
E10	**9 August 2011 – 2011 Biological Opinion for U.S. Navy Training and Testing in MIRC from August 2011 to August 2012 issued**					
9	26 Aug – 29 Sept 2011	Guam, Saipan, Tinian, Aguijan, Rota	• Baseline occurrence • Population structure	• Small vessel visual survey (non-random, non-systematic) • Photo-identification • Analysis of biopsy sampling	• Bottlenose dolphin • Spinner dolphin • Pantropical spotted dolphin • Short-finned pilot whale • Pygmy killer whale • Dwarf sperm whale	Hill et al. 2011 • Distinctive bottlenose dolphins observed off the southeast side of Saipan were observed on another day on the northwest side of Tinian. • Distinctive spinner dolphins were recognized between sightings off Rota

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/ Conclusions/Sightings (citations at top)
					• Unidentified medium delphinid • Unidentified small delphinid	• An off effort pilot whale sighting was of a distinctive individual from an on effort sighting • Spinner dolphins and a single dwarf sperm whale were observed at off shore reefs near Saipan, Tinian and Rota. Spinner dolphins sighted at Marpi Reef.
10	9 Sept 2011 – 16 Jan 2013	Guam, Saipan, Tinian	• Baseline occurrence • Contribute to monitoring questions[3]	• Moored passive acoustic monitoring using Ecological Acoustic Recorders (EARs)	• Minke whale • Humpback whale • Sperm whale • Beaked whales (not classified to species) • High-frequency delphinids (not classified to species) • Low-frequency delphinids (not classified to species) • Incidental visual sightings (Humpback whale, pantropical spotted dolphin) made during transit to EAR deployment and integrated into [19]	*Munger et al. 2014* • Acoustic activity levels of dolphins varied between sites which could be a result of different densities, residence times, and/or behavioral states • There were site-specific differences in dolphin species assemblages based on whistle classes (high-frequency, low-frequency) • Temporal trends in dolphin occurrence varied between sites • Peaks/clusters of dolphin occurrence at Tinian and Saipan showed rough 6-10 day periodicity which may indicate a relationship with a tidal or lunar cycle • MFAS was detected at Guam on 3 occasions, Saipan on 1 occasion and on zero occasions at Tinian • Sei whales have not yet been detected • M3R output suggests regular beaked whale occurrence with most foraging

[3] What species of beaked whales occur in offshore areas of the MIRC adjacent to Guam and Saipan? What is the seasonal occurrence of baleen whales in offshore areas of the MIRC adjacent to Guam and Saipan? What is the seasonal occurrence of sperm whales in offshore areas of the MIRC adjacent to Guam and Saipan? What species of delphinds occur in offshore areas of the MIRC adjacent to Guam and Saipan? Is MFAS present in the EAR data sets? Were high frequency Sei whale calls detected on any EARs?

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/ Conclusions/Sightings (citations at top)
						occurring at night. Additional validation and interpretation are on-going • This EAR data set was not optimal for baleen whale questions based on deployment period and recording parameters • Validation and interpretation of the M3R output for sperm whales and beaked whales are pending
E11	**22-23 September 2011 – Navy Passive Acoustic Monitoring Working Group, Scripps Institute of Oceanography, La Jolla, California**					
E12	**13 October 2011 – Regional scientific advisory group (rSAG) teleconference**					
E13	**20 October 2011 – Adaptive Management Meeting, NMFS & Navy, Arlington, Virginia**					
11	15-29 March 2012	Guam, Saipan	• Baseline occurrence	• Small vessel visual survey (non-random non-systematic) • Photo-identification • Dipping hydrophone recording	• Pantropical spotted dolphin • Short-finned pilot whale • Spinner dolphin • Melon-headed whale • Bottlenose dolphin • Sperm whale • Green turtle • Unidentified hard-shell turtle • Manta ray	*HDR 2012* • 21 hydrophone recordings collected during sightings
12	25 May - 3 July 2012	Guam, Saipan, Tinian, Aguijan, Rota	• Baseline occurrence • Population structure	• Small vessel visual survey (non-random, non-systematic) • Photo-identification • Analysis of biopsy samples • Dipping hydrophone recording	• Bottlenose dolphin • Spinner dolphin • Pantropical spotted dolphin • Short-finned pilot whale • Unidentified small whale • Unidentified Mesoplodon spp. • Unidentified Ziphiid • Green sea turtle	*Hill et al. 2013a* • A short-finned pilot whale sighted off Ritidian Pt. was matched to a 2011 sighting off of Rota • First time sightings of Bottlenose dolphins, pantropical spotted dolphins and Mesoplodon species off of Rota • Spinner dolphins sighted at Marpi Reef • Possibly mating green sea turtles sighted near Rota

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/ Conclusions/Sightings (citations at top)
					• Hawksbill sea turtle • Unidentified hard-shell turtle	• A single hawksbill sighted near Saipan • Discovery curves generated for short-finned pilot whales, bottlenose dolphins and spinner dolphins • Short-finned pilot whales, bottlenose dolphins and spinner dolphins are moving between islands. Pilot whales and bottlenose dolphins moved between the islands of CNMI and between Guam and the islands of CNMI. Spinner dolphins moved between the islands and Marpi Reef within CNMI.
E14	**31 July 2012 – Letter of Authorization for Navy exercises conducted in the MIRC from 12 August 2012 to 3 August 2015 issued. Effort-based metrics removed, monitoring questions added, and new techniques planned via 2012 update to MIRC monitoring plan submitted in April**					
E15	**31 July 2012 –Biological Opinion for U.S. Navy Training and Testing in MIRC from 12 August 2012 to 3 August 2012 issued**					
E16	**25 October 2012 – Adaptive Management Meeting, NMFS & Navy, Arlington, Virginia**					
13	11-20 May 2013	Guam	• Feasibility pilot study of shore station survey of windward side of the island, where sea conditions make vessel surveys infrequent	• Visual shore station survey pilot study using big-eye binoculars, hand held binoculars, super-telephoto, and theodolite	• Short-finned pilot whale • Spinner dolphin • Unidentified small dolphin • Unidentified medium cetacean • Unidentified small whale • Green turtle • Unidentified hard-shell turtle	*Deakos et al. 2014* • Species profile and sighting frequency comparable to typical small vessel survey results in the Marianas of same duration. Results show shore-based survey may be an effective platform for areas that can be problematic for small vessels. Cost-effective for survey of windward side. • Species identification made at maximum distance of 5.8 km (short-finned pilot whales) • Nearshore spinner dolphins and sea turtles sighted daily, mostly multiple times. • Innovative method for locating big eye sightings in both theodolite for fixes and super-telephoto camera for species ID. • Elevation and fix accuracy estimated for two shore stations, with preliminary

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/ Conclusions/Sightings (citations at top)
						understanding of sighting ranges for different species under various conditions
14	22 June – 27 July, 2013	Guam, Saipan, Tinian, Aguijan, Rota	• Baseline occurrence • Population structure	• Visual non-random, non-systematic survey (small vessel) • Photo-identification • Analysis of biopsy samples • Satellite tagging	• Bottlenose dolphin, • False killer whale • Pantropical spotted dolphin • Pygmy killer whale • Rough-toothed dolphin • Short-finned pilot whale • Sperm whale • Spinner dolphin • Green sea turtle • Unidentified turtle	*Hill et al. 2013b* • First use of satellite tags. 10 satellite tags deployed on bottlenose dolphins (2), false killer whales (4), rough-toothed dolphins (1) and short-finned pilot whales (3) • 3 mixed species groups sighted. 1) short-finned pilot whales/bottlenose dolphins; 2) false killer whales/bottlenose dolphins and 3) rough-toothed dolphins/bottlenose dolphins/spinner dolphins. • 76 biopsy samples collected on 8 species
15	15-21 August 2013	Guam, Saipan, Tinian	• Contribute to monitoring questions[4]	• Sea turtle tagging	• Green sea turtle • Hawksbill sea turtle	*Jones and Van Houtan 2014* • 4 green sea turtles and 2 hawksbill sea turtles were tagged off Saipan /Tinian. Preliminary data suggests habitat fidelity for both species. • A hawksbill sea turtle tagged at Tinian traveled 286 km to Guam • Kernel density estimate of habitat use computed for green and hawksbill sea turtles • Cocos Lagoon green sea turtles were evasive and difficult to hand-capture. • Dive data suggests that both species remain in deeper waters during daylight hours and move nearshore at night. The hawksbills spent more time in deep water than green sea turtles.

[4] Are there locations of greater cetacean and/or sea turtle concentration around Guam, Saipan and Tinian? What is the occurrence and/or habitat use of sea turtles in areas that the Navy conducts underwater detonations?

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/ Conclusions/Sightings (citations at top)
16	16 Jan – 12 April 2007	Mariana Islands Range Complex (entire)	• Mariana Islands Range Complex (entire)	• Acoustic analysis of archived MISCTS towed array recordings	• Minke whale • Sperm whale • Humpback whale • Sei whale • Short-finned pilot whale • False killer whale • Melon-headed whale • Pantropical spotted dolphin • Spinner dolphin • Rough-toothed dolphin • Bottlenose dolphin	*Norris et al, 2012* • Minke whale acoustically-based abundance estimate • Detection function for sperm whales • Sperm whale coda analysis and comparison to codas from different regions • Characterization of humpback whale song and comparison to Hawaiian humpback whale song units • Characterization of variable sei whale call types for waters of the Marianas • Progressive validation of classifiers for whistles
E17	**3-4 April 2014 – Adaptive Management Meeting, NMFS & Navy, Arlington, Virginia**					
17	11 -27 April 2014		• Contribute to monitoring questions[5]	• Visual non-random, non-systematic survey (small vessel) • Photo-identification • Analysis of biopsy samples • Satellite tagging	• Spinner dolphin • Bottlenose dolphin • Melon-headed whale • Pantropical spotted dolphin • Pygmy killer whale • Rough-toothed dolphin	*Hill et al. 2014* • Mixed-species encounter of bottlenose dolphins and rough-toothed dolphins off Aguijan • First encounter with melon-headed whales. Was a large (>300) group. Later in survey encountered a different group of the same species. • Sighted same group of pygmy killer whales as May 2013; sighting this year included a new calf. • See also outcomes for #18 below for all

[5] What species of beaked whales and other odontocetes occur around Guam and Saipan? Are there locations of greater relative cetacean abundance around Guam and Saipan? What is the baseline abundance and population structure of odontocetes which may be exposed to sonar and/or explosives in the near shore areas of Guam, Saipan, Tinian, and Rota? What is the seasonal occurrence of baleen whales around Guam, Saipan, Tinian, and Rota?

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/ Conclusions/Sightings (citations at top)
						2010-2014 PIFSC surveys. Results for this April 2014 survey were integrated within that report.
18	15 May—20 June 2014		• Contribute to monitoring questions	• Visual non-random, non-systematic survey (small vessel) • Photo-identification • Biopsy sampling • Satellite tagging	• Short finned pilot whale • False killer whale • Bottlenose dolphin • Pantropical spotted dolphin • Spinner dolphin • Cuvier's beaked whale • Blainville's beaked whale • Unidentified mesoplodon	• PIFSC report is in progress
E18	**15 June 2014. Finalization by NMFS of 2014 MIRC annual monitoring report** Format of this report (originally submitted 15 March 2014) was the first of any Navy range to report results by applying a qualitative metric of progress on monitoring questions.					
19	9 Feb 2010– 27 April 2014 (Report date September 2014)	Guam, Saipan, Tinian, Rota, Aguijan	• Summary of PIFSC visual small vessel surveys[6] in order to contribute to monitoring questions (see footnote 5)	• Summary report over 4 years of surveys.	• n/a	*Hill et al. 2014 (Appendix B of this report); Martien et al. 2014* • Successful 4-year NMFS PIFSC/Navy collaboration • Species were encountered in the following relative frequency from highest to lowest: spinner dolphins (1st), pantropical spotted dolphins (2nd), bottlenose dolphins(3rd), short-finned pilot whales (4th), false killer whales, pygmy killer whales, rough-toothed dolphins, sperm whales (5th), melon-headed whales, beaked whales (6th), and 1 dwarf sperm whale (7th). • 59 green sea turtles and 2 hawksbills were identified out of 152 turtle sightings and were mostly seen off Saipan. • Bottlenose dolphins prefer shallow banks

[6] Oleson and Hill 2010, Ligon *et al*. 2011, Hill *et al*. 2012, Hill *et al*. 2013

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/ Conclusions/Sightings (citations at top)
						and nearshore waters, and travel to islands north of Saipan. May associate with other species. • Short-finned pilot whales associated with nearshore waters with some distant offshore movements • Pantropical spotted dolphins are distributed with depth range from 300 m to over 3000 m, similar to pantropical spotted dolphins near the Hawaiian Islands • False killer whales occur over a broad range of depths and frequently make long-distance off-shore movements to Mariana Trench and Western Mariana Ridge • Photographic evidence suggests little exchange of spinner dolphins between Guam/Rota and the southern islands of CNMI, in contrast to genetic result of high haplotypic variability. Therefore genetic transfer may be facilitated by individuals from northern CNMI or offshore. • Short-finned pilot whales demonstrate movement between islands of Guam/Rota and the southern CNMI islands. Photo ID resights suggest some individuals may be associated with the southern CNMI islands while other groups may prefer offshore waters or northern CNMI islands. Significant genetic differences were found between the animals biopsied off Guam/Rota and the southern CNMI islands. • There has been extensive introgressive hybridization of Fraser's dolphin DNA into the Mariana Islands bottlenose dolphin gene pool; no *Tursiops aduncus* haplotypes found in bottlenose dolphin samples

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/ Conclusions/Sightings (citations at top)
20	1962-2013 (Report date September 2014)	n/a	• Compile previously unpublished incidental sightings and strandings of marine mammals and sea turtles from the Marianas	• Literature review of Navy gray literature, interviews with Navy personnel and contractors, processing of raw data sheets, interviews with DAWR and other non-DoD sources, location estimation based on available information from each record.	• Humpback whale • Blue whale • Bryde's whale • Sperm whale • Killer whale • False killer whale • Melon-headed whale • Cuvier's beaked whale • Baird' beaked whale • Pantropical spotted dolphin • Common dolphin • Bottlenose dolphin • Spinner dolphin • Dugong • Green turtle • Manta ray • Whale shark	*Uyeyama 2014 (Appendix C of this report)* • Report describes previously unpublished sightings of marine mammals, sea turtles, and elasmobranchs made incidentally in the Marianas by Navy personnel and contractors, including humpback whales and killer whales. • Also describes incidental sightings as well as strandings of marine mammals provided by Guam DAWR in a record dating back to the 1960s. Unusual entries include blue whale, killer whale, common dolphin, Baird's beaked whale. • Latitude and longitude was estimated for every sighting and stranding, and incorporated into the geo-referenced MIRC monitoring database.
21	Feb 2007-April 2013 (Report date: September 2014)	MIRC	• Integrate all marine species monitoring effort in MIRC into geo-referenced database, with GIS products to enhance management objectives	• Data management using geo-reference database	• All species from all entries in this table through 2013.	*HDR 2014 (Appendix A of this report)* • Successful implementation of data management objectives for the MIRC • Created geo-referenced database of all sightings and survey track lines • Included incidental sightings (above [19]) • Produced report with map graphics to enhance planning of MIRC monitoring objectives
E19	**8 October 2014. MIRC monitoring program review, Pearl Harbor, HI**					
22	September-November 2014	Two tracks, Northwest and South of Guam	• Fall season offshore high frequency glider survey pilot study	• Autonomous deep-diving glider with high frequency acoustic recorder	TBD	*HDR/Oregon State University/University of Washington* • New technique: deep-diving acoustic glider transitioned from ONR. • Allows for cost-effective survey to offshore areas within MIRC • Preparation for field survey in progress,

Row #	Dates of Data Collection in Field	Location	Objectives	Methods Used	Species Detected/Observed	Notable Outcomes/Events/ Conclusions/Sightings (citations at top)
						Fall season deployment expected 29 September 2014; winter season deployment expected Feb-March 2015.
23	Feb-March 2015 (planned)	Guam	• Winter season shore station survey of windward side of the island, where sea conditions make vessel surveys infrequent • Nearshore baleen whales sighting	• Shore station methodology utilizing big-eye binoculars, hand held binoculars, theodolite, super-telephoto	TBD	• TBD

3.2.1 Lessons Learned and Evolution of Methodology

This section describes the process through which changes in monitoring projects were developed through a process of integrating new knowledge and lessons learned.

The first year of monitoring in 2010 began with field work utilizing systematic visual line transect surveys, following the example of the earlier four-month large vessel (MISTCS) and exercise-monitoring aerial survey in 2007 (DoN 2007; Mobley 2007). MISTCS was proactively performed to provide marine mammal occurrence information and derivation of marine mammal density estimates for the MIRC EIS (DoN 2010a) and the Marine Resource Assessment for the Marianas (DoN 2003), under the driver of the National Environmental Policy Act. The MMPA LOA for the MIRC in 2010 had a different set of recommendations as part of the larger ICMP across all Navy at-sea range complexes given the paucity of available occurrence data. Additionally, because of the relatively high cost of large vessel surveys, multiplied by the many weeks or months required to cover large areas, continuing such a methodology would disproportionately skew the focus of the monitoring plan to this single project, and away from other projects throughout all other range complexes. Also there were safety concerns noted with regard to the remoteness from shore of the aerial survey, which had been intended to cover the end and post-exercise period of that year's Valiant Shield (VS) training exercise. Therefore the first monitoring projects in 2010 were: 1) utilizing platforms of opportunity by funding the placement of marine mammal observers on existing NMFS large-vessel surveys on the Oscar Elton Sette (OES) (PIFSC 2010a,b c; Oleson & Hill 2010); and 2) pioneering relatively nearshore surveys dedicated to marine mammals utilizing small vessels. (Ligon et al 2011; Oleson & Hill 2010). Due to prevailing difficult sea state conditions in the MIRC, utilization of non-systematic non-random survey techniques provide better sighting data than attempting a line transect with a small vessel. Since 2010, the paradigm of using small vessel surveys as a centerpiece of monitoring has continued to the present day. After the introduction of the study questions in the 2012 MIRC monitoring plan update (DoN 2012b), the small vessel surveys of the recent several years also leverage the techniques of biopsy, satellite tagging, acoustic recording by dipping hydrophone, and photo-ID to layer even more value to this monitoring platform (Hill et al. 2014); these new techniques have been productive with respect to addressing the monitoring questions, and are likely to be a primary component of any future monitoring considered for the MIRC.

However due to limited effectiveness and safety in poor sea states, small vessel surveys have had relatively little success effectively surveying the windward (eastern) and offshore waters of the islands and have likely contributed to the lack of beaked whale sightings. Additionally and importantly, no baleen whales had been detected during the bi-annual surveys. Therefore the 2012 monitoring plan update included a provision for a shore-station pilot study, and in 2013 the first shore-station survey was performed on the windward side of Guam (Deakos et al. 2014). In Figure 19 the Guam inset at bottom right depicts the viewshed of the two shore stations utilized in that survey, illustrating how the surveyed areas by this method are complementary and relatively non-overlapping from vessel survey track lines. The survey was conducted in the spring and did not detect any baleen whales; a winter survey is planned in early 2015 at the same location with one of the goals being detection of baleen whales from the windward coast of Guam.

The first MIRC monitoring plan (DoN 2010b) proposed utilizing two primary methodologies, deployment of four moored passive acoustic recording devices, and analysis of archival acoustic datasets from the MISTCS survey's towed array. Through the first two six-month deployments of the devices, there were some technical challenges, including data capacity limits for a 6-month deployment requiring duty cycling of 30 seconds every 5 minutes for the first deployment, and for the second deployment an adjustment to 30 seconds every 10 minutes. Also several devices stopped recording early, providing an incomplete record of the deployment period. Also one device was lost due to acoustic release failure. Another lesson learned was the allocation of resources between device deployment and the subsequent tail of acoustic analysis, and other monitoring needs. It was determined that the best course of action was to alternate monitoring years between deployment and analysis. The year off from deployment would also give time to consider alternate methodologies without a recurring commitment of analysis for a year or more associated with immediate redeployments during device recovery. During the analysis process, other technical challenges became apparent with regard to the correct application of the acoustic algorithms, and the significant ground-truthing needs of automated detector and classifier algorithms.

The success of the earlier data analysis of archived acoustic data from the MISTCS (Norris et al. 2012) inspired more monitoring program support toward analysis of archival data sets. Additionally, NMFS PIFSC had deployed several HARP devices during non-Navy funded efforts and preliminary analysis indicated beaked and baleen whale detections. Therefore, Navy and NMFS PIFSC partnered on analysis to target in-depth analysis for those species. NMFS PIFSC analysis has begun under the MIRC monitoring program, and has already produced significant results reported by Oleson (2014). Also, as available algorithms for analysis have progressed, the MISTCS towed array analysis was completed for the sperm whale detection function, and published as part of the 2014 annual report (Norris et al. 2012; DoN 2014). The NMFS PIFSC HARP analysis is ongoing, and additional analyses of archival acoustic data sets may be considered in the future if these will aid in addressing monitoring plan questions.

One parameter of the HARP is its high digital sampling rate, 200 kHz, giving an effective bandwidth from low frequencies up to ~100 kHz, in contrast with the EARs that were deployed with a sampling rate at 80 kHz (and bandwidth up to 40 kHz). However the moored acoustic devices and the visual surveys all have been limited to relatively near shore waters, whereas many of the sightings, including baleen whales from 2007's surveys (DoN 2007; Mobley 2007) were from at or beyond the Mariana Trench. In recent years, acoustic recorders of similarly high (~200 kHz) sampling rate mounted to autonomous glider platforms have been being developed through ONR support. Although not fully graduated through the ONR demonstration and validation phase, it was determined that one of the more mature platforms could be used for a pilot study in the MIRC. The glider platform would allow it to move offshore to the habitats surrounding Mariana Trench to the east and south, or towards the underwater ridge to the west of the islands. The first pilot study had been planned for summer 2014, but technical challenges in selecting the most mature platform delayed the project to deployment at the end of September 2014.

3.2.2 Monitoring Highlights

The four-month MISTCS cruise of 2007 was the first systematic visual line transect survey for marine mammals and sea turtles for the Mariana Islands region, resulting in a significant increase in available

information for this data-deficient area (DoN 2007). The survey was designed to provide survey coverage the expanse of the MIRC (see Figure 1), and provided empirically based density estimates for cetacean species (Fulling et al. 2011). Figure 3 illustrates the survey tracks for each of the four month-long legs. These track lines, as well all sightings from the MIRC were incorporated into data management process for MIRC monitoring described in Appendix A (HDR, 2014). Some of the most interesting sightings by the MISTCS cruise were a number of baleen whales species, none which have not been sighted since that time by dedicated small-vessel survey closer to shore. However the aerial survey (Mobley 2007) later the same year as the MISTCS cruise was similarly successful in detecting a Bryde's whale (Figure 4) in the very deep waters near the Marianas Trench, as well as several other species that have proven relatively uncommon in the subsequent small vessel surveys. See also the monitoring results in Chapter 4; most of the offshore sightings and survey effort shown in maps and described in results come from this survey (e.g., Figure 19 and Figure 20). The survey also included a comprehensive acoustic component using a towed array and sonobuoys. As the technology of algorithms necessary for performing PAM analysis have developed and improved through the years since 2007, this archived acoustic data set has been revisited and re-analyzed periodically (e.g., Norris et al. 2012).

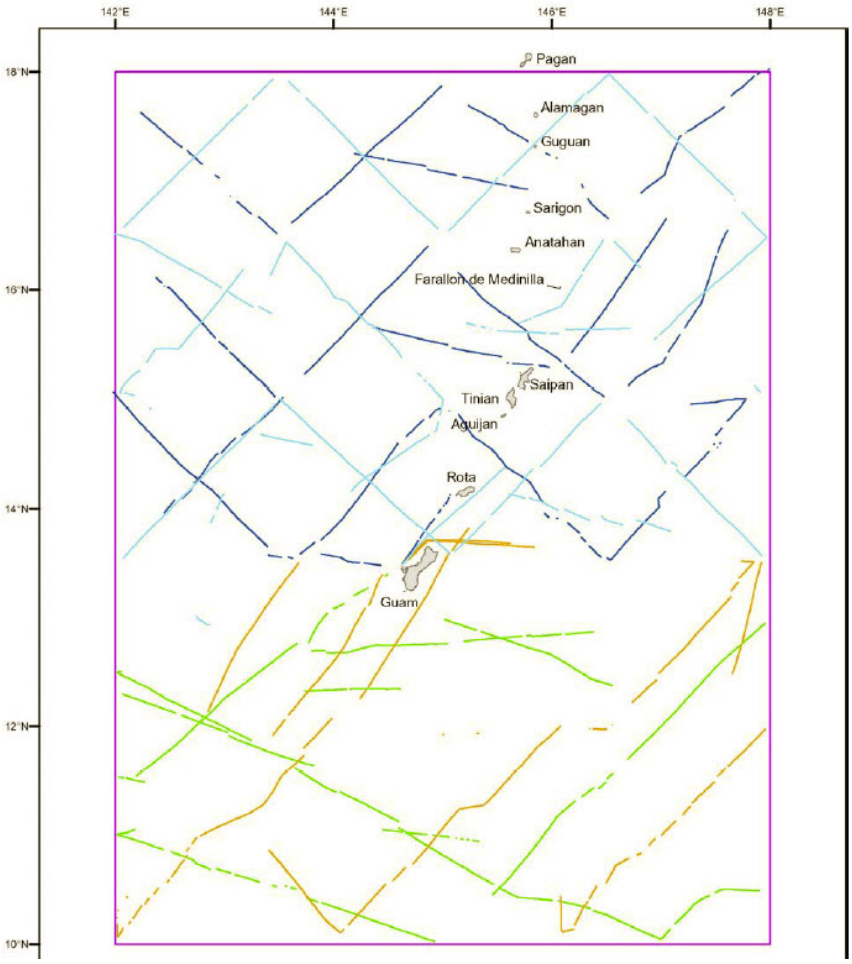


Figure 3. Survey track line of MISTCS large vessel survey

From DoN (2007). The four line colors represent four survey legs, between 16 January and 4 April 2007

Figure 4. Bryde's whale *(Balaenoptera edeni)* sighted from 2007 aerial survey (Mobley 2007)

The ten day shore station pilot study on Guam (Deakos et al. 2014) was able to produce results similar to a small vessel survey of similar duration: Small vessel survey near-shore sightings of spinner dolphins are frequent, and made almost daily especially if search is limited to shallow water by weather. Sightings of other species in deeper water are more uncommon and often do not occur in any given day. The shore station similarly made multiple sightings of both spinner dolphins and sea turtles on most days, and made sightings of other species periodically at greater distances. The farthest sighting identified to species was a group of short-finned pilot whales at a distance of about 5 km from shore. An innovative technique was able to capture this Big-Eye sighting in the narrow viewfinder of both the theodolite and the camera equipped with super-telephoto optics (500mm lens with 1.4x teleconverter). Images captured by the camera were successful in confirming species identification (Figure 5).

Figure 5. Super-telephoto images (500mm with 1.4x teleconverter and body with APS-C sensor) providing shore-based species identification of pilot whales at a distance of 5 km
From Deakos et al. (2014); photographs by M. Richlen and J. Aschettino.

Due to the relatively small quantity of dedicated marine mammal survey data available for the waters of the MIRC, sightings of marine mammals made from other efforts are valuable informing questions of occurrence, and even seasonal presence. Therefore incidental reports of sightings of marine mammals and sea turtles made within the MIRC that were previously unpublished, or not widely distributed, were compiled and the sources of these data recorded (Uyeyama 2014; Appendix C). The initial intention of this report had been to compile marine mammal sightings made incidentally to Navy-funded surveys, especially unusual sightings such as humpback whales or killer whales (Figure 6). However during the course of the collection of these data, the author was informed of the existence of a record of marine mammal sightings and strandings reported to the Guam Department of Agriculture's Division of Aquatic and Wildlife Resources (DAWR), covering a span from 1962 to 2013. Because these data are so extensive but unpublished, it was decided to include this source in the compilation. Latitudes and longitudes were estimated for every sighting and stranding for all sources for eventual incorporation into a separate effort (HDR 2014) to compile a geo-referenced database comprising survey effort and visual sightings from all MIRC monitoring.

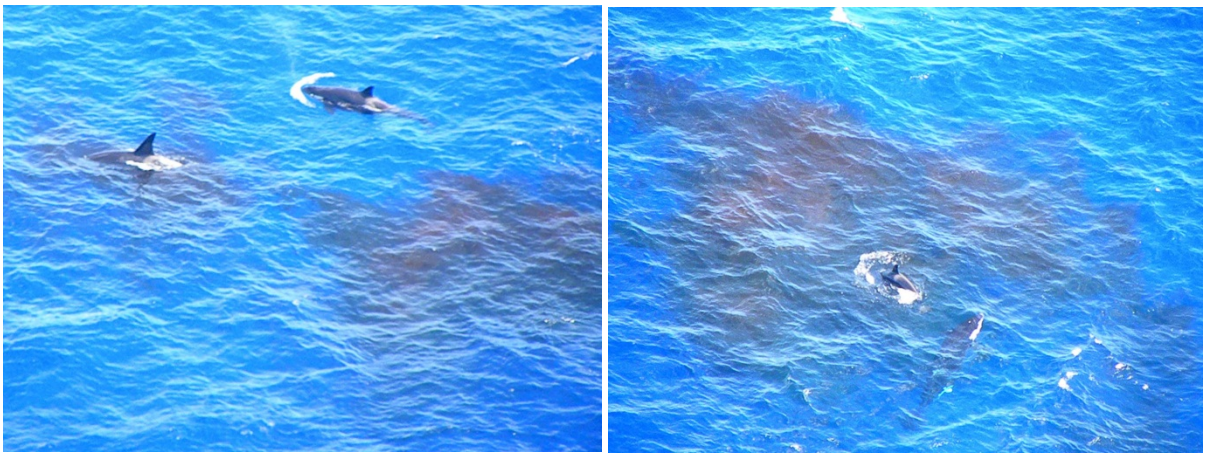


Figure 6. Killer whales engaged in hunting sighted incidentally during aerial transit between Saipan and Farallon de Medinilla on 10 May 2010 (Wenninger 2010; Uyeyama 2014)
Photos by Paul Wenninger, NAVFAC Marianas

During August 2013, the first dedicated sea turtle tagging surveys were conducted by NMFS PIFSC in the nearshore and coastal waters of Guam (Cocos Lagoon), Saipan and Tinian (Jones and Van Houtan, 2014; Appendix D). One notable result was a tagged hawksbill turtle that migrated 286 km from Tinian to Cocos Lagoon at the south of Guam (Figure 7).

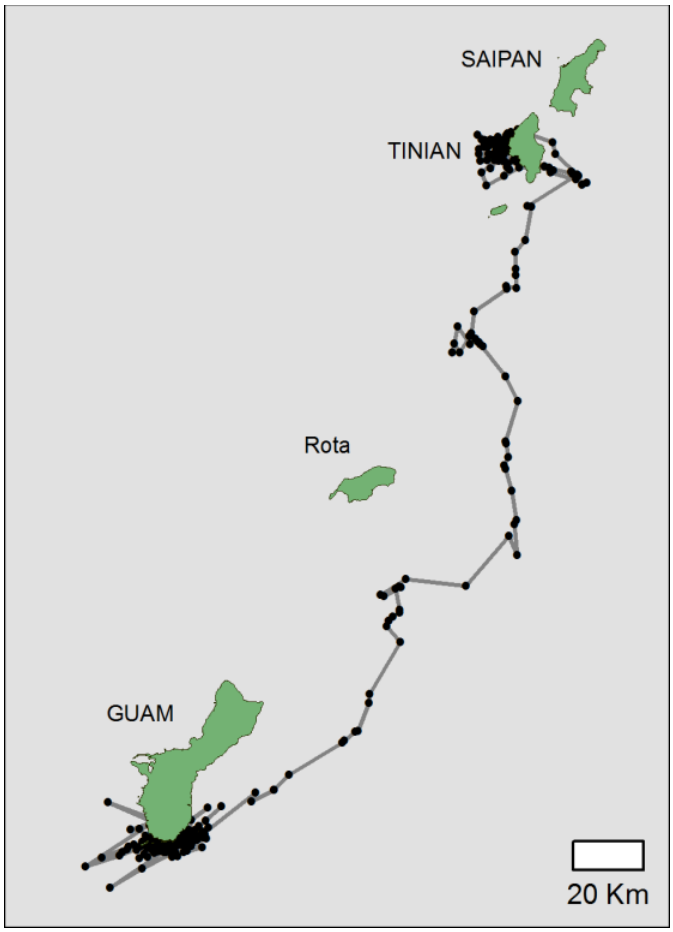


Figure 7. Migration of tagged subadult hawksbill turtle from Tinian, CNMI to Guam

From Jones & Van Houtan 2014 (Appendix D). Turtle was initially tagged on 20 August near Fleming Point, Tinian; left Tinian on 10 October; and arrived at Cocos lagoon, Guam on 17 October. The turtle resided off Tinian for 51 days, and remained in the Cocos lagoon area when the report was finalized. The migration covered a distance of 286 km and lasted 7 days.

Finally, with the cumulative collection of data from a growing list of monitoring projects in the MIRC since 2007, comprehensive data management is important to provide an integrated overview of results. Appendix A (HDR, 2014) is a monitoring "Atlas" for the MIRC, describing the methods and the results from compiling all monitoring efforts since 2007, as well as additional available data sets such as incidental sighting and stranding records. All data have been standardized and integrated into a single geo-referenced database, and GIS-based products may be produced. Also included in the MIRC atlas are species sighting maps depicting sightings of every species treated in an individual figure. Table 13 is a tabulation of all entries for all species in this geo-referenced database, and includes all MIRC monitoring through 2013, as well as incidental sighting sources. Data products were not finalized for the two small vessel surveys conducted by PIFSC in 2014, and are not yet included in this database.

Table 13. Marine mammal and sea turtle sightings from all MIRC monitoring and incidental sighting sources through 2013

From HDR 2014 (Appendix A)

Scientific Name	Common Name	# of Animals	# of Sightings	Group Size			Bottom Depth (m)	Distance from shore (km)
				Mean (SD)	Max	Min		
Marine Mammals								
Balaenoptera borealis	Sei whale	28	14	1.9 (1.17)	1	4	3,171-9,045	71-436
Balaenoptera edeni	Bryde's whale	28	18	1.6 (0.70)	3	1	1,441-8,775	33-436
Balaenoptera borealis/edeni	Sei/Bryde's whale	3	3	1 (0)	1	1	3,742-5,232	61-349
Balaenoptera musculus	Blue whale	1	1	1 (0)	1	1	384	4
Delphinus delphis	Short-beaked common dolphin	1	1	1 (0)	1	1	<200	35
Dugong dugon	Dugong	1	1	1 (0)	1	1	<200	<1
Feresa attenuata	Pygmy killer whale	20	3	6.7 (1.15)	8	6	375-4,795	1-105
Globicephala macrorhynchus	Short-finned pilot whale	851	39	21.8 (32.6)	201	1	<200-4,409	<1-308
Grampus griseus	Risso's dolphin	3	1	3 (0)	3	3	<200-4,409	<1-308
Kogia sima	Dwarf sperm whale	1	1	1 (0)	1	1	663	17
Kogia sp.	Dwarf/pygmy sperm whale	1	1	1 (0)	1	1	1,066	11
Megaptera novaeangliae	Humpback whale	48	15	3.2 (2.43)	8	1	<200-1,037	<1-29
Orcinus orca	Killer whale	26	6	4.3 (1.21)	6	3	<200-1,435	<1-36
Peponocephala electra	Melon-headed whale	292	4	73 (56.9)	135	4	296-2,901	1-<61
Physeter macrocephalus	Sperm whale	219	41	5.3 (5.01)	25	1	<200-9,452	<1-432
Pseudorca crassidens	False killer whale	325	16	20.3 (48.19)	200	1	<200-7,793	<1-359
Stenella attenuata	Pantropical spotted dolphin	1,450	46	31.5 (38.19)	200	2	<200-5,406	<1-440
Stenella coeruleoalba	Striped dolphin	267	12	22.3 (14.08)	50	6	2,430-7,970	53-343

Scientific Name	Common Name	# of Animals	# of Sightings	Group Size			Bottom Depth (m)	Distance from shore (km)
				Mean (SD)	Max	Min		
Stenella longirostris	Spinner dolphin	4,140	123	33.7 (28.44)	135	1	<200-1,441	<1-33
Steno bredanensis	Rough-toothed dolphin	25	4	6.3 (1.71)	8	4	216-5,570	<1-174
Tursiops truncatus	Bottlenose dolphin	146	20	7.3 (4.08)	14	1	<200-4,839	<1-218
Ziphius cavirostris	Cuvier's beaked whale	3	3	1 (0)	1	1	<200-8,430	<1-106
Marine Mammals (continued)								
All beaked whales		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
Unidentified *Mesoplodon* sp.		6	3	2 (0)	2	2	1,035-3,912	5-344
Sea Turtles								
Chelonia mydas	Green turtle	73	64	1.1 (0.5)	4	1	<200-1,273	<1-8
Eretmochelys imbricata	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

3.3 Projects and Methodologies

3.3.1 Passive Acoustic Monitoring

3.3.1.1 Archival Data Analysis: HARPs

PIFSC deployed two HARPs off Tinian and Saipan in 2010, 2011, and 2012 in order to further characterize cetacean occurrence and temporal trends in the MIRC. The U.S. Navy funded PIFSC to analyze some of these data (Oleson 2014) for: (1) modeled sound propagation and detection range for baleen whale calls under 1 kilohertz (kHz); (2) daily occurrence of baleen whales with low-frequency (<1 kHz) calls in all five data sets; (3) daily occurrence of all beaked whales within one dataset; (4) species identification of detected beaked whale sounds; and (5) daily occurrence of minke (*Balaenoptera acutorostrata*) and sperm whales within one dataset. Analysis of 2010 and 2011 Saipan and Tinian datasets for low-frequency (<1 kHz) baleen whales is complete, and analysis of the 2012 and 2013 datasets is underway. A beaked whale echolocation-click detector (see Appendix A) was used to analyze all datasets for beaked whale occurrence and temporal trends in vocalizations were examined. Classification of beaked whale click bouts to species is still ongoing.

PIFSC maintains long-term acoustic datasets collected near Saipan in March-August, 2010, and at two sites near Saipan and Tinian in April-October, 2011 and June 2012-May 2013. All acoustic datasets were

collected using High-Frequency Acoustic Recording Packages (HARPs) sampling at 200 kHz sample rate, resulting in effective bandwidth of 10Hz to 100 kHz.

Table 14. Acoustic datasets collected near Saipan and Tinian by PIFSC since 2010
(From: Oleson, 2014)

Dataset	Deployment Location		Recording Dates		Sample rate & Duty cycle (min on/total)
	Latitude	Longitude	Start	End	
Saipan01	15-19.0 N	145-27.5 E	3/5/10	8/25/10	200kHz, 5/40
Saipan02	15-19.0 N	145-27.5 E	4/247/11	10/20/11	200kHz, 5/20
Saipan03	15-19.1 N	145-27.4 E	6/20/12	3/8/13	200kHz, 5/6
Tinian02	15-02.3 N	145-45.1 E	4/136/11	11/22/11	200kHz, 5/20
Tinian03	15-02.4 N	145-45.3 E	6/23/12	5/14/13	200kHz, 5/6

3.3.1.2 Archival Data Analysis: MISTCS towed array

The 2007 MISTCS cruise (DoN 2007; Fulling 2011) followed standard line-transect methodology, and also included passive acoustic monitoring utilizing a towed hydrophone array and sonobuoy drops. Only preliminary acoustic results were presented in the original report (DoN 2007). Since that time the algorithms and analysis methods to support acoustic analysis and density estimation of marine mammal calls has progressed, and this archived acoustic data was analyzed.

The main goals of these analyses were to: 1) provide acoustically-derived density estimates when feasible (e.g., minke whales); 2) estimate an acoustically-derived 'detection function' (e.g., sperm whales); 3) describe and compare acoustic signals for some species and populations for which limited information is available (e.g., sei whales and humpback whales); and 4) assess the success of automated classification algorithms for several species of delphinids.

Correspondingly, the resulting report (Norris et al. 2012) is divided into five sections: Section 1 is an assessment of the abundance of calling minke whales; Section 2 is a classification of recorded whistles; Section 3 is an evaluation of the sperm whale encounter; Section 4 is an analysis of humpback whale song; and Section 5 addresses sei whale vocalizations. During the course of this analysis, when updated methods for analyzing sperm whale encounters became available, Section 3 on this topic was modified and updated using this new methodology. In these new analyses of 2013, acoustic data were subjected to additional post-processing and analysis in order to: 1) localize sperm whale encounters in MIRC waters; 2) estimate sperm whale acoustic detection functions that can be used for line-transect abundance/density estimation; and 3) to identify, characterize, and classify sperm whale codas (broadband click patterns) detected during the cruise, and compare these to codas from different areas.

3.3.1.3 Long Duration Autonomous Recorders: EARs

Four Ecological Acoustic Recorders (EARs) were deployed in September 2011 in order to characterize cetacean species occurrence, distribution, and temporal trends in the MIRC (Munger et al. 2014). Two instruments were deployed off Guam, one off Tinian, and a fourth off Saipan, and were redeployed after an initial long-term deployment (Table 15). Automated detectors were utilized to search the recordings for the presence of five species of baleen whales (blue [*Balaenoptera musculus*], fin [*Balaenoptera*

physalus], sei [*Balaenoptera borealis*], minke [*Balaenoptera acutorostrata*] and humpback [*Megaptera novaeangliae*]), two genera of beaked whales (*Ziphius* and *Mesoplodon*), and sperm whales (*Physeter macrocephalus*). Manual analysis was used to detect odontocete whistles and clicks (excluding beaked whale clicks), as well as "high-frequency" sei whale calls characteristic of the MIRC. Diel, monthly, lunar, and seasonal patterns in cetacean occurrence were topics of investigation, as well as any spatial patterns in species assemblages. Also being investigated is whether or not detection rates change during mid-frequency active sonar exposure. Finally performance of automated detectors were evaluated to measure the proportion of positive, false and missed detections of humpback, fin, blue, minke, sperm, and beaked whale calls. This will elucidate whether call prototypes collected in other regions are appropriate for application to species residing in the MIRC.

Table 15. EAR deployments in the MIRC

First deployment

Location gloss	Decimal latitude	Decimal longitude	approx. depth (meters)	Deployment date	End recording date	Recovery date	Months successfully recorded	Duty cycle	Sampling rate (kHz)
Guam N	13.69635	144.75310	820	4 Sep 2011	6 Jan 2012	3 Apr 2012	4.1	30 s/ 5 min	80
Guam S	13.22320	144.47172	952	4 Sep 2011	17 Nov 2011	4 Apr 2012	2.4	30 s/ 5 min	80
Saipan N	15.45487	145.84897	850	4 Sep 2011	29 Dec 2011	6 Apr 2012	3.8	30 s/ 5 min	80
Tinian W	15.07670	145.44460	869	4 Sep 2011	28 Nov 2011	7 Apr 2012	2.8	30 s/ 5 min	80

Second deployment

Guam N	13.69648	144.75348	778	3 Apr 2012	5 Sep 2012	1 Jan 2013	5.1	30 s/ 10 min	80
Guam S	13.22313	144.47128	944	4 Apr 2012	device lost	Attempts on 16-17 Jan 2013	0	30 s/ 10 min	80
Saipan N	15.45472	145.84885	840	6 Apr 2012	22 Sep 2012	15 Jan 2013	5.5	30 s/ 10 min	80
Tinian W	15.07675	145.44445	860	7 Apr 2012	23 Apr 2012	14 Jan 2013	0.5	30 s/ 10 min	80

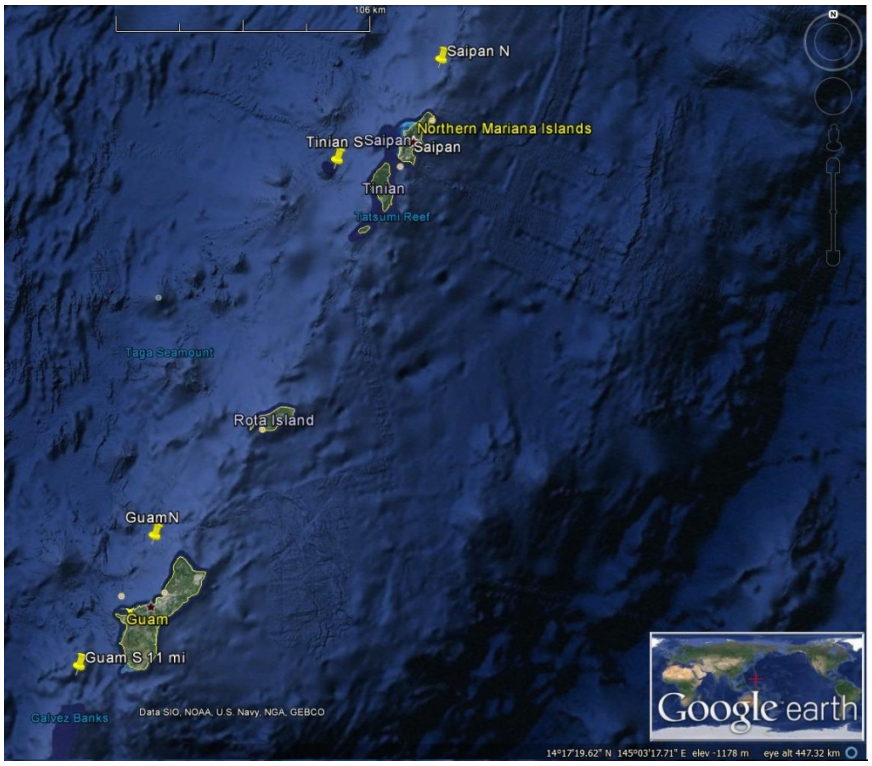


Figure 8. Map of MIRC EAR deployments. Yellow pushpins indicate EAR deployments
From Munger et al. (2014). Labels for EARs correspond to those listed in Table 15

3.3.1.4 Dipping hydrophone

One of the difficulties with PAM data analysis in the MIRC has long been the lack of prototype recordings from the Marianas where the species identification has been visually validated, in particular for species which may have variable acoustic characteristics in different water areas, as described by performers such as BioWaves and others at the Navy PAM working group workshop held in La Jolla, CA in September 2011, as well as by NMFS PIFSC. Therefore the 2012 update to the MIRC monitoring plan introduced a new passive acoustic technique, the use of a dipping hydrophone, to accompany visual surveys when possible in order to obtain acoustic recordings of marine mammals that have been visually verified to species.

3.3.1.5 Glider

In 2012 it became apparent that the plan to conduct PAM recordings throughout the year using moored devices was technically challenging, with device failures limiting the value of the collected data to address questions of seasonal marine mammal presence. Some alternate approaches implemented were analysis of archived acoustic datasets.

A new potential passive acoustic study solution that began to be explored in 2013 was validation of an alternate acoustic monitoring technology mounted to a glider platform. One requirement of the fleet monitoring program was that the overall glider package be specifically designed and optimized for marine mammal study, in contrast to a commercial off-the-shelf solution. The glider package chosen was

capable of diving deeply and recording sounds of a significantly higher frequency to better capture beaked whale vocalizations as compared to the existing PAM device, and could better explore offshore waters of the MIRC, where vast majority of baleen whale detections were made by the 2007 MISTCS survey (DoN 2007). Although a continuous recording throughout the year was not possible with these parameters, multiple glider deployments targeted to different seasons had the potential to produce quality seasonal data, with the likelihood of better providing progress on the goals of the monitoring plan than the moored device. This alternative acoustic monitoring project addressing the same monitoring question began its first deployment in late September 2014; this schedule was chosen so that field deployment would occur after the final deployment of the moored devices had ended and the associated acoustic data analysis was still ongoing.

3.3.2 Systematic Visual Line Transect

3.3.2.1 Large vessel: MISTCS

The four-month MISTCS cruise of 2007 was the first systematic visual line transect survey for marine mammals and sea turtles for the Mariana Islands region, resulting in a significant increase in available information for this data-deficient area (DoN 2007; Figure 9). The survey was designed to provide survey coverage the expanse of the MIRC (see Figure 1), and provided empirically based density estimates for cetacean species (Fulling et al. 2011).

Figure 9. Survey vessel M/V Kahana during Leg 2 of MISTCS line transect survey, sighted from aerial survey to FDM, 18 February 2014

Photo credit: Tim Sutterfield and Curt Kessler, Naval Facilities Engineering Command

3.3.2.2 Large vessel: PISFC Oscar Elton Sette (OES)

After the surveys of 2007 (DoN 2007; Mobley 2007), the Navy began a collaboration with NMFS PIFSC to survey the waters of the MIRC. In the first year of MIRC monitoring, there were four such collaborative

surveys, three of which leveraged a platform of opportunity by funding the placement of marine mammal observers on existing NMFS large-vessel surveys on the Oscar Elton Sette (OES) (PIFSC 2010 a,b,c; Oleson & Hill 2010). Two of these were open ocean transits between Guam and Hawaii (PIFSC 2010 a,c), and one was conducted in offshore waters entirely within the MIRC (PIFSC 2010b).

3.3.2.3 Aerial

In the summer of the same year as the MISTCS (2007) survey, an aerial survey in offshore waters to the south east of Guam was performed in association with the Navy training exercise Valiant Shield. The survey overlapped the end of the exercise, and was primarily conducted post-exercise.

3.3.3 Other Visual Survey, Satellite Tagging, Biopsy, Photo-ID

3.3.3.1 Pacific Islands Fisheries Science Center Small Vessel Surveys

Five small vessel surveys were conducted in the waters off Guam, Saipan, Tinian, Aguijan, and Rota between February 2010 and June 2014 (Ligon et al. 2010; Hill et al. 2011; Hill et al. 2013a; Hill et al. 2013b; Hill et al. 2014). Photo-identification, acoustic recording, and biopsy sampling/sloughed skin collection for assessment of genetic population structure were performed when possible. Beginning with the summer 2013 survey, satellite tagging was also performed to improve knowledge of movement patterns, habitat use, and population structure.

During the PIFSC small vessel surveys of 2013 and April 2014, 13 satellite tags were deployed on a total of 5 species: short-finned pilot whale, false killer whale, rough-toothed dolphin, bottlenose dolphin, and melon-headed whale (Hill et al. 2014). Table 16 lists all deployed tags.

Table 16. PIFSC Satellite tag deployment information and summary of depth and distance to shore for the Douglas ARGOS filtered tag locations by species and tag ID

From Hill et al. 2014 (Appendix B)

Species and Tag IDs	Deployment Location	Deployment Date-Time (GMT +10)	Duration (Days)	No. Tag Locations	Median Depth (Range) - m	Median Shore Distance (Range) -km
Short-finned pilot whales				1232*	1086 (24-9660)	15.8 (0.1-416.6)
128884	Guam	06/30/2013 7:08	17.9	138	1437 (38-3267)	18.3 (0.2-50.8)
128885	Guam	06/30/2013 8:46	64.0	449	1322 (33-9660)	26.7 (0.2-416.6)
128886	Guam	07/01/2013 13:20	234.7	645*	910 (24-8646)	10.7 (0.1-15.7)
False killer whales				1145	3149 (24-8585)	74.1 (0.1-550)
128903	Rota	07/06/2013 9:06	4.0	19	1418 (295-4192)	31.7 (1.6-204)
128904	Rota	07/06/2013 9:26	22.3	198	1158 (65-4307)	25.5 (0.2-273)
128906	Rota	07/06/2013 11:06	98.9	392	1852	33.9

Species and Tag IDs	Deployment Location	Deployment Date-Time (GMT +10)	Duration (Days)	No. Tag Locations	Median Depth (Range) - m	Median Shore Distance (Range) -km
					(24-8160)	(0.1-303)
128908	Rota	07/07/2013 11:42	198.3	536	3686 (902-8585)	146.1 (7.9-550)
Rough-toothed dolphin				80	440 (53-785)	4.0 (0.4-13.0)
128896	Aguijan	07/15/2013 10:33	11.7	80	440 (53-785)	4.0 (0.4-13.0)
Bottlenose dolphins				234	612 (28-2320)	8.1 (0.1-43.4)
128897	Aguijan	07/15/2013 10:52	20.5	157	611 (28-2320)	9.9 (0.1-43.4)
128898	Saipan	07/17/2013 14:06	8.8	77	615 (29-1522)	6.5 (0.1-20.8)
Melon-headed whales				294	1658 (308-3726)	33.6 (4.2-85.6)
128915	Saipan/Tinian	04/18/2014 21:13	2.6	0	-	-
128916	Saipan/Tinian	04/18/2014 21:58	15.9	245	1537 (308-3726)	30.1 (4.2-85.6)
128918	Saipan/Tinian	04/18/2014 23:20	3.1	49	2926 (873-3653)	33.6 (9.5-79.2)

*For the calculation of the median depth, 2 records were removed because no value was obtained from the bathymetry datasets.

3.3.3.2 HDR Small Vessel Survey

In winter 2011 and 2012, HDR performed two small vessel surveys one in waters off Guam (HDR 2011), and the other off Guam and Saipan (HDR 2012). The timing of the surveys was intended to be complementary to surveys in the opposing season of each year performed by NMFS PIFSC. Methods were designed to be comparable to the PIFSC surveys, and some of the observers were shared between the HDR and PIFSC projects, enabling PIFSC-funded biopsy collection, with resulting tissue samples becoming part of a set later funded by the Navy for genetic analysis (Hill et al. 2014). Photographs taken on both HDR surveys were provided to PIFSC to contribute to the establishment of photo-identification catalogs (Hill et al. 2014). NAVFAC Pacific personnel participated in the HDR's 2012 survey as contact oversight, and cooperatively with PIFSC's April 2014 survey.

Figure 10. Melon-headed whales *(Peponocephala electra)* sighted from small vessel survey near Guam 15 March 2012

From HDR 2012. Photo taken by Mark Deakos under NMFS permit 14451

3.3.3.3 HDR Shore Station Surveys

A 10-day visual survey from two shore stations at the Andersen Air Force Base on Guam was conducted in May 2013 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-boat visual surveys challenging (Figure 11). These areas include the windward side of the islands and most MIRC waters during the winter season due to strong wind and large swells. The shore-based observers searched for marine mammals and sea turtles and were equipped with a theodolite for fixing sighting locations, a pair of Fujinon 25 × 150-millimeter "bigeye" binoculars for scanning long distances away from the shore station, and super-telephoto photography to assist in species identification (Figure 12).

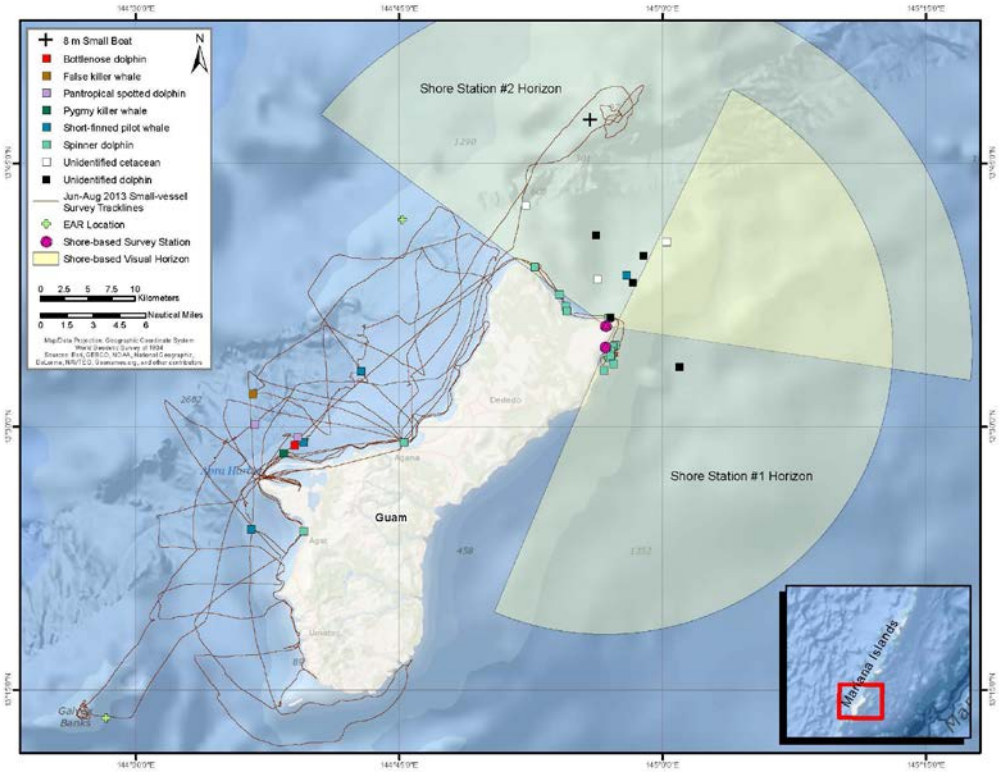


Figure 11. Comparison of shore station survey viewshed at Guam with survey effort track lines for small vessel surveys

From sightings summary of all monitoring performed, in 2014 MIRC annual monitoring report (DoN 2014).

Figure 12. Shore station marine mammal survey on Guam utilizing Big Eye binoculars, theodolite, super-telephoto photography, and hand-held binoculars. (Deakos et al. 2014)

3.3.4 Sea Turtle Distribution and Density

During August 2013, dedicated sea turtle surveys conducted by NMFS PIFSC) were conducted from small vessels in the nearshore and coastal waters of Guam (Cocos Lagoon), Saipan and Tinian (Jones and Van Houtan, 2014; Appendix D). When sea turtles were encountered, they were captured by hand while snorkeling or diving, and instrumented with either a temperature-depth tag or an ARGOS temperature-only Platform Transmitter Terminal tag in order to characterize sea turtle movements, dive profiles, and kernel density estimates of habitat use in the MIRC. The long term goal of this project is to evaluate potential exposure of sea turtles to Navy underwater detonation training sites. Added this based on your other additions elsewhere. Additionally, line transect surveys were conducted by Navy divers off Tinian and will be repeated in 2015.

4 Progress on Monitoring Questions and lessons learned

4.1 Progress on Monitoring Question

Notable results, discussed in detail in Chapter 3, have contributed to our greater understanding of the five study questions first developed in the FY12 MIRC monitoring plan. These results (organized by study question) are summarized in Table 17 below, and discussed in more detail in sections 4.1.1–4.1.5.

Table 17. Progress made on FY10-FY14 Monitoring Plan Study Questions
(Monitoring questions effective from August 2012)

Monitoring Question	Timeline Project #	Progress Made on Monitoring Questions
1. What species of beaked whales and other odontocetes occur around Guam and Saipan?	[1] Visual survey/Large vessel survey (MISTCS)	For offshore waters, sperm whale was the most frequently visually-sighted species, with three times as many acoustic detections. Pantropical spotted dolphin was the delphinid with the highest sighting frequency, followed by false killer whale and striped dolphin. Other odontocetes sighted in offshore waters included melon-headed whale, short-finned pilot whale, pygmy killer whale, bottlenose dolphin, spinner dolphin, and rough-toothed dolphin and unidentified beaked whale.
	[2] Visual survey/ Aerial survey	For offshore waters, Cuvier's beaked whale, pygmy or dwarf sperm whale, pantropical spotted dolphin, and rough-toothed dolphins were sighted.
	[3], [6], [7] Visual survey/Large vessel survey (PIFSC OES)	For offshore waters, these surveys sighted melon-headed whale, Risso's dolphin, short-finned pilot whale, and striped dolphin. Nearshore of Guam, pantropical spotted dolphins were sighted.
	[5] Acoustics/ PIFSC HARPs	Odontocete occurrence in the MIRC, as measured by visual and acoustic methods, was consistent with that observed in previous years. Cuvier's beaked whale, *Mesoplodon* species, and unidentified beaked whales were identified around Saipan and Tinian. Vocalizations of beaked whales heard year-round, no seasonality
	[8], [11] Visual/Small vessel survey (HDR)	Species sighted were: pantropical spotted dolphin, short-finned pilot whale, spinner dolphin bottlenose dolphin, melon-headed whale, sperm whale, pygmy killer whale, and dwarf sperm whale
	[10] Acoustics/EARs	Beaked whale calls (Cuvier's beaked whale and *Mesoplodon* species) were grouped together and occurred nearly daily as well as sperm whales; however these preliminary results pending ongoing validation of automated detector algorithms.
	[13] Visual survey/Shore Station	Species observed were consistent with other visual survey platforms. No beaked or baleen whales observed. A sighting rate of 0.47 sightings per hour or 2.6 sightings per day (65% being spinner dolphins) suggests low densities of marine mammals in the surveyed areas. This pilot study is showing promise for a new, cost-effective method to survey marine mammals in waters that are challenging by boat.
	[16] Acoustics/ MISTCS towed array analysis	Acoustic validation of sperm whale sightings in the MIRC; detection function developed.

Monitoring Question	Timeline Project #	Progress Made on Monitoring Questions
	[18], [19] (integrating [4], [9], [12], [14], [17]): Visual survey/ Small-boat surveys (PIFSC)	During 2010 through April 2014 nearshore (small vessel) surveys, in order of frequency from high to low, odontocetes sighted are: spinner dolphin, pantropical spotted dolphin, bottlenose dolphin, short-finned pilot whale, false killer whale, pygmy killer whale, rough-toothed dolphin, sperm whale, melon-headed whale, and dwarf sperm whale. Thirteen satellite tags deployed on 5 species (short-finned pilot whale, false killer whale, rough-toothed dolphin, bottlenose dolphin, melon-headed whale), revealing habitat utilization patterns and inter-island/offshore movements. May/June 2014 survey identified Cuvier's beaked whale and Blainville's beaked whale. Species discovery curve developed for these surveys; it is likely that most other tropical delphinids also occur in this region, though may typically inhabit waters beyond surveyed area, such as offshore waters, or archipelago north of Saipan.
	[22] Acoustics/ Autonomic gliders	A 30-day acoustic survey using autonomous gliders offshore of Guam and Saipan is planned for Fall 2014 and winter 2015. Results from this survey have the potential to provide relative abundance information across wide ranges of the MIRC study area, including offshore waters.
2. Are there locations of greater cetacean and/or sea turtle relative abundance around Guam and Saipan?	[5] Acoustics/ PIFSC HARPs	Blue whales heard off Tinian but not Saipan, minke and humpback whales off Saipan but not Tinian. Fin whales detected at Saipan and Tinian. Unidentified baleen whales detected off Tinian but not Saipan. Preliminary results from ongoing data analysis are not yet sufficient to address the question of relative abundance of marine mammals and/or sea turtles in MIRC waters. Analysis of daily occurrence rates of various species groups is in-progress at each HARP location.
	[10] Acoustics/ EARs	Of the four EAR locations (See Table 15), highest delphinid encounter rates overall around Saipan, followed by Tinian and Guam, possibly due to higher density, longer residency, or both. Low-frequency whistlers more likely to occur around Guam than high-frequency whistlers. Greatest sperm whale encounter rates at Tinian W, then Guam, followed by Saipan, but these preliminary sperm whale results revealed potential artifacts and are ongoing further validation.
	[13] Visual survey/ Shore Station (HDR)	A greater number of spinner dolphin sightings occurred on the northeastern side of Guam compared with the north side. Spinner dolphins sighted multiple times on most days. Many more offshore odontocete sightings occurred on the north-facing side. Sea turtles sighted multiple times below shore stations on both sites on most days, some identified as green turtles.
	[16], [1] Acoustics/ MISTCS towed array analysis	Sperm whale detections were clustered in the northeast, central, and southwest portions of the MIRC study area, with relatively few detections in the trench and offshore regions. May reflect preference by at least some animals to inhabit waters near islands, while some offshore areas may be utilized for breeding activities.

Monitoring Question	Timeline Project #	Progress Made on Monitoring Questions
2. Are there locations of greater cetacean and/or sea turtle relative abundance around Guam and Saipan? (continued)	[18], [19] Visual survey/ Small-boat surveys (PIFSC)	All sightings around Guam, Rota, Aguijan, and Tinian were within 8 kilometers (km) of land. Saipan surveys, which generated the greatest number of sightings, had the majority of sightings within 8 km of land however three species (sperm whales, pantropical spotted and spinner dolphins) were sighted 25, 18, and 15 km offshore of Saipan respectively. The three offshore spinner dolphin sightings occurred at Marpi Reef, where depths can be shallower than 100 m. Telemetry from 3 short-finned pilot whales (longest tag 235 days) satellite tagged at Guam remained near the southernmost islands with a preference to Guam, except for one which also traveled southward beyond the Mariana Trench toward the Federated States of Micronesia. Satellite telemetry from 4 false killer whales (longest duration 198 days) tagged near Rota indicate large-scale movements across the entire MIRC region including near Anatahan and FDM with frequent migrations to offshore banks and seamounts up to 500km from the islands. A single tagged rough-toothed dolphin moved between islands but remained almost consistently on the west side of the islands, remaining within 15 km from shore. Preliminary results suggest that a tagged bottlenose dolphin and separately tagged false killer whale associated and traveled together over three days while moving north past Anatahan and FDM.. Photo ID catalog established for three species: spinner dolphins, bottlenose dolphins, short-finned pilot whales. Resights of individuals giving insight into habitat preferences of each species.
	[15] Sea Turtle Tagging/ Small-boat surveys (PIFSC)	The six tags deployed on green and hawksbill sea turtles indicate small home ranges, typically less than 4 km^2, and limited movement between islands. However, the 286-km, 7-day trek from Tinian to Guam performed by one tagged hawksbill sea turtle suggests large, migratory, inter-island movements can also occur. Some diel migration from deeper water in daytime to shallower water at night. Average depth for green sea turtles is 12.6 ± 5.3 m and 10.0 ± 3.3 m for day and night, respectively. Hawksbill sea turtle average depth was 22.6 ± 13.8 m and 17.4 ± 6.4 m for day and night, respectively.
	[22] Acoustics/ Autonomous gliders	30-day acoustic surveys using pairs of autonomous gliders to the SE and NW of Guam is planned for fall 2014 and winter 2015. Results from this survey have the potential to provide occurrence information across wide ranges of the MIRC study area, including offshore waters.

Monitoring Question	Timeline Project #	Progress Made on Monitoring Questions
3. What is the baseline abundance and population structure of odontocetes which may be exposed to sonar and/or explosives in the nearshore areas of Guam, Saipan, Tinian, and Rota?	[1] Visual large vessel survey (MISTCS) and [16] Acoustics/ MISTCS towed array analysis	Overall across the MIRC, detection functions were estimated from visual sightings from a large vessel survey for sperm whale as well as three pooled groups of species: Balaenoptera spp., blackfish (medium-size odontocetes), and small dolphins. Abundance in the study area was estimated for: sperm whale, sei whale, Bryde's whale, false killer whale, short-finned pilot whale, melon-headed whale, pygmy killer whale, pantropical spotted dolphin, striped dolphin, bottlenose dolphin spinner dolphin, and rough-toothed dolphin. Notable is presence of sei whale south of 20°N. Detection functions and abundances were estimated from acoustic towed array data from the same survey for calling minke whales. Also a detection function was developed using sperm whale 'slow' and 'fast' clicks. Sperm whale "coda" patterns recorded in the MIRC displayed similarities to vocal repertoires of North Pacific as well as eastern South and Central Pacific clans, documenting the "short" clan coda in the western pacific for the first time, suggesting a possible social link between these regions. Humpback whale song unit from recording near Saipan/Tinian shared known song units with song recorded off Maui, Hawaii.
	[18], [19] Biopsy/ Small-vessel surveys	One third of bottlenose dolphin sample possess Fraser's dolphin haplotypes, but photography confirms these individuals are morphologically bottlenose dolphins, suggesting introgressive hybridization. No *Tursiops aduncus* haplotypes found in bottlenose dolphin samples Photo ID catalog established for three species: spinner dolphins, bottlenose dolphins, short-finned pilot whales. Resights of individuals giving insight into habitat preferences of each species. Pilot whale matches vary from individuals resighted multiple times, whereas other groups have only been sighted once, suggesting some groups may be associated primarily with the southern islands, whereas others may tend to inhabit other waters such as offshore or the archipelago north of Saipan. From photography, no spinner dolphins have been documented moving between the southern islands of the CNMI and Guam or Rota Bank, which contrasts with genetic findings of high haplotypic diversity. Satellite telemetry and visual sightings of odontocetes 2010-2014 compared to locations of underwater detonation training sites.
4. What is the seasonal occurrence of baleen whales around Guam,	[1] Visual survey/Large vessel survey (MISTCS)	Four-month survey covering all or MIRC detected Bryde's whale, sei whale, humpback whale, and minke whale in deep offshore waters during the January-mid-April survey period.
	[2] Visual survey/ Aerial survey	Bryde's whale detected in deep offshore waters near the Mariana Trench in the month of August.

Monitoring Question	Timeline Project #	Progress Made on Monitoring Questions
Saipan, Tinian, and Rota?	[3], [6], [7] Visual survey/Large vessel survey (PIFSC OES)	Minke whales and unidentified baleen whales detected acoustically and visually in 2010 in offshore areas in or near MIRC east of Guam on 4 February, 5 February, 20 April, and 21 April.
	[5] Acoustics/ PIFSC HARPs	Results from 2010-2011 recordings indicate blue, fin, minke, and humpback whales were detected using PAM; blue, fin, and minke whales were detected between February and May and peaked in March/April; Blue whales were more consistent in winter but peaked in May and stayed until July. Unidentified baleen whales were detected from August to December off Tinian but not Saipan. This suggests some evidence of seasonality but further analysis is pending. Further assessment of the daily occurrence of minke whale calls is ongoing.
	[10] Acoustics/ EARs	Very few minke and humpbacks whale detections suggest very little use of the area at least during the summer months since no recordings occurred during the winter period (January–April). No sei whale calls detected.
	[8], [11], [13] Visual survey/Small vessel survey and shore station	No baleen whales observed during all surveys: 17 Feb – 3 March 2011 15-29 March 2012 11–21 May 2013 Winter shore station survey to search for baleen whales planned for February or March 2015.
	[4], [9],[12] [14] [17], [18], [19] Visual survey/ Small-boat surveys	No baleen whales observed during all surveys: 9 Feb – 3 March 2010 26 Aug – 29 Sept 2011 25 May - 3 July 2012 22 June – 27 July 2013 11 -27 April 2014 15 May—20 June 2014
	[20] Incidental sightings compilation	Incidental sightings of baleen whales in the MIRC are primarily humpback whales, but also include Bryde's whale and blue whale. Humpback whales incidentally sighted near Guam and Saipan peak in late February-March
	[22] Acoustics/ Autonomous gliders	30-day acoustic surveys using pairs of autonomous gliders to the SE and NW of Guam is planned for fall 2014 and winter 2015. Results from this survey have the potential to provide occurrence information of baleen whales across wide ranges of the MIRC study area, including offshore waters.
5. What is the occurrence and habitat use of sea	[18] Visual survey/ Small-boat surveys [21] Data management	Sea turtle sighting locations from marine mammal surveys were recorded and reported and incorporated into the monitoring program's geo-referenced database for future reference.

Monitoring Question	Timeline Project #	Progress Made on Monitoring Questions
turtles in areas where the Navy conducts underwater detonations?	[15] Sea Turtle Tagging/ Small-boat surveys	Sea turtle sighting locations were reported in interim report and a map of the DoD UNDET sites are provided for comparison. Kernel density estimates of habitat use computed. Preliminary data shows small home ranges for both green and hawksbill turtles.

4.1.1 What species of beaked whales and other odontocetes occur around Guam and Saipan?

Beaked whales:

The 2007 MISTCS cruise (DoN 2007) had three unidentified beaked whale sightings in depths between 2212-3984 m, two which were described as mesoplodonts. The sightings were offshore between 249 and 363km north to northwest of Saipan. The same year's aerial survey (Mobley 2007) made a beaked whale sighting, also in deep offshore waters, a Cuvier's beaked whale near the Mariana Trench 106km south of Guam.

Closer to the islands, Hill et al. (2014) reports that 28% of the PIFSC small vessel survey effort between 2010 and April 2014 were in water depths of 800-220m, and there were two sightings of unidentified beaked whales. The results for the recent May-June 2014 PIFSC small vessel survey have not been analyzed, but PIFSC preliminarily reports having made identifications to species for two beaked whale species, the Blainville's beaked whale and Cuvier's beaked whale. The preliminary analysis from the HARPs at Saipan and Tinian (Oleson 2014) describe detections that indicate beaked whales are present year-round at both sites. Given the high frequency nature of their calls, these animals are relatively near the devices when calls are detected.

Munger et al. (2014) reports beaked whale detections based on an automated detector nearly daily, on about 80% of days, recorded by EARs deployed at depths ranging from 778m to 952 m north of Guam, north of Saipan, and west of Tinian(see Figure 8 for map of deployment locations). In contrast the device south of Guam produced very few detections. Although preliminary results from their interim progress report indicated a strong diel pattern with higher detection rates suggesting foraging in nighttime hours between 1800 and 0600, the authors note that irregularities in the beaked whale results have necessitated further ground-truthing of the application of the automated detector, which is ongoing and expected to be completed by the final report.

Other odontocetes:

Hill et al. (2014) reports that across all PIFSC small vessel surveys 2010-April 2014 in waters near Guam and Saipan, ten species of odontocetes other than beaked whales have been visually detected. In order of frequency from high to low, these are: spinner dolphin, pantropical spotted dolphin, bottlenose dolphin, short-finned pilot whale, false killer whale, pygmy killer whale, rough-toothed dolphin, sperm whale, melon-headed whale, and dwarf sperm whale. Figure 13 shows effort, encounters, and depth ranges for all of these species. Figure 14 shows the species discovery curve for PIFSC small vessel surveys by trackline distance surveyed through the April 2014 survey, and the species are composed entirely of odontocetes. The authors report that it is likely most other tropical delphinids also occur in

the MIRC, although some may typically inhabit waters beyond the range of small vessel surveys, such as deep offshore waters, or the remote islands north of Saipan.

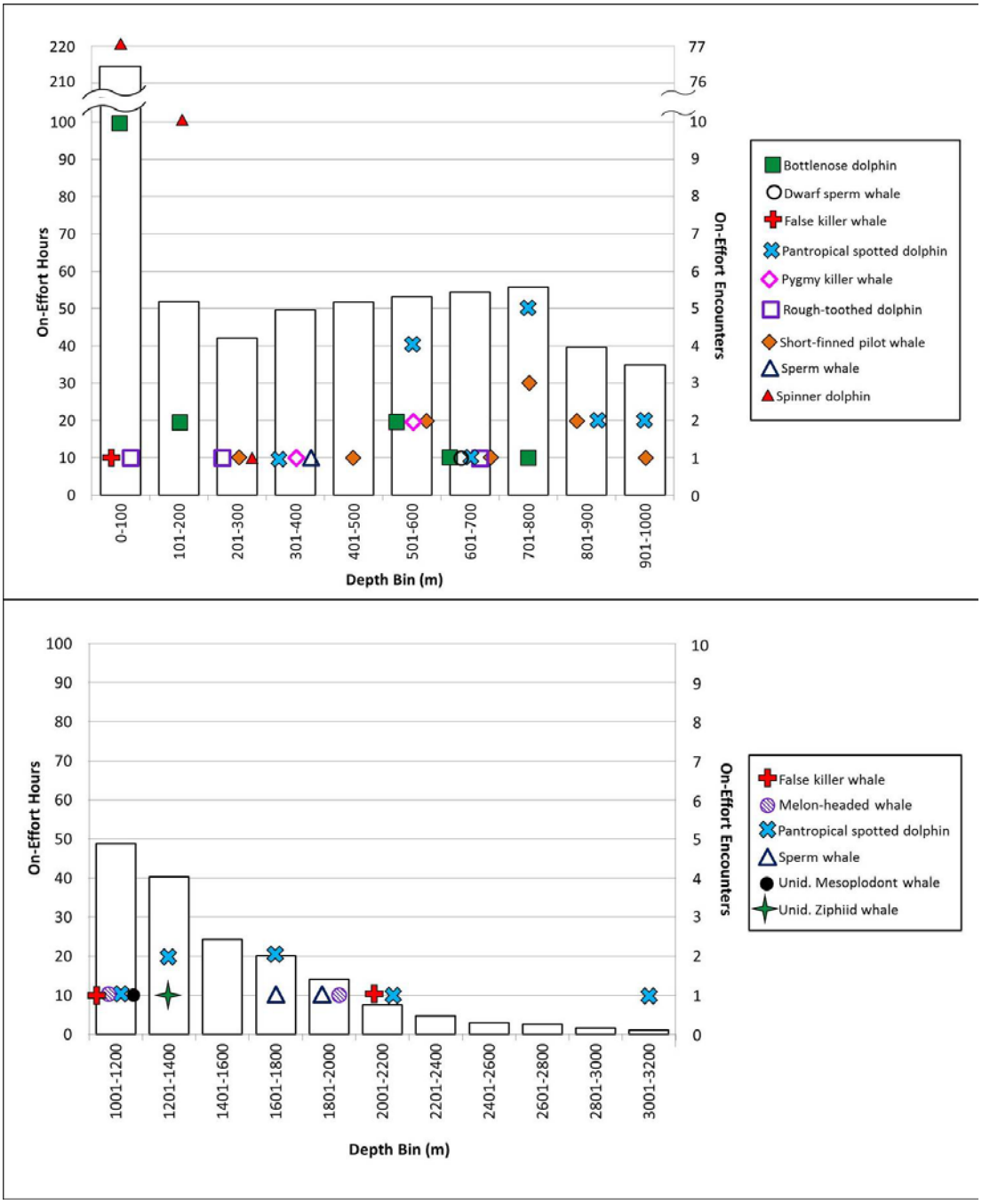


Figure 13. Distribution of cetacean encounters and search effort across depth profiles (including resights)

From Hill et al. 2014 (Appendix B).The top panel displays depths 0-1000 m divided into 100 m interval depth bins for all locations combined. The bottom panel displays depths 1001-3200 m divided into 200 m interval depth bins for all locations combined. Total on-effort hours = 816.8.

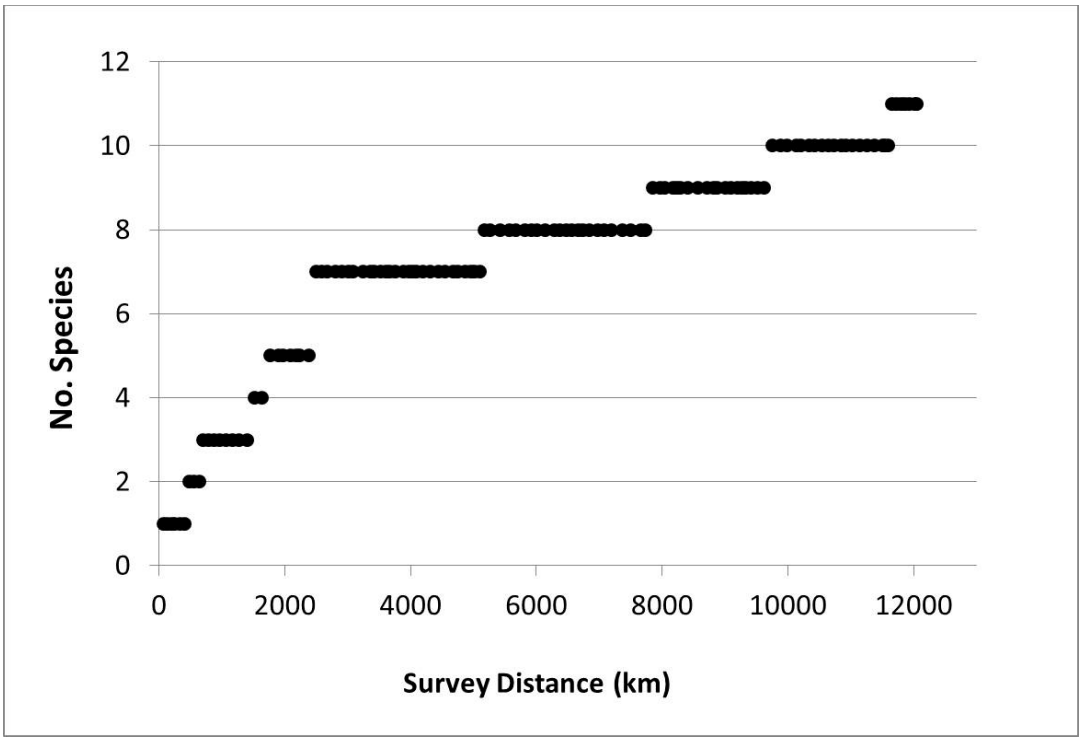


Figure 14. Species discovery by distance of trackline surveyed by PIFSC small vessel surveys 2010-April 2014

From Hill et al. 2014 (Appendix B)

For offshore waters, the results of the MISTCS cruise (DoN 2007) were that the sperm whale was the most frequently visually-sighted odontocete, as well as most-frequently sighted species overall, with an acoustic detection rate three times higher than the visual one. The pantropical spotted dolphin was the delphinid with the highest visual sighting frequency, followed by the false killer whale and the striped dolphin; other odontocete species sighted were melon-headed whale, short-finned pilot whale, pygmy killer whale, bottlenose dolphin, spinner dolphin, and rough-toothed dolphin. The aerial survey of the same year (Mobley 2007) sighted pygmy or dwarf sperm whale, pantropical spotted dolphins, and rough-toothed dolphin. The PIFSC OES 10-01 survey (PIFSC 2010a; Oleson & Hill 2010) made only one odontocete sighting within the waters of the MIRC during the transit from Wake Island, an encounter with melon-headed whales about 60km east of Guam. The closest acoustic detection of an odontocete made near the MIRC was an unidentified dolphin 100km outside eastern border of the MIRC study area at longitude E 153.07602° about halfway between Guam and Wake. The PIFSC OES 10-03 survey (PIFSC 2010b; Oleson & Hill 2010) positively identified three odontocete species, with one encounter with Risso's dolphins (205 km northeast of Saipan), one with short-finned pilot whales (198km northeast of Saipan), and two with striped dolphins (226km and 340km southwest of Guam beyond the Mariana Trench). The PIFSC OES 10-04 survey (PIFSC 2010c; Oleson & Hill 2010 made one odontocete sighting within the MIRC, an encounter with pantropical spotted dolphins 4km outside of Apra Harbor, Guam.

HDR (2014) (Appendix A) compiled a visual sighting atlas of odontocetes sighted in the MIRC from all monitoring surveys through 2013, including those listed above (DoN 2007; Mobley 2007; Oleson & Hill

2010; Hill et al. 2014), as well as the HDR small vessel and shore surveys (HDR 2011; HDR 2012; Deakos et al. 2014), and incidental sightings (Uyeyama 2014). The HDR (2014) report (see Appendix A) contains maps illustrating all such sightings made for each species individually. Figure 15 is an example from the MIRC visual sightings atlas showing all beaked whale sightings in the MIRC across all sighting sources.

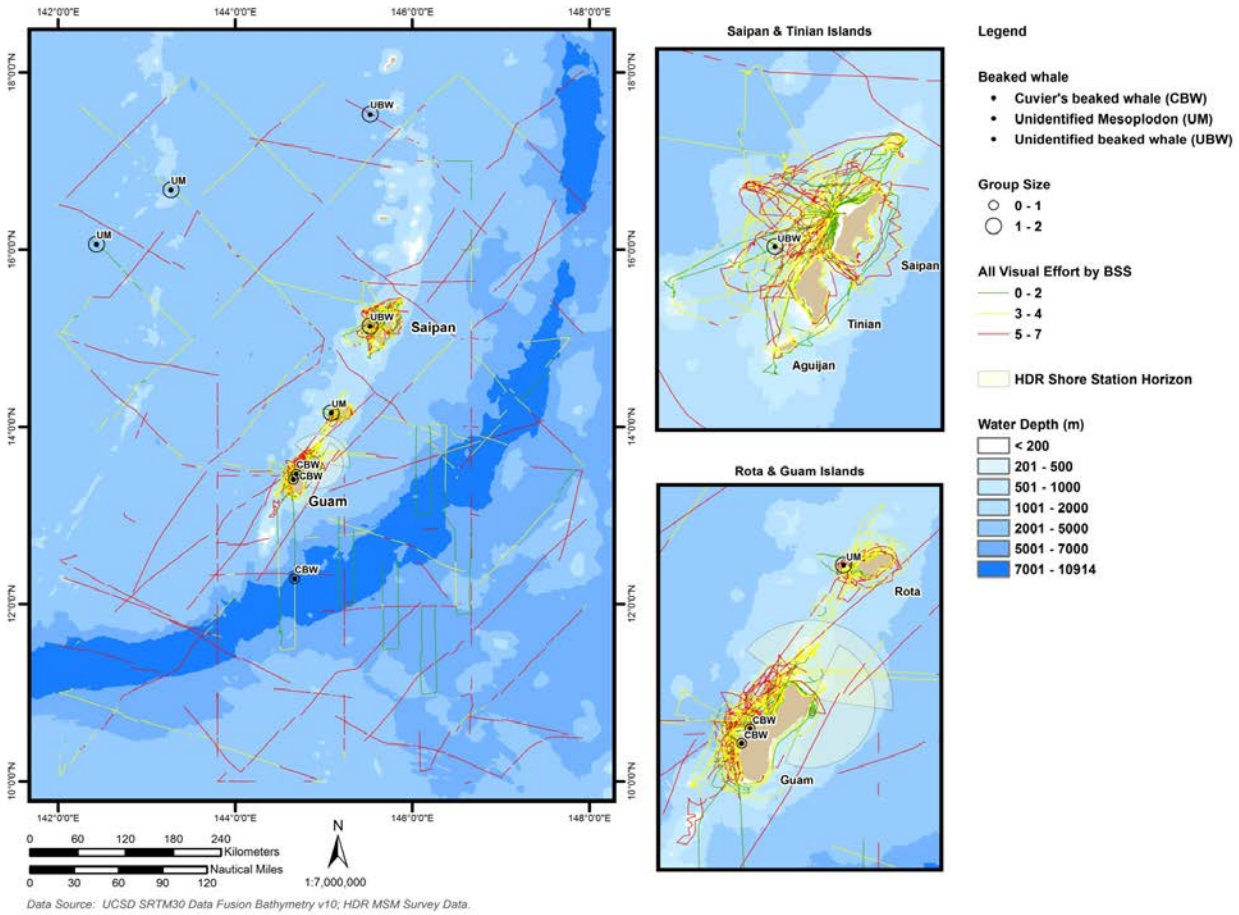


Figure 15. All beaked whale sightings from MIRC monitoring 2007-2013
From HDR 2014 (Appendix A)

Munger et al. (2014) reports that detections from the EARs (see Figure 8 for map of deployment locations) for delphinids have not been classified to species but the general categories of the detections likely correspond to false killer whale, short-finned pilot whale, and rough-toothed dolphins for low-frequency whistles, bottlenose dolphins for low- and high-frequency whistles, and spinner dolphins and pantropical spotted dolphins for high frequency whistles. Irregularities discovered in automated sperm whale and beaked whale results have necessitated further ground-truthing of automated detector and classifier algorithms before results for these species can be reported with confidence.

Analysis of archived acoustic data from PIFSC-deployed HARPs off Saipan and Tinian (Table 14) revealed that beaked whales are present year-round at both sites. The automated beaked whale detector employed for this analysis does not classify beaked whale click bouts to species, so all detections were

classified as unidentified beaked whales. However, limited assessment of beaked whale occurrence by species was reported by Baumann-Pickering et al. (2013, 2014), indicating that Cuvier's, Blainville's (*Mesoplodon densirostris*) and an as-yet unidentified beaked whale were detected at the Saipan and Tinian sites. Further data analysis is ongoing.

4.1.2 Are there locations of greater relative cetacean and/or sea turtle abundance around Guam and Saipan?

Hill et al. (2014) summarized the progress on the analysis of all thirteen satellite tags deployed on odontocetes by the PIFSC small vessel surveys beginning in 2013 (Hill et al. 2013b) through the April 2014 survey (see Table 16 for detail on each tag). Analysis of the tag data from the most recent May-June 2014 survey is in progress.

The satellite telemetry from these preliminary efforts reveals that false killer whales (Figure 16) and bottlenose dolphins (Figure 17) move into the northern islands beyond Saipan, and possibly associating for multiple days during traveling. False killer whale tracks also show individuals moving to deep offshore areas to both the west of the island chain toward the West Mariana Ridge, as well as the east toward the Mariana Trench (Figure 16). Bottlenose dolphins tended to be limited to more nearshore areas and shallower banks, although the authors note that the MISTCS cruise (DoN 2007) encountered bottlenose dolphins in deeper waters ranging from 3295-5011 meters. The preliminary telemetry from tags on rough-toothed dolphins and melon headed whales showed movements limited to the southern islands, with melon-headed whales traveling at a range of depths up to and beyond 3000m, and rough-toothed dolphins generally staying within the1000m isobaths.

Hill et al. (2014) also summarized patterns in visual sighting locations from small vessel PIFSC surveys between 2010 and April 2013. Although the small vessels were generally limited to nearshore waters, the surveys opportunistically took advantage of favorable survey conditions to venture to deeper offshore waters when possible. Spinner dolphins tended to be associated with nearshore shallow bank waters within 1 km of shore, as well as offshore sightings at Marpi Reef and Rota Bank. Short-finned pilot whales have been sighted in relatively nearshore waters between 400-1000m, corroborating by preliminary satellite tag telemetry revealing a medium depth near 1000m, with some movements offshore, although limited to waters near Guam south of Marpi Reef. Visual sightings of pantropical spotted dolphins and false killer whales were associated with a wide range of depths, from several hundred to several thousand meters in depth. The authors note that the encounter rates for the small vessel surveys were low (0.025/100 km; n=3), in contrast with the offshore MISTCS cruise (DoN 2007; Norris et al. 2012), for which sperm whales were the most frequently sighted species, with acoustic detections at a rate three times higher than visual detections. Observations of large bulls on that survey with fresh rake mark scars suggested that some of the offshore areas may be used for breeding by sperm whales. Sperm whale detections were clustered in the northeast, central, and southwest portions of the MIRC study area, with relatively few detections in the trench and offshore regions, which may reflect preference by at least some animals to inhabit waters near islands. Norris et al. (2012) improved the detection-function model for sperm whale clicks by stratifying localizations by click type

(slow vs. regular), allowing more accurate density estimation for this species averaged across the entire MIRC study area.

Hill et al. (2014) note that there is thus far insufficient information for other species (whether visual, photo-ID or satellite tag) to make conclusions for other species' preference for nearshore or offshore waters, or for utilization of habitat of the northern or southern islands.

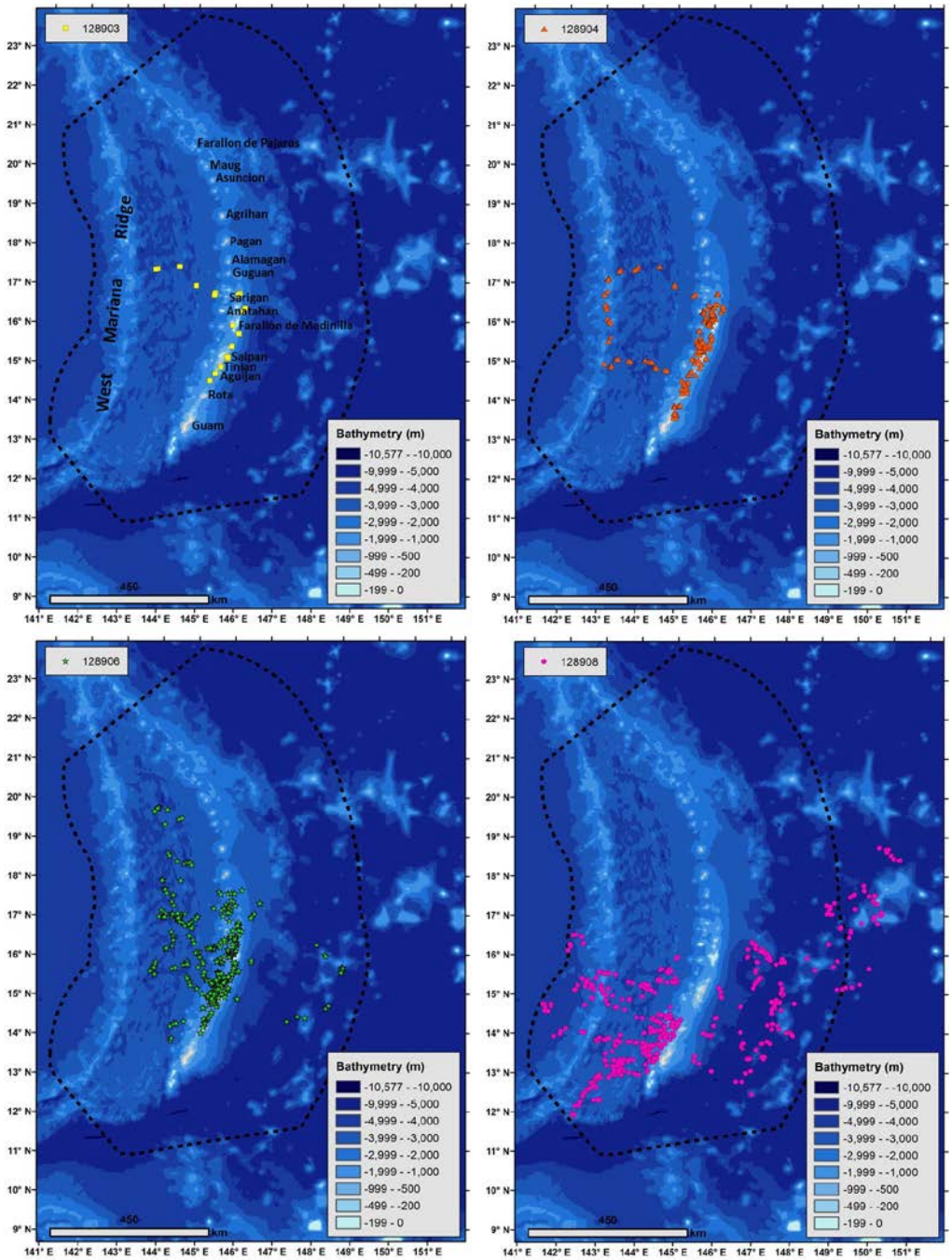


Figure 16. Satellite locations for deployed on false killer whales off Rota in 2013

From Hill et al. 2014 (Appendix B).Tag numbers are 128903, 128904, 128906, and 128908. Deployment durations were 4.0 d, 22.3 d, 98.9 d, and 198.3 d respectively. The dashed line is the EEZ boundary surrounding Guam and CNMI.

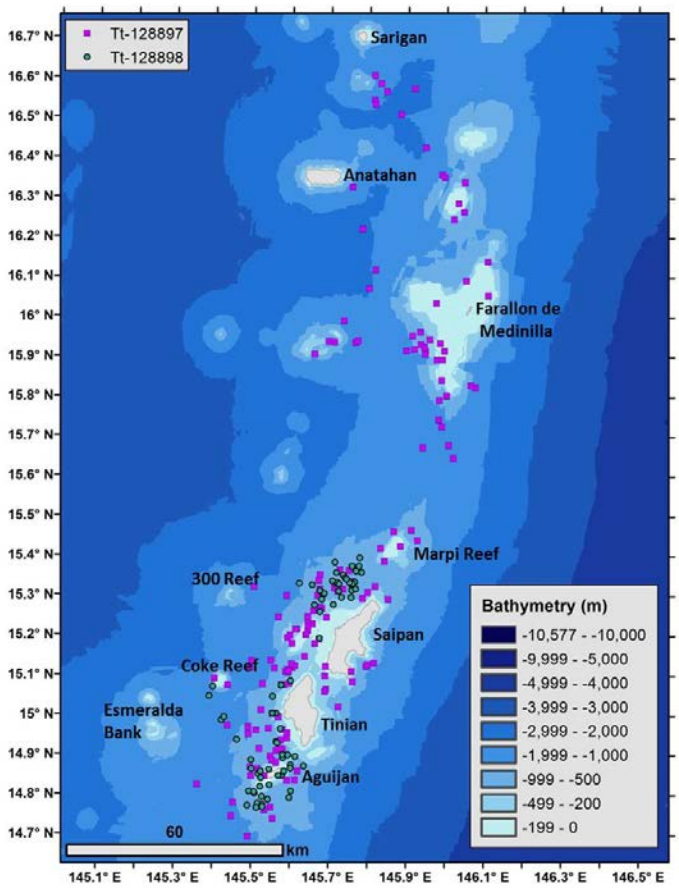


Figure 17. Satellite locations for tags 128897 and 128898 deployed on bottlenose dolphins off Aguijan and Saipan, respectively in 2013

From Hill et al. 2014 (Appendix B).Deployment durations were 20.5 d and 8.8 d respectively.

Munger et al. (2014) reports that of the four EAR locations (See Table 15: Guam S, Guam N, Saipan N, Tinian W), highest delphinid encounter rates overall were observed around the Saipan device, followed by those at Tinian and Guam, possibly due to higher density, longer residency, or both. Species with low-frequency whistles were more likely to occur around Guam than high-frequency whistlers. Low encounter rates at Guam may be an artifact of the device being positioned on a remote pinnacle. Greatest sperm whale encounter rates were observed at Tinian W, then Guam, followed by Saipan, with maximum encounter durations of 10, 7, and 14 hours respectively, suggesting some short-term site fidelity to these areas. Saipan by far had the most low-frequency, clicking, and high-frequency followed by Tinian and Guam. Guam was surprisingly quiet. However sperm whale results were questionable with possible artifacts identified, and the automated algorithms utilized to develop these preliminary results are ongoing further validation.

Deakos et al (2014) reported on shore-based survey that occurred on two sites at Guam, with greater relative number of spinner dolphin sightings occurred on the northeastern side of Guam compared with the north side. Spinner dolphins sighted multiple times on most days. Many more offshore odontocete sightings occurred on the north-facing side, possibly due to greater concentrations of marine mammals

in this shallower area or due to greater visual detection capability in calmer waters. Sea turtles were sighted multiple times below shore stations at both sites on most days, some identified as green turtles.

Jones and Van Houtan (2014) report that telemetry from six tags deployed on green and hawksbill sea turtles indicate small home ranges, typically less than 4 km^2, with some diel migration from deeper water in daytime to shallower water at night. Average depth for green sea turtles is 12.6 ± 5.3 m and 10.0 ± 3.3 m for day and night, respectively. Hawksbill sea turtle average depth was 22.6 ± 13.8 m and 17.4 ± 6.4 m for day and night, respectively.

Additionally, a 30-day acoustic survey using a pair of deep diving and profiling autonomous gliders commenced field deployment in late September 2014. A subsequent survey repeating the same track lines is also scheduled for the winter of early 2015. One glider will survey to the southeast of Guam toward and beyond the Mariana Trench, and the other will survey to the northwest toward the Western Mariana Ridge. Results from these surveys have the potential to provide occurrence information across wide ranges of the MIRC study area, including offshore waters.

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

Hill et al. (2014) summarized the preliminary results from genetic tissue analysis from biopsy samples collected from the PIFSC vessel surveys between 2010 and April 2014. This analysis was performed by SWFSC using mitochondrial DNA (mtDNA) sequences to investigate the genetic diversity and structure in bottlenose dolphins, short-finned pilot whales, spinner dolphins, and melon-headed whales, and is described in greater detail by Martien et al. (2014). Photographic individual identification catalogs have also been established by PIFSC for three species, bottlenose dolphins, short-finned pilot whales, and spinner dolphins based on photographs from the PIFSC and HDR surveys (HDR 2011; HDR 2012)

With regard to bottlenose dolphins, it was notable that no *Tursiops aduncus* haplotypes were found in the samples. Five of the samples, representing a proportion of about a third collected from this species, revealed a haplotype similar to that found in Fraser's dolphin (*Lagenodelphis hosei*) samples from near the Philippines; corresponding photographs from the encounters from which the samples were collected confirm that all five individuals appear morphologically to be bottlenose dolphins. Martien et al. (2014) concludes that there has been extensive introgressive hybridization of Fraser's dolphin mtDNA into the Mariana Islands bottlenose dolphin gene pool, the implications which are being further investigated, including an assessment of population structure between islands once the pool of available tissue samples is larger. Hill et al. (2014) also note that PIFSC visual and satellite telemetry have indicated frequent and persistent associations with other species lasting multiple days. PIFSC was able to establish a photographic catalog of bottlenose dolphins, composed of 47 individuals from 15 encounters, with resightings among all surveyed islands. Preliminary photo-ID and satellite data (Figure 17) from individuals sampled in the southern islands covered by the small vessel surveys (i.e., Guam to Saipan) indicate this population is distributed among the southern islands and as far north as Sarigan (Martien et al. 2014).

Short-finned pilot whales have been sighted in relatively nearshore waters between 400-1000m, corroborating by preliminary satellite tag telemetry revealing an average depth near 1000m, with some movements offshore, although these have been limited to waters near Guam south of Marpi Reef. Genetic data for pilot whales was stratified between those collected near Guam and Rota, and those collected near or Saipan, Tinian and Aguijan. Pilot whale photographic matches vary from individuals resighted multiple times, whereas other groups have only been sighted once, suggesting some groups may be associated primarily with the southern islands, whereas others may not. Based on visual, tag, and genetic data collected from small vessel surveys limited to the southern islands, it is unknown if different populations of short-finned pilot whales occur within the southern islands, in the northern islands beyond Saipan, or offshore (Hill et al. 2014).

A photo-identification catalog for spinner dolphins was established from 24,762 photos from 77 encounters between 9 February 2010 and 27 July 2013, with 307 individuals cataloged across all locations and years (Hill et al. 2014). More than half of individuals were sighted during more than a single encounter, with resights occurring between Saipan, Tinian, Aguijan, Rota, and Marpi Reef. Three individuals identified at Guam were also sighted at Rota Bank, but no matches were found between Guam or Rota Bank with any of the CNMI locations. However Martien et al. (2014) did not find evidence for genetic differentiation between islands, with the sampled individuals sharing haplotypes common throughout the Pacific, with high haplotypic diversity higher than the Hawaiian population, suggesting the population in the Marianas may not be as isolated as Hawaiian spinner dolphins. The authors hypothesize the results might be explained by genetic transfer with offshore populations, or ones resident to the northern islands.

Conclusions for melon-headed whales are limited, given the few relatively few number of encounters with this species. Although three satellite tags were deployed on this species, one tag malfunctioned, and another transmitted only for 3.1 days. The limited satellite telemetry data revealed broad movements among the southern islands of the CNMI (Hill et al. 2014). Only two melon-headed whales have been biopsied so far, and each had different mtDNA haplotypes previously observed in the central Pacific (Martien et al. 2014).

With regard to relative abundance patterns in nearshore areas around Guam, Hill et al. (2014) presents visual sightings of various odontocetes, and satellite telemetry locations for short-finned pilots whales, with respect to underwater detonation sites used for Navy training activities (Figure 18). Cetacean and sea turtle encounters in areas of potential Navy training utilizing sonar is visualized by the compilation of sightings across the MIRC from the MIRC Atlas (Figure 19; HDR 2014)

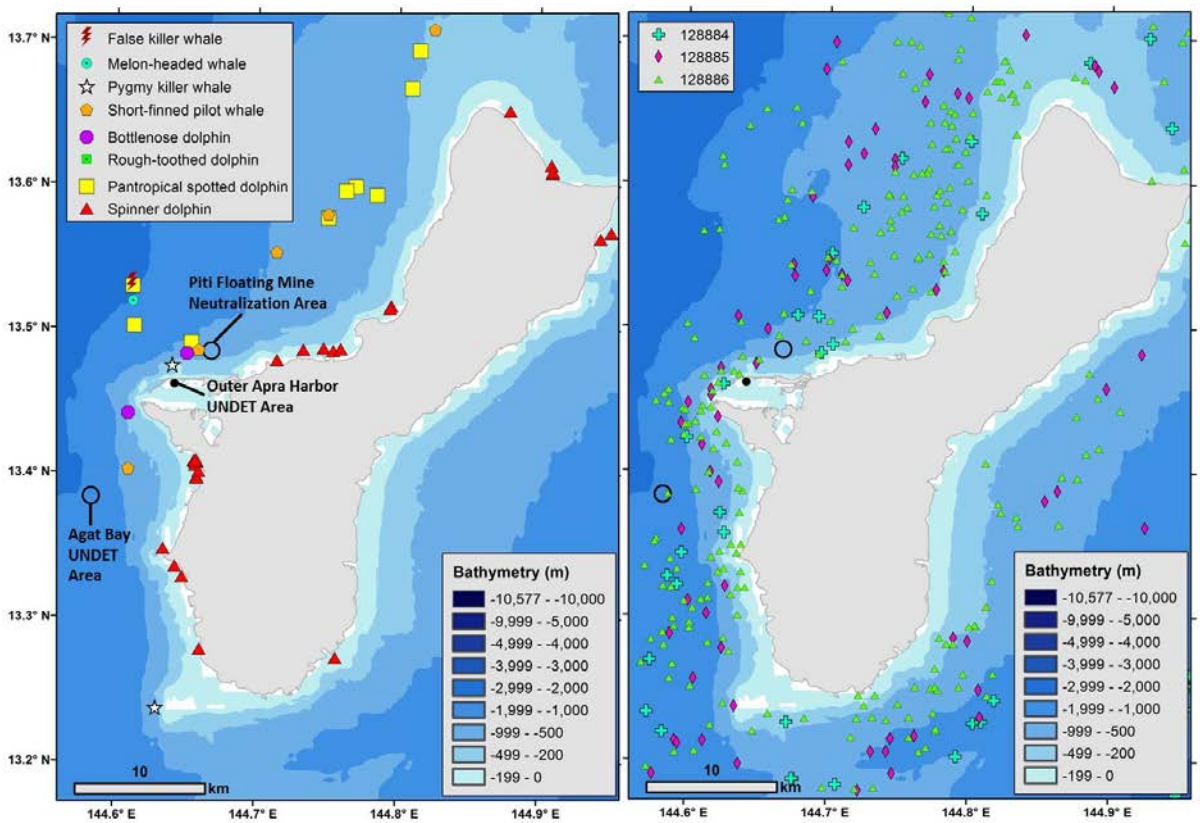


Figure 18. Navy underwater detonation and explosive ordnance areas, cetacean encounter locations and short-finned pilot whale satellite tag locations

From Hill et al. 2014 (Appendix B). The circles at the Piti Floating Mine Neutralization Area and the Agat Bay UNDET Area represent the 640 m exclusion zone around the detonation site.

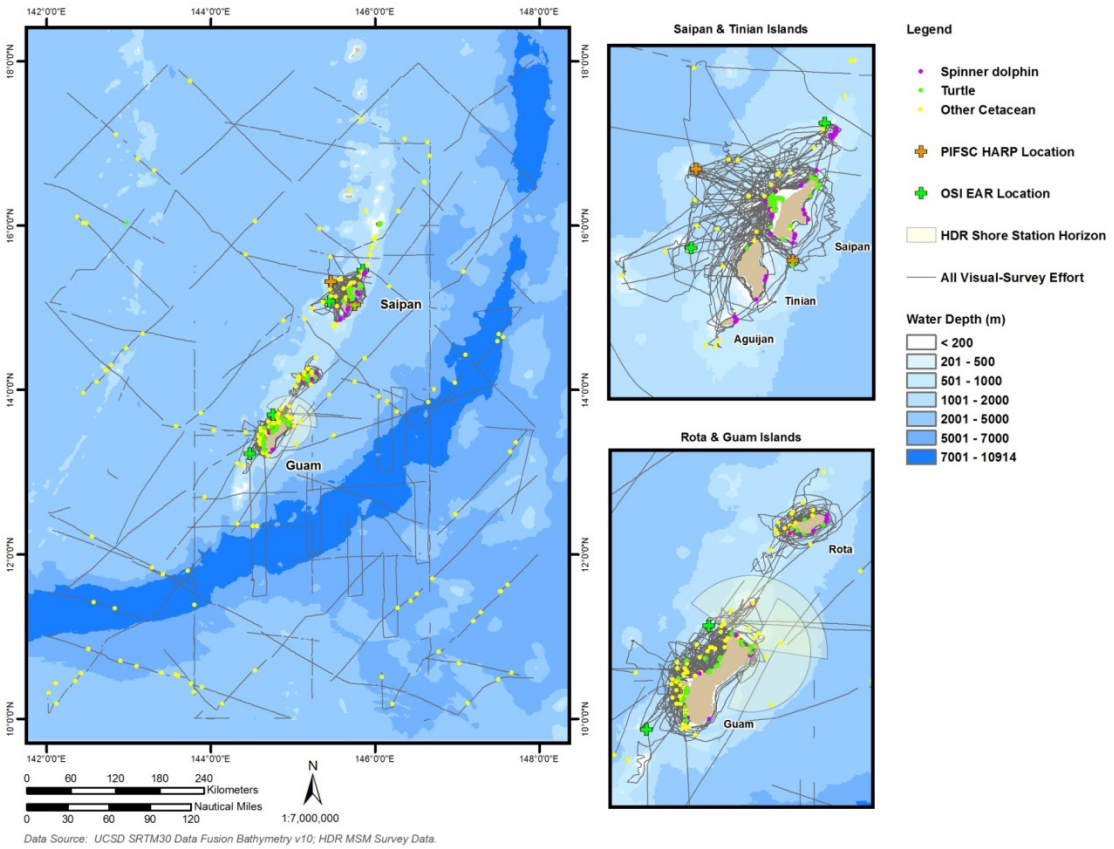


Figure 19. Combined all survey effort and all cetacean and sea turtle sightings within the MIRC, 2007-2013

From HDR 2014 (Appendix A)

Overall across the broader study area of the MIRC, detection functions were estimated from visual sightings from the MISTCS large vessel survey for sperm whale as well as three pooled groups of species: Balaenoptera spp., blackfish (medium-size odontocetes), and small dolphins (Fulling et al. 2011). Abundance in the study area based on these detection functions was estimated for: sperm whale, sei whale, Bryde's whale, false killer whale, short-finned pilot whale, melon-headed whale, pygmy killer whale, pantropical spotted dolphin, striped dolphin, bottlenose dolphin spinner dolphin, and rough-toothed dolphin. A notable finding is the presence of north Pacific sei whales in the study area, which lies south of 18°N, whereas worldwide distribution is generally north of 20°N. Using the acoustic detections from the towed-array of the same survey, progress was made toward abundance estimation (Norris et al. 2012). Detection functions and abundances were estimated in the study area for calling minke whales, as well as a detection function developed for sperm whales using both "slow" and "regular" click types. On a qualitative basis, the authors also noted patterns in the geographic position of sperm whale localizations, with the suggestion of clusters in three regions of the study area, the northeast, central and southwest portions, respectively, with the remainder near the Mariana trench or offshore areas. The central cluster was nearest the archipelago, and tended to produce codas typical of social groups, and suggest possible use of this area by matrilineal units.

The authors also compared the acoustic detections with parameters known from other populations of several species. The three sperm whale coda patterns recorded in the MIRC are documented from clans in other geographic regions in the North and even the eastern South and Central Pacific (e.g., near the Galapagos Islands and off Chile). In particular the documentation of the "short" clan coda in the MIRC is the first known in the western Pacific, and suggests a possible social link between these regions. With regard to humpback whales, one song phrase type was identified as shared between a recording made near Saipan and Tinian, with a song recorded at Maui in Hawaii.

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

The MISTCS cruise of 2007 (DoN 2007) was the first systematic visual line transect survey for marine mammals and sea turtles in the MIRC, and the entire range complex including offshore waters for the Mariana Islands region (Figure 3), and detected Bryde's whale, sei whale, humpback whale, and minke whale. Minke whales were not sighted visually but only detected acoustically, and are the first record of minke whales in these waters. Bryde's whales and sei whales were the second and third most frequently sighted cetacean on the survey. The survey was conducted from January through mid-April, and most sightings were in offshore deep waters. An aerial survey in the summer of that same year detected one baleen whale, a Bryde's whale, in deep offshore waters near the Mariana Trench (Mobley 2007). The subsequent systematic large vessel surveys in the MIRC were in 2010, on the PIFSC surveys aboard the Oscar Elton Sette. The OES 10-01 survey (PIFSC 2010a; Oleson & Hill 2010) transited from Hawaii to Guam with acoustic detections of minke whales along the transit, including one just outside eastern border of the MIRC on February 4 at N 15.0256° E 150.5291°. Humpback whales were not detected. Also an unidentified rorqual was visually sighted within the MIRC approximately 185km east of Guam on February 5 at N13.811° E146.683°. The OES 10-03 survey (PIFSC 2010b; Oleson & Hill 2010) between 20 March and 11 April only utilized visual search, and traversed water areas entirely within the MIRC, and did not detect any baleen whales. The OES 10-04 survey (PIFSC 2010c; Oleson & Hill 2010) transited from Guam to Hawaii beginning on 19 April did not visually detect any baleen whales within the MIRC. However acoustic detections were made of minke whales, two on 20 April (N13.930° E147.049° and N14.100° E 147.577°), and two near but just beyond the eastern border of the MIRC on 21 April (N14.910° E150.148° and N15.137° E 150.891°). There was also a probable sei whale call detected within the MIRC on 20 April (N 13.930° E147.049°).

In contrast, no baleen whales have been detected in the relatively nearshore surveys conducted by small vessels 2010-2014 (Ligon et al. 2010, Hill et al. 2011, Hill et al. 2013a, Hill et al. 2013b Hill et al. 2014; HDR 2011; HDR 2012), nor by the shore-based survey on Guam conducted in May 2013 (Deakos et al. 2014). In chronological order, the dates of these surveys are:

- 9 Feb – 3 March 2010
- 17 Feb – 3 March 2011
- 26 Aug – 29 Sept 2011
- 15-29 March 2012

- 25 May - 3 July 2012
- 11–21 May 2013
- 22 June – 27 July 2013
- 11 -27 April 2014
- 15 May—20 June 2014

However, a number of incidental sightings made during non-Navy/NMFS surveys, mostly humpback whales, have been reported closer to the archipelago (Uyeyama 2014). From incidental sightings made by Navy-funded efforts, humpback whales were sighted predominantly in February and March on the following dates, listed here by month: 15 January 2013, 16 January 2013, 23 January 2006, 18 February 2007, 22 February 2000, 26 February 2001, 20 March 2006, 24 March 2003, 24 March 2003. All sightings were at FDM, with the exception of the sighting on 16 January 2013 nearshore off the west coast of Saipan, as well as an unidentified balaenopterid sighted at the same location the previous day on 1/15/2013. The locations reflect the bias that the survey series to FDM was the only regular visual survey over water conducted by the Navy in the MIRC that incidentally searched for marine mammals, whereas over-water surveys were not conducted elsewhere. These surveys were also performed frequently over many years, almost monthly from 1997 through 2009, and quarterly thereafter; humpback whales were sighted in only 15% of survey days during the months of January through March. Two unidentified whales were also sighted at FDM on 22 January 2007 and 22 February 2000. Incidental sightings of humpback whales reported to Guam DAWR also occurred during February and March: 13 February 1991, 16 February 1996, 24 February 1996, 25 February 1978, 2 March 1996 and 19 March 1996. The other baleen whales from incidental sightings were: 1) Bryde's whale (7/28/2007 in transit to FDM, 2) a whale stranding of unconfirmed species 31 August 1978 reported to DAWR corresponding to the NMFS stranding identifier NMFS-XX-78-07-SD); 3) a blue whale sighted by Gerry Davis of Guam DAWR on 1 July 1995; and 3) a sei whale from DAWR records with no year or month listed.

Figure 20 from the MIRC Atlas (HDR 2014) depicts all baleen whale sightings in the MIRC from both monitoring efforts 2007-2014, including MISTCS and the aerial survey from 2007, as well as incidental sightings sources 1962-2013.

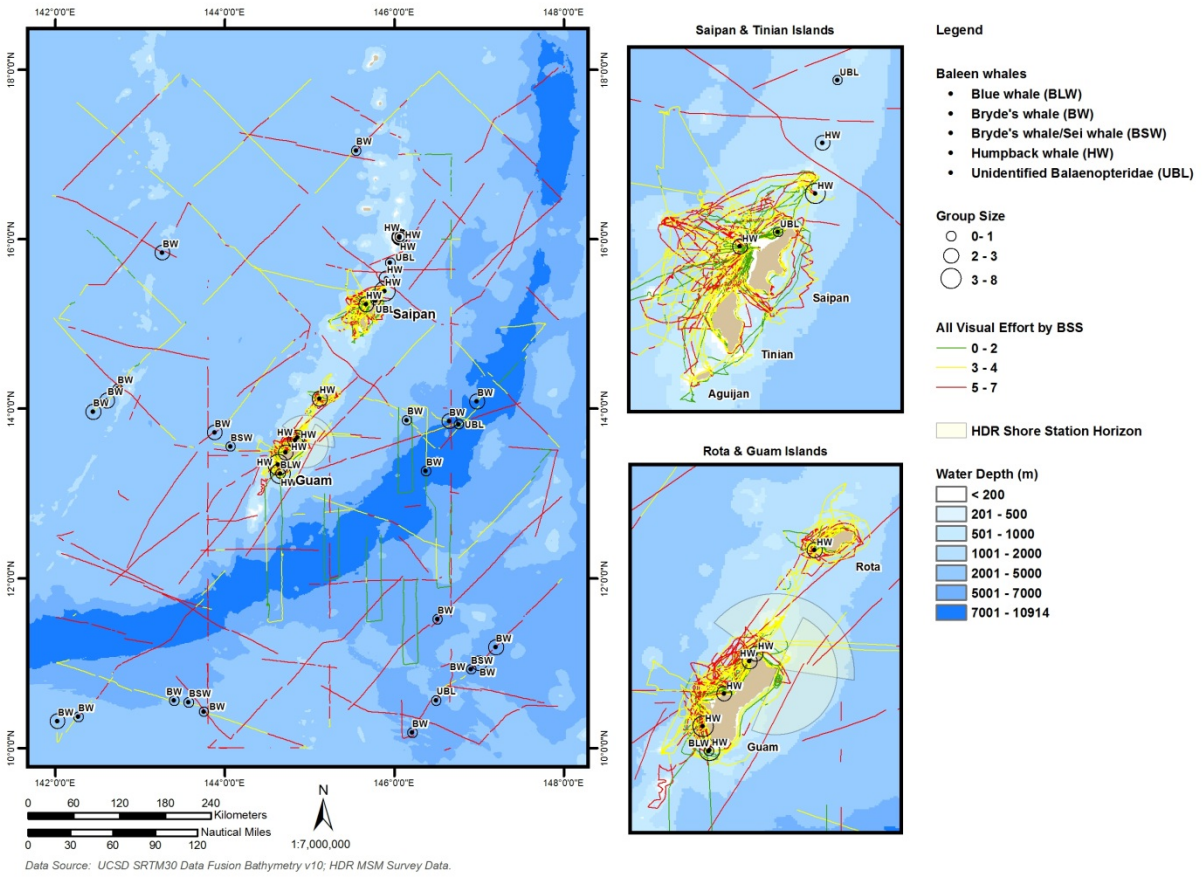


Figure 20. All baleen whale sightings from MIRC monitoring 2007-2013, and incidental sightings
From HDR 2014 (Appendix A)

Munger et al. (2014) reports baleen whale detections by passive acoustic monitoring utilizing EARs (See Table 15 and Figure 8 for deployment locations and dates). The automated baleen whale detector made three detections of minke whales during the recording period of the first deployment at northern Guam (4 September 2011-6 January 2012), and two detections of humpback whales during the recording period of the first deployment at northern Saipan (4 September-29 December 2011). During the recording period of the second deployment the EAR at Saipan (6 April-22 September 2012) humpback whales were detected on two days. Automated detectors for high frequency sei whale calls typical to the Mariana Islands region were also applied to all EAR recordings, but no detections were made. No other baleen whale detections were made at the other EARs or on other deployments, however these data must be considered with respect to the recording periods of the devices (Table 15), in particular that no recording occurred during 6 January and 6 April.

Acoustic datasets from PIFSC-deployed HARPs off Saipan and Tinian (Table 14; Figure 19) were analyzed for low-frequency (<1 kHz) baleen whale vocalizations (Oleson 2014). Analysis of 2010 and 2011 Saipan and Tinian datasets is complete, and analysis of the 2012–2013 datasets is ongoing. Baleen whale species detected include fin whale, blue whale, humpback whale, and minke whale. In this interim

progress report, seasonal occurrence was analyzed in monthly bins across the 2010–2011 datasets (Figure 21). In general the months of February/March through May represented a seasonal peak for humpback whales, minke whales, and fin whales as recorded off Saipan, and for fin whales recorded off Tinian. Additionally blue whales were detected between April and July on the Tinian HARP. An unidentified whale was detected throughout most months on the Tinian HARP, although the record of analyzed recordings for this analysis is incomplete for the months between December and March. A more comprehensive analysis, including data from 2012–2013, is ongoing.

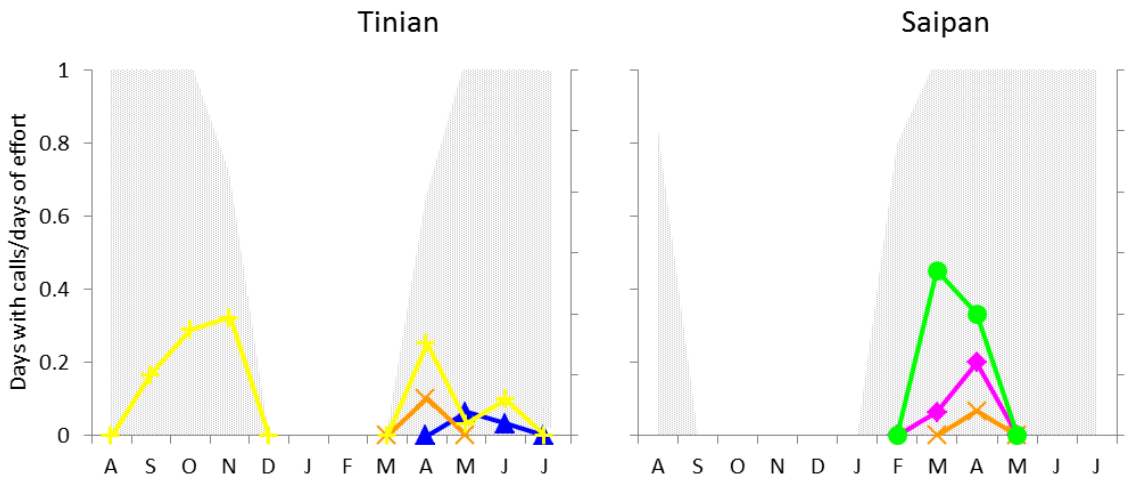


Figure 21. Proportion of days with calls in relation to recording effort, by month with recording effort combined across years

From Oleson, 2014. Lines and symbols represent different large whale species, with proportion of calls to effort quantified on left vertical axis. Light gray shading quantifies the proportion of days per month with recording effort. Orange = fin whale, Blue = blue whale, Green = humpback whale, Pink = minke whale, and Yellow = Unidentified whale.

Finally there are two 30-day acoustic surveys using deep diving and profiling autonomous gliders planned for fall 2014 and winter 2015. Each survey is planned to deploy two gliders each, one to the southeast of Guam, and the other to the northwest. Results from this survey have the potential to provide occurrence information across wide ranges of the MIRC study area, including offshore waters.

4.1.5 What is the occurrence and habitat use of sea turtles in areas where the U.S. Navy conducts underwater detonations?

Figure 19 below, from the MIRC Atlas (HDR 2014), depicts all sea turtle sightings in the MIRC from monitoring efforts 2007-2014, comprised mostly of sightings from small vessel cetacean surveys, but also including one offshore sighting from the MISTCS cruise (DoN 2007). The figure also includes incidental sightings made at FDM during regular aerial avian surveys at that island (HDR 2014; Uyeyama 2014).

During August 2013, dedicated sea turtle surveys conducted by NMFS PIFSC were conducted from small vessels in the nearshore and coastal waters of Guam (Cocos Lagoon), Saipan and Tinian (Jones and Van Houtan, 2014; Appendix D). Only green turtles (*Chelonia mydas*) and hawksbill turtles (*Eretmochelys imbricata*) were encountered on these surveys. When sea turtles were encountered, they were captured by hand while snorkeling or diving, and instrumented with either a temperature-depth tag or an ARGOS temperature-only Platform Transmitter Terminal tag in order to characterize sea turtle movements and habitat use in the MIRC. Four green turtles and two hawksbill turtles were captured at Tinian and Saipan and instrumented a with satellite tags. Turtles encountered at Guam at Cocos Lagoon were evasive and avoided capture and tagging. Kernel density estimates revealed habitat fidelity and limited movements for one hawksbill while resident off Tinian and Guam. The other five turtles remained in the nearshore environment off Garapan, Saipan. Kernel density estimates show sustained use and residency by all five in the area of original capture. Dive patterns suggest that both hawksbill and green turtles remain in deeper waters during daylight hours and move nearshore during the night. Hawksbills spent more time in deeper waters than the greens, reaching depths of 100 m or more. Green turtle average depth was 12.6 ± 5.3 m and 10.0 ± 3.3 m for day and night, respectively. Hawksbill turtle average depth was 22.6 ± 13.8 m and 17.4 ± 6.4 m for day and night, respectively. The data suggest a dichotomy in selected habitat and habitat use for green and hawksbill turtles. Both species display small home ranges, typically less than 4 km^2, and limited movement between islands with only one turtle, a hawksbill, making a 286-km, seven-day trek from Tinian to Guam (Figure 7, above). While dive profiles, typical home range sizes, and potential for inter-island migration are relevant for informing potential exposure to Navy training activities, this monitoring project is ongoing and the subsequent 2014 survey was successful in tagging sea turtles within Guam's Apra Harbor, in closer proximity to the Navy's underwater detonation sites.

Additionally all small vessel surveys that were conducted primarily as marine mammal surveys 2010 2014 (Ligon et al. 2010, Hill et al. 2011, Hill et al. 2013a, Hill et al. 2013b Hill et al. 2014; HDR 2011; HDR 2012) also followed a protocol to record all sea turtle sightings, as did the shore -based survey on Guam (Deakos et al. 2014). Through the programmatic data management applied under the MIRC monitoring program, all turtle sightings on these surveys through 2013 have been integrated within a single geo-referenced database (HDR, 2014), and data from 2014 and beyond will continue to be integrated.

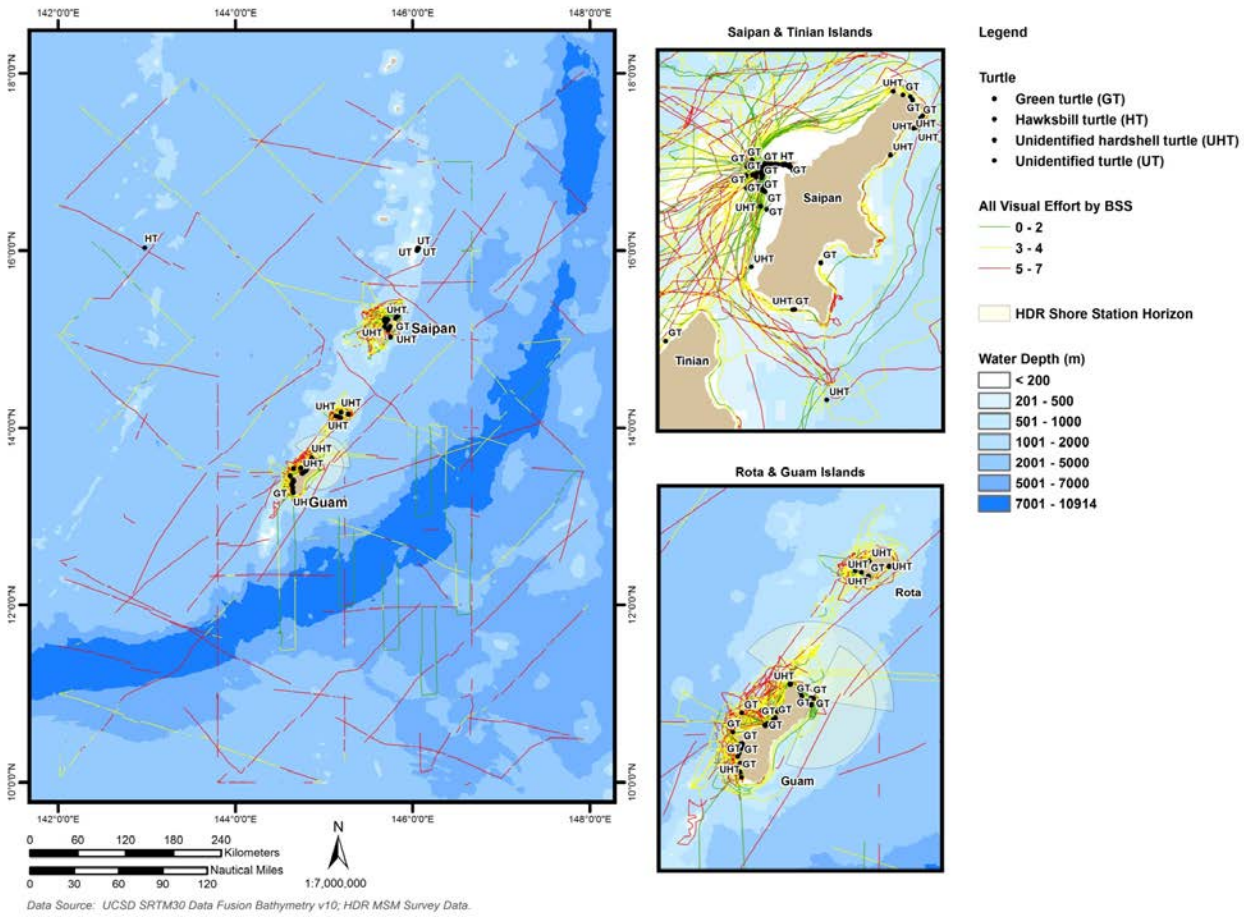


Figure 22. All sea turtle sightings from MIRC monitoring, 2007-2013

From HDR 2014 (Appendix A)

5 FUTURE DIRECTIONS

5.1 REVISION TO THE COMPLIANCE MONITORING STRUCTURE

5.1.1 ADAPTIVE MANAGEMENT

Concurrent with implementation of the original range-specific monitoring plans developed for MIRC monitoring as part of the MMPA/ESA authorization process, the Navy and NMFS began development of the ICMP, as described in Section 1.1. Part of the agreed-upon process of monitoring was that the NMFS, the Marine Mammal Commission, and the Navy would meet yearly to discuss results and progress from monitoring, as the science in this field is evolving fairly quickly. Upcoming monitoring requirements would be adapted to meet gaps in knowledge of marine species on Navy ranges or emergent issues. Some other meetings that were required under the LOAs for monitoring were built into the schedule to provide Navy feedback and input from scientific and public parties on Navy marine species monitoring.

A October 2010 Navy monitoring meeting initiated a critical evaluation of Navy monitoring plans and began development of revisions to existing range-specific monitoring plans and associated updates to the ICMP. This process included the establishment of the SAG which convened in March 2011. The focus of the Scientific Advisory Group (SAG) was evaluation of current Navy monitoring approaches under the ICMP and existing LOAs and development of objective scientific recommendations that would serve as a basis for a Strategic Planning Process which would be incorporated as a major component of the ICMP. Composed of leading academic and civilian scientists with significant expertise in marine species monitoring, acoustics, ecology, and modeling, the group produced a consensus report which laid out over-arching and range-specific recommendations for the Navy's Marine Species Monitoring program and is described in Section 5.1.2.

Further Adaptive Management Review (AMR) meetings in October 2011, October 2012, and April 2014 between the Navy and NMFS have continued to refine the Navy's monitoring program. Consensus has been that the ICMP, in conjunction with annual AMR review, and the strategic planning process, would continue the evolution of Navy marine species monitoring towards a single integrated program. The Navy wide monitoring program will incorporate SAG recommendations when appropriate and logistically feasible, and establish a more collaborative framework for evaluating, selecting, and implementing future monitoring across the all Navy range complexes through AMR and Strategic Planning Process described in 5.1.3).

5.1.2 SCIENTIFIC ADVISORY GROUP RECOMMENDATIONS

The SAG developed a framework for evaluating all Navy range complexes under the ICMP and for formulating objective, expert scientific recommendations for addressing top-level goals of the ICMP. The recommendations were at multiple conceptual levels from broad to specific:

- Broad level concepts which defined a continuum of knowledge in which monitoring objectives could be placed in context;

- Mid-level recommendations on practical program structure and management which could be implemented at the overall Navy-wide program level but also at the range complex level;
- Range-specific recommendations which were based on an assessment of our understanding of marine species at each range complex along the continuum of knowledge and provided specific guidance for monitoring approaches.

In this section, the broad and mid-level recommendations are summarized because of the relevance to practical decisions made for MIRC monitoring as well as the range-specific recommendations.

The participants of the 2010 meeting recommended, and the SAG concurred with recasting the original five questions into a conceptual framework of occurrence, exposure, response, and consequence. Occurrence represents basic or baseline information on presence and diversity of species that occur on a Navy range, but also includes patterns of habitat use, population structure, density and abundance, and elements of behavioral ecology. Exposure represents information on Navy training activities in order to allow estimation of RLs and other metrics of interest. When combined with occurrence information, it is possible to improve the estimated exposures to Navy sounds sources. Response incorporates how animals react over multiple time scales. If animals respond in a way that reduces exposures, this can be used to refine exposure estimates. And finally, consequence represents the long-term impacts of exposures and responses, including cumulative impacts to fitness.

Programmatic recommendations which have, in many cases, been considered and applied at the Navy-wide level are also relevant at the range complex level. The recommendations are applied through revisions to range complex monitoring plans and implementation "on the ground". These programmatic recommendations include:

- Increased transparency to, and collaboration with, the scientific community on how monitoring plans are developed, revised, and implemented;
- Increased and consistent availability of data (classified and unclassified) as well as refinement of data standards;
- A change of mindset for both Navy and NMFS away from evaluating the compliance monitoring program via metrics of effort and instead evaluating progress toward scientific objectives;
- A focus on different ecological scales including individual, group and population
- Establishment of the time scales that monitoring studies at training events are intended to capture;
- Collection of baseline occurrence and behavioral data when required;
- Expansion of acoustic exposure metrics beyond RL;
- Ensure access to all required data required for analysis;
- Moving away from planning for retrospective data analysis and instead utilizing prospective experimental design with sufficient statistical power based on objectives identified by the strategic planning process and the upcoming change to study-question-based range complex monitoring plans;
- Conduct an assessment of existing data sets to ensure that they are utilized to the full extent practicable;

- Incorporation of existing data from the effects of sonar into a meta-analysis as data sets become sufficiently mature to support such analyses;
- Conduct annual science review meetings and convene an interdisciplinary working group on PAM and how to best focus on response to sonar activities;
- Collaboration with NOAA whenever possible;
- Focus on explosives and low frequency active sonar (LFAS) in addition to MFAS.

MIRC was rated high on the need for basic occurrence information and the diversity of marine mammals that would potentially be encountered. It was rated medium/high on the level of sonar activity, because this was expected (at the time) to increase. Rating was medium/low for the density of marine mammals and low for logistics, conditions, ability to address exposure/response/consequences. The suggested relative level of investment was medium. The SAG concurred with Navy's approach and specifically recommended baseline studies for basic occurrence because so little was known about species in the area. Passive acoustic monitoring, in combination with recording from small boat to obtain species-specific vocalizations, was also recommended. Other recommended methods to collect occurrence data included small boat surveys, biopsy sampling, satellite tagging and photo-identification (photo-ID).

In addition to the SAG, a smaller regional scientific advisory group (rSAG) was also convened and consulted at a 13 October 2011 teleconference. The rSAG provided more detailed suggestions which included:

- Complementing visual based methods (e.g. small boat photo-ID work, large vessel surveys, aerial surveys, shore-based surveys) with passive acoustic methods, including autonomous bottom recorders, dipping and/or towed hydrophones from small vessels, sonobuoys, and other passive acoustic methods;
- Collecting group size, species identification (especially the occurrence of mixed species schools for delphinids), gender (from biopsies) and behavioral activities of animals in conjunction with PAM in order to improve interpretation results of PAM data ;
- Collecting surface recordings near autonomous recorders whenever possible in order to validate classifiers/detectors across recording methods;
- Validating acoustic classifiers with visual data;
- Establishing shore based surveys for inaccessible waters;
- Focusing on basic questions of patterns of presence, distribution, density, and population connectivity through a series of visual/acoustic surveys using large/medium vessels, incorporating both line transect and photo-ID sampling; passive acoustic monitoring; targeted biopsy and tagging studies, and possibly some aerial survey work;
- Conducting a Lookout Effectiveness Study embarkation in the MIRC;
- Focusing on determination if there are areas of higher relative activity and/or seasonal occurrence;
- Conducting surveys during summer months when the sea conditions are conducive to survey;
- Conducting systematic aerial line transect surveys for species diversity, distribution, abundance, and some behavioral data.

The input from the SAG and rSAG has been carefully considered and applied to the evolution of the monitoring program in the MIRC, resulting in the design of the 2012 update to the MIRC monitoring plan and the updates thereafter in 2013 and 2014, as described in detail in Sections 3.1-3.1.1.

5.1.3 Strategic Planning Process

The U.S. Navy has engaged in a Strategic Planning Process (DoN 2013b) to enhance its marine species monitoring program in association with Marine Mammal Protection Act and Endangered Species Act regulatory compliance. The purpose of this process are to more effectively and efficiently address objectives of the ICMP and achieve top-level monitoring goals established by the Navy in coordination with the NMFS. This process improvement is part of the adaptive management review of ongoing compliance monitoring within Navy at-sea training and testing range complexes.

The Strategic Planning Process provides guidelines and processes necessary to develop, evaluate, and fund individual projects based on objective scientific study questions. The process uses an underlying framework designed around top-level goals, a conceptual framework incorporating a progression of knowledge, and in consultation with the SAG and other regional experts.

"Compliance" with the Navy's monitoring requirements is evaluated through the annual reporting and AMR process in coordination with NMFS and the Marine Mammal Commission (MMC), as opposed to arbitrary effort-based metrics previously incorporated into regulatory requirements. In addition, the Navy will implement an independent program review process to provide feedback on program performance and progress in addressing ICMP goals and objectives.

In the MMPA LOA Phase II marine species monitoring program, the Strategic Planning Process for Marine Species Monitoring has five major implementation steps to: 1) identify intermediate overarching scientific objectives; 2) develop individual monitoring project concepts; 3) Evaluate, prioritize, and select monitoring projects to fund or continue supporting for a given fiscal year; 4) Execute selected monitoring projects; 5) Report and Evaluate progress and results. This process will also address relative investments to different range complexes based on goals of the U.S. Navy marine species monitoring program across all range complexes, and monitoring would leverage multiple techniques for data acquisition and analysis when optimal.

The November 2013 update of the Strategic Planning Process for Marine Species Monitoring (DoN 2013b) is available on the U.S. Navy's monitoring website http://www.navymarinespeciesmonitoring.us and at http://www.nmfs.noaa.gov/pr/permits/incidental/military.htm.

5.2 Final Year Compliance Monitoring (February 2014 to February 2015)

The evolution of the MIRC monitoring program has been, and continues to be, concurrent with or at the forefront of the evolution of larger U.S. Navy Marine Species Monitoring Program. While systematic changes are in process, marine species monitoring in the MIRC to the present time demonstrate incremental changes made specifically as a result of the above processes, documents and practical experience to optimally fulfill the monitoring goals of the ICMP.

Divergence from effort-based metrics and specifically planned projects. The monitoring program is committed to advancing our knowledge of marine species on U.S. Navy range complexes by addressing the topics which are outlined in the ICMP. The advantages of replacing quantitative effort-based metrics with qualitative ones based on progress on monitoring questions has already proven its value both in the Hawaii Range Complex as well as in the MIRC. One of the most apparent impacts is realized in the monitoring plan itself, which with the 2012 update (DON 2012b) introduced methodologies new to MIRC monitoring in the service of addressing these questions: biopsy with genetic analysis, satellite tagging, and photo-ID with mark-recapture analysis. The new course for FY14-FY15 described in the 2014 update to the MIRC monitoring plan (DoN 2014) is to also move away from identifying and planning specific projects years in advance. Monitoring in the MIRC has already shown that changes in needs, opportunities, or lessons learned occur on shorter time scales, which has necessitated revising the monitoring plan in three consecutive years. Passive acoustic monitoring provides an example from MIRC monitoring where prospective listing of specific projects has become obsolete, necessitating later changes in the monitoring plan: technical challenges from deployments of one type of moored acoustic device has required adjustments in the type of analytical effort (e.g., an increased emphasis on validation), in schedules and types of analysis planned (e.g., supporting analysis of archived HARP data), and responding to the opportunities of new technologies (e.g., improved methods of producing towed-array detection functions for sperm whales, and supporting a pilot study demonstrating and validating the use of autonomous deep-diving acoustic gliders). Although the mechanism for such changes is institutionalized in the AMR process, having an updated encapsulation of the monitoring plan will reduce the administrative burden of even small changes, and better fit with the current progression of the Strategic Planning Process (DoN 2013b) towards flexible planning of the monitoring program. The first MIRC monitoring program review meeting held on 8 October 2014 discussed monitoring progress and lessons learned and was able to inform planning for multiple contingencies of potential monitoring opportunities, such that a successful monitoring program could be optimally implemented in 2015 and beyond.

FY14-FY15 projects. With regard to specific projects that are planned for the closeout of FY14 and into FY15, most are continuations of existing previously-funded projects. For passive acoustic monitoring, EAR analysis is ongoing and expected to continue to the beginning of FY15, with the emergent need for validation of automated detector algorithms. Analysis of archival PIFSC HARP data is continuing, with analysis of seasonal trends being expanded into more recent years of recorded data through 2013 as well as acoustic propagation modeling for cetacean calls. Potential new directions for supporting HARP analysis include classification of beaked whales to species (including ones other than Cuvier's beaked whale and Blainville's beaked whale. Visual surveys will continue in the form of a winter leg of the shore station pilot study. Any continuations of small vessel survey methodology will likely continue to utilize the methodologies of photo-ID, biopsy, and satellite tagging. The sea turtle tagging study is still in progress, and tagging will continue off Guam, with Apra Harbor as a focus. Future turtle projects in consideration for support to address the turtle-related monitoring plan questions include visual line transect surveys in water areas close to Navy underwater detonation training sites on Guam and a second field season off Tinian. A new project that is initiating its field component is the acoustic glider pilot study, which was deployed in late September 2014 (Figure 23). This survey is the first of four glider

surveys in different range complexes including Hawaii Range Complex, Gulf of Alaska Temporary Maritime Activities Area, and returning to MIRC for a comparison winter survey. As the MMPA LO Phase I monitoring in the MIRC is completed and transitions to Phase II monitoring for the MITT in FY2015, the results presented in this report will inform future evolution of the ICMP and Strategic Planning Process, as the Navy, in cooperation with NMFS via the AMR process, programmatically continues to consider relative monitoring needs in the course of planning monitoring execution across all Navy fleet and SYSCOM range complexes.

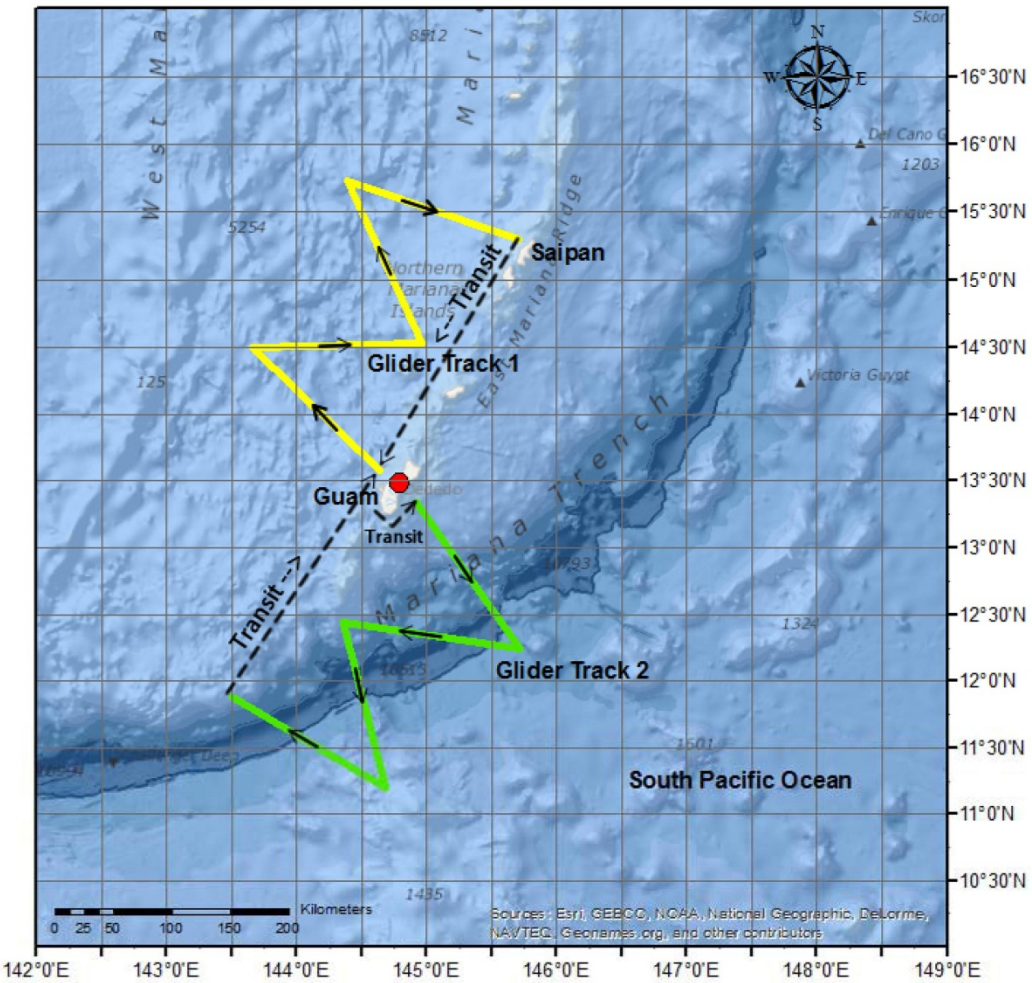


Figure 23. Planned survey track for offshore acoustic glider survey, deployed 29 September 2014

6 REFERENCES

Baumann-Pickering, S., M.A. McDonald, A.E. Simonis, A. Salson Berga, K.P.B. Merkens, E.M. Oleson, A.R. Roch, S.M. Wiggins, S. Rankin, T.M. Yack, and J.A. Hildebrand. (2013). Species specific beaked whale echolocation signals. Journal of the Acoustical Society of America 134(3): 2293-2301.

Baumann-Pickering, S., M.A. Roch, R.L. Brownell, A.E. Simonis, M.A. McDonald, A. Solsona-Berga, E.M. Oleson, S.M. Wiggins, and J.A. Hildebrand. (2014). Spatio-temporal patterns of beaked whale echolocation signals in the North Pacific. PlosONE 9(1): e86072. doi:10.1371/journal.pone.0086072.

Deakos, M.H., R.K. Uyeyama, M.F. Richlen, J.M. Aschettino, (2014). Guam Marine Species Monitoring Survey, Shore Station Feasibility Study. Prepared for Commander, U.S. Pacific Fleet. Submitted to Naval Facilities Engineering Command Pacific, Pearl Harbor, HI under Contract #N62470-10-D-3011, Task Order KB23, issued to HDR Inc., Honolulu, Hawaii. Submitted by HDR Inc., Honolulu, HI, 24 March 2014.

Department of the Navy (DoN). (2001). Year 2001 Assessment of Marine and Fisheries Resources: Farallon de Medinilla, Commonwealth of the Northern Mariana Islands. Final report. Contract #N62742-99-D-1807; DO 0019. Prepared by Belt Collins Hawaii, Honolulu, Hawaii. 50 pp.

DoN. (2003). Marine Resources Assessment for the Marianas Operating Area. Department of the Navy, Commander. U.S. Pacific Fleet. 416 pp.

DoN. (2005). Year 2004 Assessment Marine and Fisheries Resources Farallon De Medinilla Commonwealth of the Northern Mariana Islands. Prepared by T. E. Company. Submitted to Pacific Division, NAVFAC (Pearl Harbor, HI) under Contract #N62742-02-D-1802. 68 pp.

DoN. (2007) Marine Mammal and Sea Turtle Survey and Density Estimates for Guam and the Commonwealth of the Northern Mariana Islands. Authors: Thorson P., Fulling G., Norris T., Hall C., Sawyer K. Prepared by Man-Tech SRS Technologies and Geo-Marine under Contract #N68711-02-D-8043 Task Order 0036, for Commander, US Pacific Fleet, Pearl Harbor, Hawaii.

DoN. (2010a). Mariana Islands Range Complex Final Environmental Impact Statement/Overseas Environmental Impact Statement. May 2010.

DoN. (2010b). Marine Species Monitoring Plan for the Mariana Islands Range Complex. May 2010. Prepared for NMFS, Protected Resource Division by U.S. Pacific Fleet Environmental.

DoN. (2010c). United States Navy Integrated Comprehensive Monitoring Program. Washington D.C., Department of the Navy.

DoN. (2011). Marine Species Monitoring for the U.S. Navy's Mariana Island Range Complex – Annual Report. 8 April 2011. Department of the Navy, Commander, U.S. Pacific Fleet. Author: Julie Rivers.

DoN. (2012a). Mariana Islands Range Complex Marine Species Monitoring Plan, FY13-2015. Prepared for the National Marine Fisheries Service, Office of Protected Resources by U.S. Pacific Fleet Environmental Readiness Division, Pearl Harbor, HI.

DoN. (2012b). Marine Species Monitoring for the U.S. Navy's Mariana Island Range Complex - Annual Report. 11 April 2012. Department of the Navy, Commander, U.S. Pacific Fleet. Author: Julie Rivers.

DoN. (2013a). Mariana Islands Testing and Training Activities Draft Environmental Impact Statement/Overseas Environmental Impact Statement. Naval Facilities Engineering Command, Pacific. Pearl Harbor, HI. September.

DoN. (2013b). Marine Species Monitoring for the U.S. Navy's Mariana Island Range Complex - Annual Report. 11 April 2013. Department of the Navy, Commander, U.S. Pacific Fleet. Author: Julie Rivers.

DoN. (2013c). U.S. Navy Strategic Plan for Marine Species Monitoring. Chief of Naval Operations, Energy and Environmental Readiness Division. 15 November 2013. Available at: http://www.navymarinespeciesmonitoring.us/index.php/download_file/view/543/311/311/

DoN. (2014). Marine Species Monitoring Report for the U.S. Navy's Mariana Island Range Complex – 2014 Annual Report. Department of the Navy, Commander, U.S. Pacific Fleet, Pearl Harbor, Hawaii. 15 April 2014.

Eldredge, L. G. (1991). Annotated checklist of the Marine Mammals of Micronesia. Micronesica, 24(2), 217-230.

Eldredge, L. G. (2003). The marine reptiles and mammals of Guam. Micronesica, 35-36, 653-660.

Fulling G.L., Thorson P.H., Rivers J. (2011) Distribution and Abundance Estimates for Cetaceans in the Waters off Guam and the Commonwealth of the Northern Mariana Islands. Pacific Science 65:321-343. DOI: 10.2984/65.3.321.

HDR. (2011) Guam Marine Species Monitoring Survey: Vessel based monitoring Surveys Winter 2011. Prepared for Commander, US Pacific Fleet, Pearl Harbor, Hawaii. Submitted to Naval Facilities Engineering Command Pacific under Contract #N62470-10-D-3011 Task Order KB08. 19 pp.

HDR. (2012). Guam-Saipan marine species monitoring winter-spring survey March 2012. Final Report. Prepared for Commander, US Pacific Fleet, Pearl Harbor, Hawaii. Submitted to Naval Facilities Engineering Command Pacific under Contract #N62470-10-D-3011 Task Order KB17. 15 pp.

HDR. (2014). Summary Report: Compilation of Visual Survey Effort and Sightings for Marine Species Monitoring in the Mariana Islands Range Complex. Prepared for Commander, U.S. Pacific Fleet, Pearl Harbor, Hawaii. Submitted to Naval Facilities Engineering Command Pacific (NAVFAC), EV2 Environmental Planning, Pearl Harbor, Hawaii under Contract No. N62470-10-D-3011, Task

Order KB23 issued to HDR, Inc., Honolulu, Hawaii. Authors: Kristen Ampela, John Chadbourne, Dagmar Fertl, Jennifer Latusek-Nabholz, and Dana Spontak. 1 October 2014.

Hill M.C., Ligon A.D., Deakos M.H., U A.C., Norris E., Oleson E. (2011) Cetacean Surveys of Guam and CNMI Waters: August - September, 2011, National Marine Fisheries Service, Pacific Islands Fisheries Science Center, Honolulu, Hawaii.

Hill M.C., A.D. Ligon, M.H. Deakos, A.C. Ü, A.J. Milette-Winfree, and E.M. Oleson. (2013a). Cetacean Surveys of Guam and CNMI Waters: May – July, 2012: Including Individual Photo-Identification of Pilot Whales, Spinner Dolphins and Bottlenose Dolphins (2010-2012). Prepared for the U.S. Pacific Fleet Environmental Readiness Office. PIFSC Data Report DR-13-001. 40pp.

Hill M.C., A.D. Ligon, M.H. Deakos, A.C. Ü, and E.M. Oleson. (2013b). Cetacean Surveys of Guam and CNMI Waters: June – July, 2013. Prepared for the U.S. Pacific Fleet Environmental Readiness Office. PIFSC Data Report DR-13-019. 21 pp.

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

Jones, T.J., and K.S. Van Houtan. (2014). Sea Turtle Tagging in the Mariana Islands Range Complex (MIRC). Interim Report. Prepared for the U.S. Navy by the Marine Turtle Assessment Group, Protected Species Division, Pacific Islands Fisheries Science Center, National Marine Fisheries Service, Honolulu, HI.

Ligon, A.D., M.H. Deakos, A.C. Ü. (2011). Small-boat cetacean surveys off Guam and Saipan, Mariana Islands, February-March 2010. Report to the Pacific Islands Fisheries Science Center AB133F-10-SE0930. 34 pp

Martien, K. K., M.C. Hill, A.M. Van Cise, K.M. Robertson, S.M. Woodman, L. Dollar, V.L. Pease, and E.M. Oleson. (2014). Genetic diversity and population structure in four species of cetaceans around the Mariana Islands. NMFS Technical Memorandum NOAA-TM-NMFS-SWFSC-536. August.

Mobley J.R. (2007) Marine Mammal Monitoring Surveys in Support of "Valiant Shield" Training Exercises (Aug. 13-17, 2007). Prepared for Commander, US Pacific Fleet, Pearl Harbor, HI. Submitted to Naval Facilities Engineering Command Pacific, Pearl Harbor, HI, under contract N62742-07-P-1903.

Munger, L.M., M.O. Lammers, and W.W.L. Au. 2014. Passive Acoustic Monitoring for Cetaceans within the Mariana Islands Range Complex (MIRC). Preliminary Report. Submitted to Naval Facilities Engineering Command Pacific, Honolulu, HI under Contract No. N62470-10-D-3011, Task Orders KB14 and KB 17, issued to HDR Inc., Honolulu, HI. Prepared by Oceanwide Science Institute, Honolulu, Hawaii and Hawaii Institute of Marine Biology, Kaneohe, HI. February 2014.

NMFS 2010a. Taking and Importing Marine Mammals; Military Training Activities and Research, Development, Testing and Evaluation Conducted Within the Mariana Islands Range Complex. Final Rule. Vol. 75, No. 148, pp. 45527-45556. 3 August 2010.

NMFS 2010b. Letter of Authorization to Take Marine Mammals Incidental to Navy Exercises Conducted in the Mariana Islands Range Complex. Valid for 12 August 2010 through 11 August 2011.

NMFS 2011. Letter of Authorization to Take Marine Mammals Incidental to Navy Exercises Conducted in the Mariana Islands Range Complex. Valid for 12 August 2011 through 11 August 11,2012.

NMFS 2012. Letter of Authorization to Take Marine Mammals Incidental to Navy Exercises Conducted in the Mariana Islands Range Complex. Valid for 12August 2012 through 3 August 2015.

Norris, T.F., J. Oswald, T. Yack, E. Ferguson, C. Hom-Weaver, K. Dunleavy, S. Coates, and T. Dominello. (2012). An Analysis of Acoustic Data from the Mariana Islands Sea Turtle and Cetacean Survey (MISTCS): March 2014 Revision. Prepared for Commander, Pacific Fleet, Pearl Harbor, HI. Submitted to Naval Facilities Engineering Command Pacific, Pearl Harbor, HI, under Contract No. N62470-10D-3011 Task Order KB08 issued to HDR, Inc. Submitted by Bio-Waves Inc., Encinitas, CA 92024. March 2012. Revised March 2014.

Oleson, E. 2014. Interim Progress Report: Analysis of Long-term Acoustic Datasets from MIRC. Report prepared under Agreement No. NOAA-NMFS-PIFSC-13-008 between National Marine Fisheries Service and the U.S. Navy.

Oleson, E.M. and M.C. Hill. (2010). Report of cetacean surveys in Guam, CNMI, and the high-seas and follow up on 2009 main Hawaiian Islands cetacean survey. Report to the Commander, U.S. Pacific Fleet. 29 pp.

PIFSC (NMFS Pacific Island Fisheries Science Center). (2010a). Cruise Report Vessel: Oscar Elton Sette, Cruise SE-10-01 (SE-77) for PSD Cetacean Survey, January 20-February 6, 2010. NOAA-NMFS-PIFSCPSD-CRP Cruise Report CR-10-006.

PISFC. (2010b). Cruise Report Vessel: Oscar Elton Sette, Cruise SE-10-03 (SE-79) for EOD Oceanography, March 20-April 12, 2010. NOAA-NMFS-PIFSC-EOD Cruise Report CR-10-004.

PIFSC. (2010c). Cruise Report Vessel: Oscar Elton Sette, Cruise SE-10-04 (SE-80) for PSD Cetacean Line-Transect Surveys, April 19-May 4, 2010. NOAA-NMFSPIFSC-CRP Cruise Report CR-10-005.

Randall, R.H., Tsuda, R.T., Jones, R.S., Gawel, M.J., Chase, J.A., Rechebei, R. (1974). Marine Biological Survey of the Cocos Barrier Reefs and Enclosed Lagoon. University of Guam Marine Laboratory Technical Report No. 17. August.

Smith, S.H., & Marx, D.E. (2006). Year 2005 Assessment: Marine and Fisheries Resources - Farallon de Medinilla, Commonwealth of the Northern Mariana Islands. Prepared by Naval Facilities

Engineering Command Engineering Service Center Scientific Diving Services for Commander, U.S. Pacific Fleet. May. 29 pp.

Smith, S.H., & Marx, D.E. (2009). Assessment of Near Shore Marine Resources at Farallon de Medinilla: 2006, 2007, and 2008. Commonwealth of the Northern Mariana Islands. Prepared by Naval Facilities Engineering Command Engineering Service Center Scientific Diving Services for Commander, U.S. Pacific Fleet. February. 75 pp.

Smith, S.H., & Marx, D.E. (2010). Assessment of Near Shore Marine Resources at Farallon de Medinilla: 2009 and 2010. Commonwealth of the Northern Mariana Islands. Prepared by Naval Facilities Engineering Command Engineering Service Center Scientific Diving Services for Commander, U.S. Pacific Fleet. December. 86 pp.

Smith, S.H., Marx, D.E., & Shannon, L.H. (2013). Calendar Year 2012 Assessment of Near Shore Marine Resources at Farallon de Medinilla, Commonwealth of the Northern Mariana Islands. Site Specific Report SSR-NAVFC-EXWC-EV-1307. Prepared by Naval Facilities Engineering Command Engineering and Expeditionary Warfare Center Scientific Diving Services for Commander, U.S. Pacific Fleet. April. 108 pp.

Trianni, M.S., & Tenorio, M.C. (2012). Summary of recorded cetacean strandings in the Commonwealth of the Northern Mariana Islands. *Micronesica (43),* 1-13.

Uyeyama, R.K. (2014). Compilation of incidental marine mammal and sea turtle sightings in the Mariana Islands Range Complex. Prepared by Naval Facilities Engineering Command, Pacific (Pearl Harbor, HI) for Commander, U.S. Pacific Fleet (Pearl Harbor, HI). 35 pp. September.

Vogt, S. (2005). Fiscal Years 1999-2003 Five Year Report for 61755NR410: Wildlife Surveys on Military Leased Lands, Farallon de Medinilla CNMI. Prepared by NAVFAC Pacific (Honolulu, HI). February. 11 pp.

Vogt, S. (2008). Fiscal Years 2007-2008 Annual Report for 61755NR410. Wildlife Surveys on Military Leased Lands, Farallon de Medinilla, Commonwealth of the Northern Mariana Islands. Prepared by NAVFAC Pacific (Pearl Harbor, HI) April. 16 pp.

Vogt, S. (2009). Wildlife surveys on military leased lands, Tinian, Commonwealth of the Northern Mariana Islands. U.S. Navy, Pacific Fleet, Honolulu, Hawaii.

Wenninger, P. (2010). FY2010 Annual Report. Wildlife Surveys on Military Leased Lands, Farallon de Medinilla CNMI. Naval Base Guam Public Works. 7 pp.