2016 U.S. Navy Annual Marine Species Monitoring Report for the Pacific:

A Multi-Range-Complex Monitoring Report for Hawaii-Southern California Training and Testing (HSTT), Mariana Islands Training and Testing (MITT), Northwest Training and Testing (NWTT), and the Gulf of Alaska Temporary Maritime Activities Area (GOA TMAA)

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National Marine Fisheries Service
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Photo Credit:
False killer whales (*Pseudorca crassidens*) in the Mariana Islands photographed by NMFS-PIFSC under NMFS Permit No. 15240 and CNMI-DFW permit, license no. 03086-2015.

Executive Summary

The United States (U.S.) Navy conducts training and testing activities in the Pacific study areas described in the following Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) documents: Hawaii-Southern California Training and Testing (HSTT) (Department of Navy [DoN] 2013a), Mariana Islands Training and Testing (MITT) (DoN 2015a), Northwest Training and Testing (NWTT) (DoN 2015b), and the Gulf of Alaska Navy Training Activities (DoN 2011a).The ranges covered by these documents include the Hawaii Range Complex (HRC), Southern California Range Complex (SOCAL), Mariana Islands Range Complex (MIRC), Northwest Training Range Complex (NWTRC), Keyport Range Complex, and the Gulf of Alaska Temporary Maritime Activities Area (GOA TMAA).

To authorize these actions, the National Marine Fisheries Service (NMFS) under the Marine Mammal Protection Act (MMPA) issued 5-year Final Rules to Commander, U.S. Pacific Fleet and Commander, Naval Sea Systems Command for HSTT (NMFS 2013a, 2014c), MITT (NMFS 2015a), NWTT (NMFS 2015e), and GOA TMAA (NMFS 2011a, b); Letters of Authorization (LOA) under the MMPA for HSTT (NMFS 2013b, c), MITT (NMFS 2015b, 2016a), NWTT (NMFS 2015f, g), and GOA TMAA (NMFS 2011c, 2013d); and Biological Opinions (BOs) under the Endangered Species Act for HSTT (NMFS 2014a), MITT (NMFS 2015c), NWTT (NMFS 2015h), and the GOA TMAA (NMFS 2011d, 2013e).

The U.S. Navy is required by the Final Rules, LOAs, and BOs above to implement marine species monitoring. The regulations issued with the Final Rules for HSTT, MITT, NWTT, and GOA TMAA require the U.S. Navy to submit an annual monitoring report, as specified at 50 CFR § 218.75(e) (HSTT), § 218.95(e) (MITT), § 218.145(f) (NWTT), and § 218.125(d) (GOA TMAA).

This monitoring report was prepared in accordance with the annual monitoring reporting requirements for 2016, as described in these regulations.

This report presents NMFS with results and progress made during the period of 1 January 2016 to 31 December 2016. The marine species monitoring described herein was conducted in accordance with project objectives listed on the U.S. Navy's Marine Species Monitoring website: http://www.navymarinespeciesmonitoring.us/regions/pacific/current-projects/.

MMPA authorizations are issued for a period of 5 years. The MITT, HSTT, and NWTT monitoring programs are currently within the second set of 5-year authorizations and environmental planning for the U.S. Navy. Monitoring goals for these study areas are framed in terms of progress made on question-based scientific objectives and programmatic Intermediate Scientific Objectives. Monitoring associated with NWTT for 2016 was comprised of ongoing projects carrying over from the original effort-based compliance metrics of its first authorization that ended in 2015, though the project goals are now re-framed as question-based scientific objectives.

These objectives are considered within the conceptual framework that was developed in consultation with the Scientific Advisory Group (SAG) (DoN 2011b). This conceptual framework is centered on gathering monitoring information within the categories of "*occurrence, exposure, response, and consequences*" as a progression of knowledge on marine species and their interaction with U.S. Navy training and testing activities.

With regard to these conceptual framework categories, much of the monitoring efforts in 2016 were focused on documenting the *occurrence* of protected marine species in U.S. Navy training and testing ranges. Several projects, particularly in HRC and SOCAL, also involved estimating the *exposure* of these animals to mid-frequency active sonar (MFAS) and explosives, assessing animals' *responses* to underwater noise generated by U.S. Navy training and testing activities, and beginning the process of the assessment of any population *consequences* resulting from these activities by investigating population trends. Highlights of this progress include the following:

- Analyzed passive acoustic monitoring data from high-frequency acoustic recording packages in the SOCAL, NWTT, and GOA TMAA, providing information on marine mammal species' presence and seasonal occurrence.
- Conducted visual cetacean surveys and tagging, and recorded acoustic activity with dipping hydrophones offshore of Guam and Rota, to characterize species' presence in nearshore waters of the MITT. Highlights included:
    - The team's first encounters with *Mesoplodon* beaked whales, rough-toothed dolphins (*Steno bredanensis*), and dwarf sperm whales (*Kogia sima*) off Guam.
    - The first deployments of satellite tags on sperm whales (*Physeter macrocephalus*) and a pantropical spotted dolphin (*Stenella attenuata*) in the Marianas.
- Sound exposure levels were estimated for three minke whales (*Balaenoptera acutorostrata*) localized and tracked at the Pacific Missile Range Facility (PMRF) during a training event using MFAS; beaked whale dives were analyzed before, during, and after periods of MFAS activity at PMRF in order to identify any changes in foraging behavior.
- Conducted visual surveys of odontocetes (including photography, biopsy, and satellite tagging) to collect data to be used in conjunction with marine mammal monitoring on U.S. Navy ranges passive acoustic monitoring at PMRF; recorded the first sighting of pantropical spotted dolphins during small-vessel surveys off Kauai and Niihau since 2003.
- Estimated MFAS exposure levels for three rough-toothed dolphins, five short-finned pilot whales (*Globicephala macrorhynchus*), and a false killer whale (*Pseudorca crassidens*) instrumented with satellite tags at PMRF.
- Deployed satellite tags on blue whales (*Balaenoptera musculus*), fin whales (*Balaenoptera physalus*) , and humpback whales (*Megaptera novaeangliae*) to study

movement patterns and habitat use along the West Coast; analyzed genetic samples to determine sex of the individuals, to define haplotypes for stock analysis, and to confirm species identification. Other accomplishments include:

  - Documented travel of satellite-tagged baleen whales in SOCAL moving throughout the range and into the NWTT.
  - Deployed dive monitoring tags on whales to record dive depths, duration and body orientation/acceleration that reveal behavioral states such as foraging and traveling.
  - Obtained tracking data on humpback whales off Newport, Oregon.

- Deployed satellite tags on Southern Resident Killer Whales in the NWTT; created duration-of-occurrence and state-space models to identify areas of high use and travel corridors.
- Beaked whale abundance and density were estimated using a dive-counting passive acoustic method, and was applied to PMRF and Southern California Offshore Range detection archives from 2010 to 2014. There was no indication of a population decline over the 5-year project period.
- An initial risk function was completed for Cuvier's beaked whales. This proof-of-concept study was the first application of passive acoustic methods to the derivation of risk function for this species.
- Conducted the final winter season systematic line-transect aerial surveys for marine mammals in Puget Sound, Washington, completing a survey series spanning multiple seasons 2013–2016; estimated seasonal in-water density and abundance of marine mammals, particularly harbor porpoise (*Phocoena phocoena*) and harbor seals (*Phoca vitulina*); confirmed recolonization of the region by harbor porpoise.
- Continued transition of the Marine Mammal Monitoring on U.S. Navy Ranges (M3R) project from the U.S. Navy's Living Marine Resources applied research program to U.S. Pacific Fleet compliance monitoring.

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Acronyms and Abbreviations

ADB	advanced dive behavior
AMR	Adaptive Management Review
ASW	anti-submarine warfare
AUTEC	Atlantic Undersea Test and Evaluation Center
BIA	Biologically Important Area
BO	Biological Opinion
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CARB	Compact Acoustic Recording Buoy
CFC	Conceptual Framework Category
CFR	Code of Federal Regulations
CI95	95% confidence interval
CNMI	Commonwealth of the Northern Mariana Islands
CRC	Cascadia Research Collective
CRP	Cetacean Research Program
CSEL	cumulative sound exposure level
CV	coefficient of variation
dB re 1µPa	decibel(s) referenced to 1 microPascal
dB re µPa^{2}s	decibel(s) re 1 microPascal-squared-second
DCLTDE	Detection, Classification, Localization, Tracking, and Density Estimate
DemVal	Demonstration-Validation
DM	dive monitoring
DoN	Department of Navy
DSC	dominant signal component
EA	Environmental Assessment
EAR	Ecological Acoustic Recorder
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FM	frequency-modulated
FY	fiscal year
GOA	Gulf of Alaska
HARP	high-frequency acoustic recording package
hr	hour(s)
HRC	Hawaii Range Complex
HSTT	Hawaii-Southern California Training and Testing
Hz	Hertz
ICMP	Integrated Comprehensive Monitoring Program
ISO	Intermediate Scientific Objective
kHz	kilohertz
KIWB	kernel interpolation with barriers
km	kilometer(s)
km^2	square kilometer(s)
LFAS	low-frequency active sonar
LIMPET	Low Impact Minimally Percutaneous Electronic Transmitter
LO	lookout
LOA	Letters of Authorization
LOE	lookout effectiveness
m	meter(s)
M3R	Marine Mammal Monitoring on Navy Ranges
MarEcoTel	Marine Ecology and Telemetry Research
MFAS	mid-frequency active sonar
MHI	Main Hawaiian Islands
min	minute(s)
MIRC	Mariana Islands Range Complex
MITT	Mariana Islands Training and Testing
MMO	marine mammal observer

MMPA	Marine Mammal Protection Act
MOA	Military Operations Area
MRADS	Marine Resource Assessment Diving Services
mtDNA	mitochondrial DNA
NAEMO	Navy Acoustic Effects Model
NAVFAC EXWC	Naval Facilities Engineering and Expeditionary Warfare Center
nm	nautical mile(s)
NMFS	National Marine Fisheries Service
NTE	Navy Training Event
NUWC	Naval Undersea Warfare Center
NWTRC	Northwest Training Range Complex
NWTT	Northwest Training and Testing
NOAA	National Oceanic and Atmospheric Administration
OCNMS	Olympic Coast National Marine Sanctuary
OEA	Overseas Environmental Assessment
OEIS	Overseas Environmental Impact Statement
OPAREA	operating area
PAM	passive acoustic monitoring
PCAD	Population Consequences of Acoustic Disturbance
PCoD	Population Consequences of Disturbance
Photo-ID	photo-identification
PIFSC	Pacific Islands Fisheries Science Center
PMRF	Pacific Missile Range Facility
PIT	Passive Integrated Transponder
RHIB	rigid-hulled inflatable boat
RL	received level(s)
RL_{rms}	root-mean-squared received level
RMS	root mean squared
SAG	Scientific Advisory Group
SCC	Submarine Commanders Course
SCL	straight carapace length
SCORE	Southern California Offshore Range
SD	standard deviation
SEL	sound exposure level
SIO	Scripps Institution of Oceanography
SOAR	Southern California Offshore Antisubmarine Warfare Range
SOCAL	Southern California Range Complex
SPL	sound pressure level
SPOT	Smart Position and Temperature
SRKW	Southern Resident killer whale
SSC PAC	Space and Naval Warfare Systems Center Pacific
SWFSC	Southwest Fisheries Science Center
TB	terabyte(s)
TMAA	Temporary Maritime Activities Area
UNDET	underwater detonation/demolition
U.S.	United States
WC	Wildlife Computers
WDFW	Washington Department of Fish & Wildlife

1. Introduction

The United States (U.S.) Navy conducts training and testing activities in the Pacific study areas described in the following Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) documents: Hawaii-Southern California Training and Testing (HSTT) (Department of Navy [DoN] 2013a), Mariana Islands Training and Testing (MITT) (DoN 2015a), Northwest Training and Testing (NWTT) (DoN 2015b), the Gulf of Alaska Navy Training Activities (DoN 2011a). The ranges covered by these documents include the Hawaii Range Complex (HRC), Southern California Range Complex (SOCAL), Mariana Islands Range Complex (MIRC), Northwest Training Range Complex (NWTRC), Keyport Range Complex, and the Gulf of Alaska Temporary Maritime Activities Area (GOA TMAA).

To authorize these actions, the National Marine Fisheries Service (NMFS) under the Marine Mammal Protection Act (MMPA) issued 5-year Final Rules to Commander, U.S. Pacific Fleet and Commander, Naval Sea Systems Command for HSTT (NMFS 2013a, 2014c), MITT (NMFS 2015a), NWTT (NMFS 2015e), and GOA TMAA (NMFS 2011a, b); Letters of Authorization (LOA) under the MMPA for HSTT (NMFS 2013b, c), MITT (NMFS 2015b, 2016a), NWTT (NMFS 2015f, g), and GOA TMAA (NMFS 2011c, 2013d); and Biological Opinions (BOs) under the Endangered Species Act (ESA) for HSTT (NMFS 2014a), MITT (NMFS 2015c), NWTT (NMFS 2015h), and the GOA TMAA (NMFS 2011d, 2013e).

The U.S. Navy is required by the Final Rules, LOAs, and BOs above to implement marine species monitoring. The regulations issued with the Final Rules for HSTT, MITT, NWTT, and GOA TMAA require the U.S. Navy to submit an annual monitoring report, as specified in Title 50 of the Code of Federal Regulations (CFR) § 218.75(e) (HSTT), § 218.95(e) (MITT), § 218.145(f) (NWTT), and § 218.125(d) (GOA TMAA).

This monitoring report was prepared in accordance with the annual monitoring reporting requirements for 2016, as described in these regulations. The authorizations for GOA TMAA were valid through May 4, 2016, though analysis and reporting efforts for previously-collected monitoring data in this study area were continued beyond this date.

MMPA authorizations are issued for a period of 5 years. The MITT, HSTT, and NWTT monitoring programs are currently within the second set of 5-year authorizations and environmental planning for the U.S. Navy. Monitoring goals for these study areas are framed in terms of progress made on question-based scientific objectives and programmatic Intermediate Scientific Objectives. Monitoring associated with NWTT for 2016 was comprised of ongoing projects carrying over from the original effort-based compliance metrics of its first authorization that ended in 2015, though the project goals are now re-framed as question-based scientific objectives.

Furthermore, the regulations cited above associated with the authorizations for HSTT, MITT, and NWTT (i.e., § 218.75(e), § 218.95(e), and § 218.145(f), respectively) have in common an option for satisfying the monitoring report requirement with a multi-range report:

> *"…the Navy may submit a multi-Range Complex annual Monitoring Plan report to fulfill this requirement. Such a report would describe progress of knowledge made with respect to monitoring plan study questions across all Navy ranges associated with the Integrated Comprehensive Monitoring Program. Similar study questions shall be treated together so that progress on each topic shall be summarized across all Navy ranges. The report need not include analyses and content that do not provide direct assessment of cumulative progress on the monitoring plan study questions."*

For 2016 (through 4 May), GOA TMAA was in its first 5-year cycle of authorization and its regulation at § 218.125(d) similarly reads, "The Navy shall standardize data collection methods across ranges to allow for comparison in different geographic locations." Therefore, monitoring results from all Pacific U.S. Navy ranges, i.e., HSTT, MITT, NWTT, and GOA, are treated in this report in an integrated fashion to order to allow comparison across ranges and a cumulative view of progress made on monitoring goals across ranges. This is the second such "multi-range" annual monitoring report (see DoN 2016).

1.1 Background

Current marine species monitoring projects being conducted in the HSTT, MITT, NWTT, and GOA TMAA Study Areas in support of MMPA and ESA authorizations are listed on the U.S. Navy Marine Species Monitoring website (http://www.navymarinespeciesmonitoring.us/regions/pacific/current-projects/). This report contains a review of progress made on these projects in the year 2016 monitoring period. Final reports and data from these projects will be made available on the individual project profile pages and the Reading Room at the U.S. Navy Marine Species Monitoring website as they become available (http://www.navymarinespeciesmonitoring.us/reading-room/pacific/).

HSTT

The HSTT Study Area (DoN 2013a) is comprised of established operating and warning areas in the north-central Pacific Ocean, from southern California west to Hawaii and the International Date Line (**Figure 1**). The Study Area includes two existing U.S. Navy range complexes: HRC (**Figure 2**) and SOCAL (**Figure 3**).

A range complex is a designated set of specifically bounded geographic areas and encompasses a water component (above and below the surface), airspace, and sometimes a land component, where training and testing of military platforms, tactics, munitions, explosives, and electronic warfare systems occur. Range complexes include established ocean operating areas (also known as OPAREAs), Restricted Areas, and special use airspace, which may be further divided to provide better control of the area and events for safety reasons.

In addition to naval range complexes, the HSTT Study Area includes other areas where training and testing activities occur, including pier-side locations in San Diego Bay and Pearl Harbor, the transit corridor between SOCAL and HRC, the Puuloa Underwater Detonation (UNDET) range, the Pacific Missile Range Facility (PMRF), and other locations throughout north and central San Diego Bay (**Figures 1 through 5**). Vessel transit corridors are the routes typically used by U.S. Navy ships to traverse from one area to another, where training and sonar testing may occur during vessel transit. The majority of mid-frequency active sonar (MFAS) occurs in SOCAL and HRC.

MITT

The MITT Study Area (DoN 2015a) (**Figure 6)** is composed of the established ranges (at-sea ranges and land-based training areas on Guam and Commonwealth of the Northern Mariana Islands [CNMI]), operating areas, and special use airspace in the region of the Mariana Islands that are part of the MIRC (**Figure 7**) and its surrounding seas, and includes a transit corridor. The transit corridor is outside the geographic boundaries of the MIRC and is a nominal route across the high seas for U.S. Navy ships in transit between the MIRC and the HRC. The MITT Study Area also includes pier-side locations within Inner Apra Harbor where surface ship and submarine sonar maintenance and testing occur. In addition, the MITT Study Area includes the MIRC at-sea operating areas and land training areas that were previously addressed in the MIRC EIS/OEIS (DoN 2010a) with modifications to the special use air-space that were addressed in the MIRC Airspace Environmental Assessment (EA)/Overseas EA (OEA) (DoN 2013b), and the seaward extensions to the northern and western edges of the MIRC. The MIRC ocean surface and subsurface areas, and special use airspace, extend from the waters south of Guam, and northward to the waters surrounding the CNMI and from the Pacific Ocean east of the Mariana Islands to the Philippine Sea to the west, encompassing 501,873 square nautical miles (1.7 million square kilometers) of open ocean.

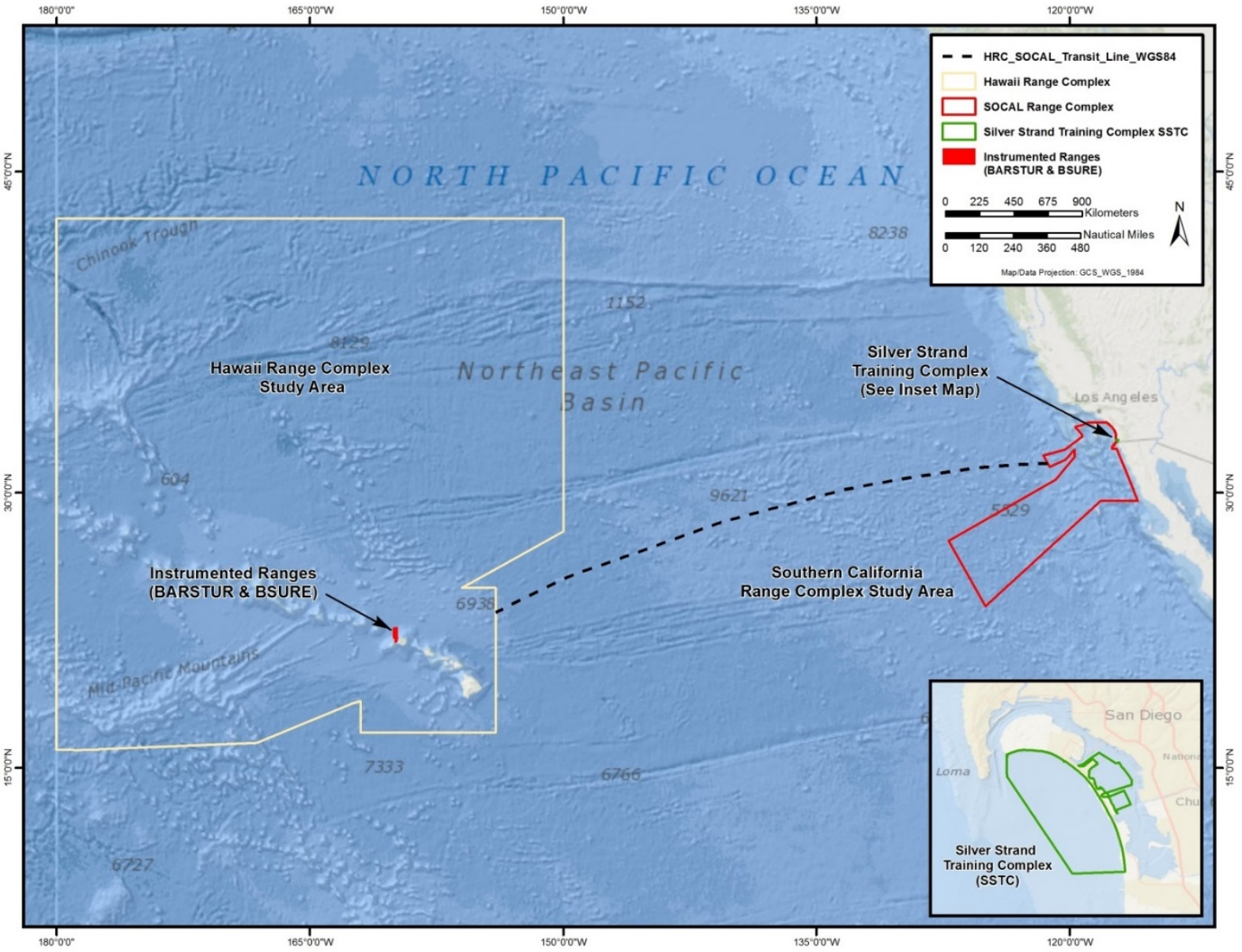

Figure 1. Hawaii-Southern California Training and Testing Study Area, showing Hawaii Range Complex, Southern California Range Complex, the transit lane between them, and Silver Strand Training Complex. From DoN (2013a).

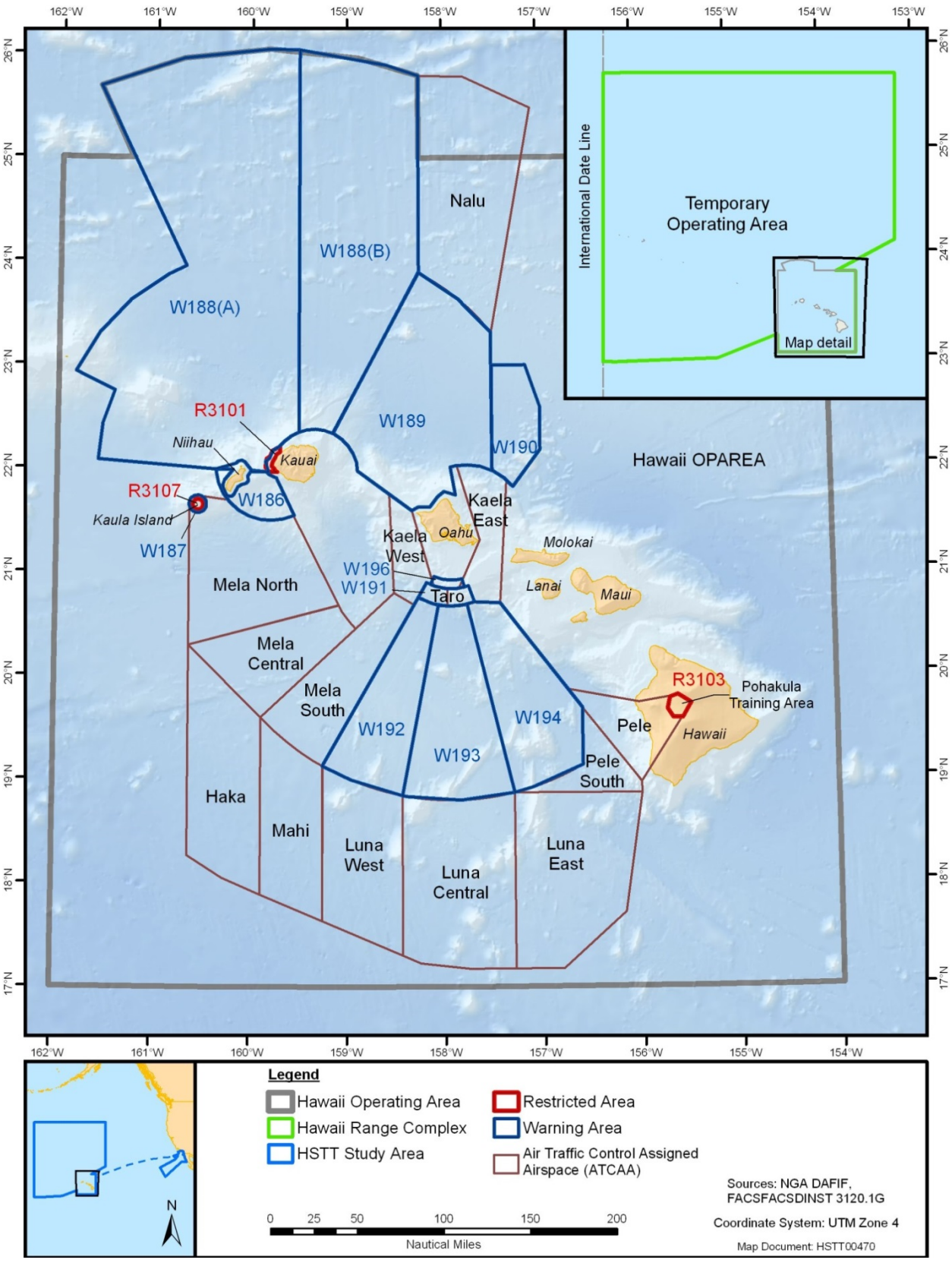

Figure 2. Hawaii Range Complex. From DoN (2013a).

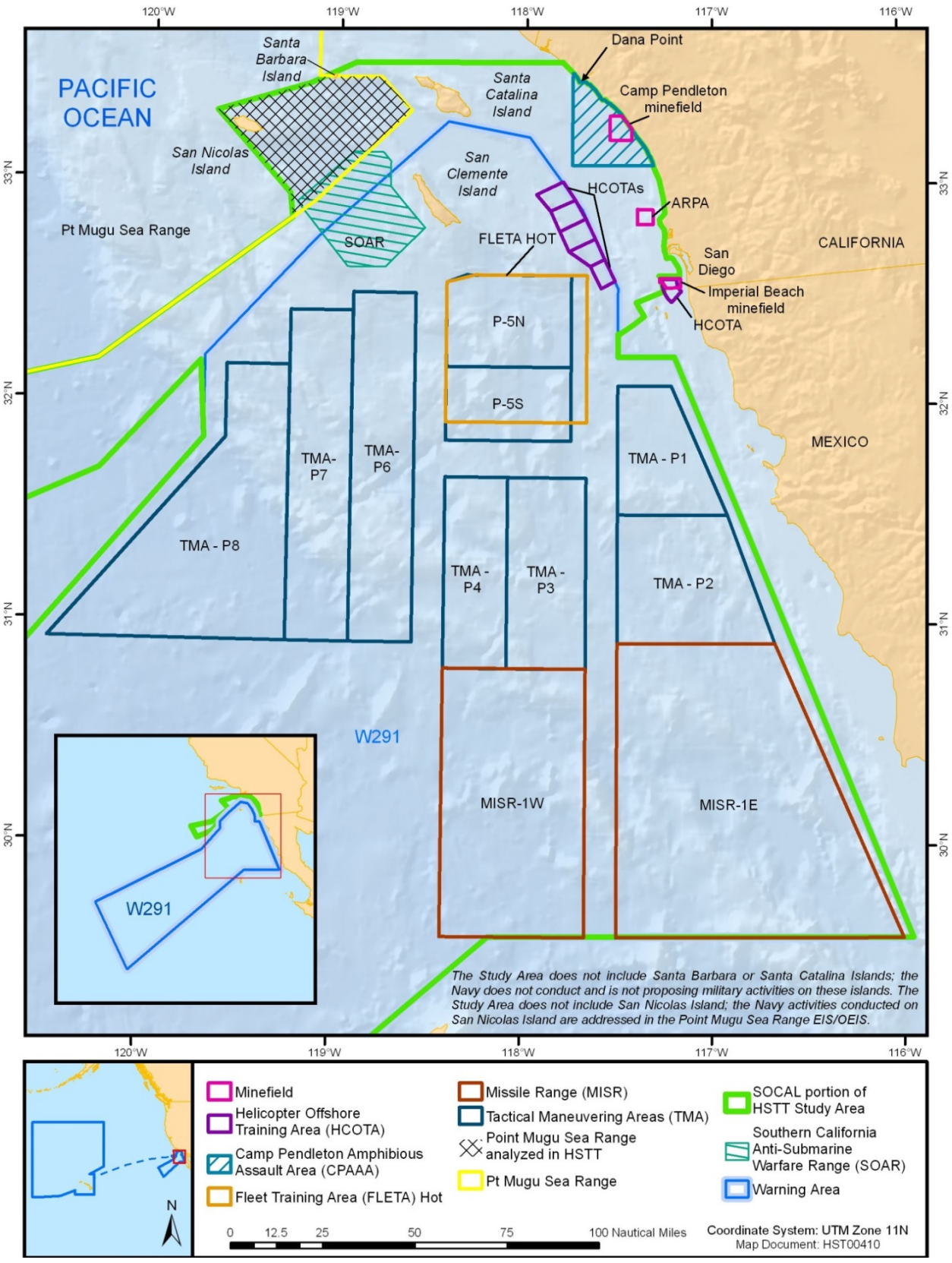

Figure 3. Southern California Range Complex. From DoN (2013a).

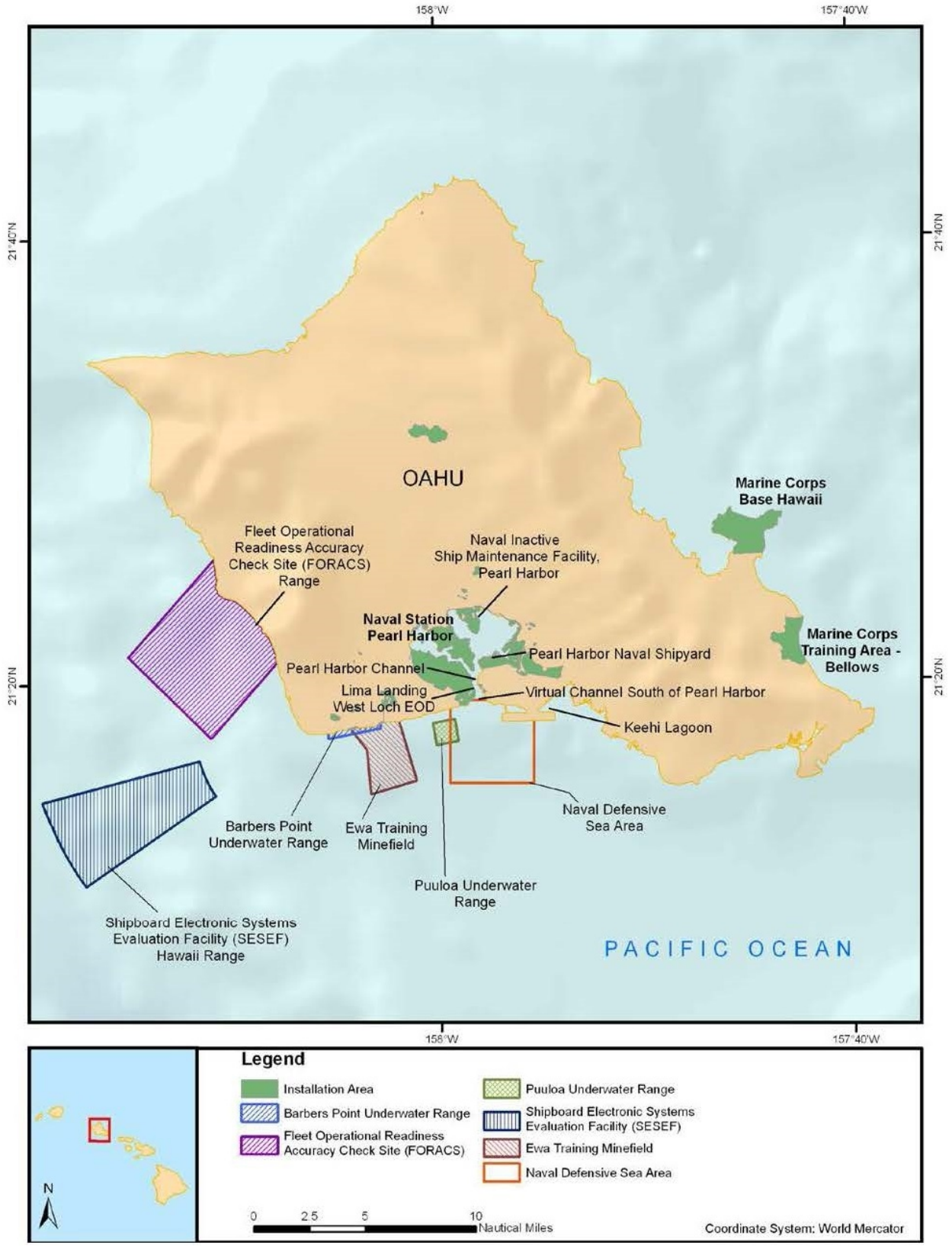

Figure 4. Oahu Training Areas, specifically the Puuloa Underwater Detonation Range. From DoN (2013a).

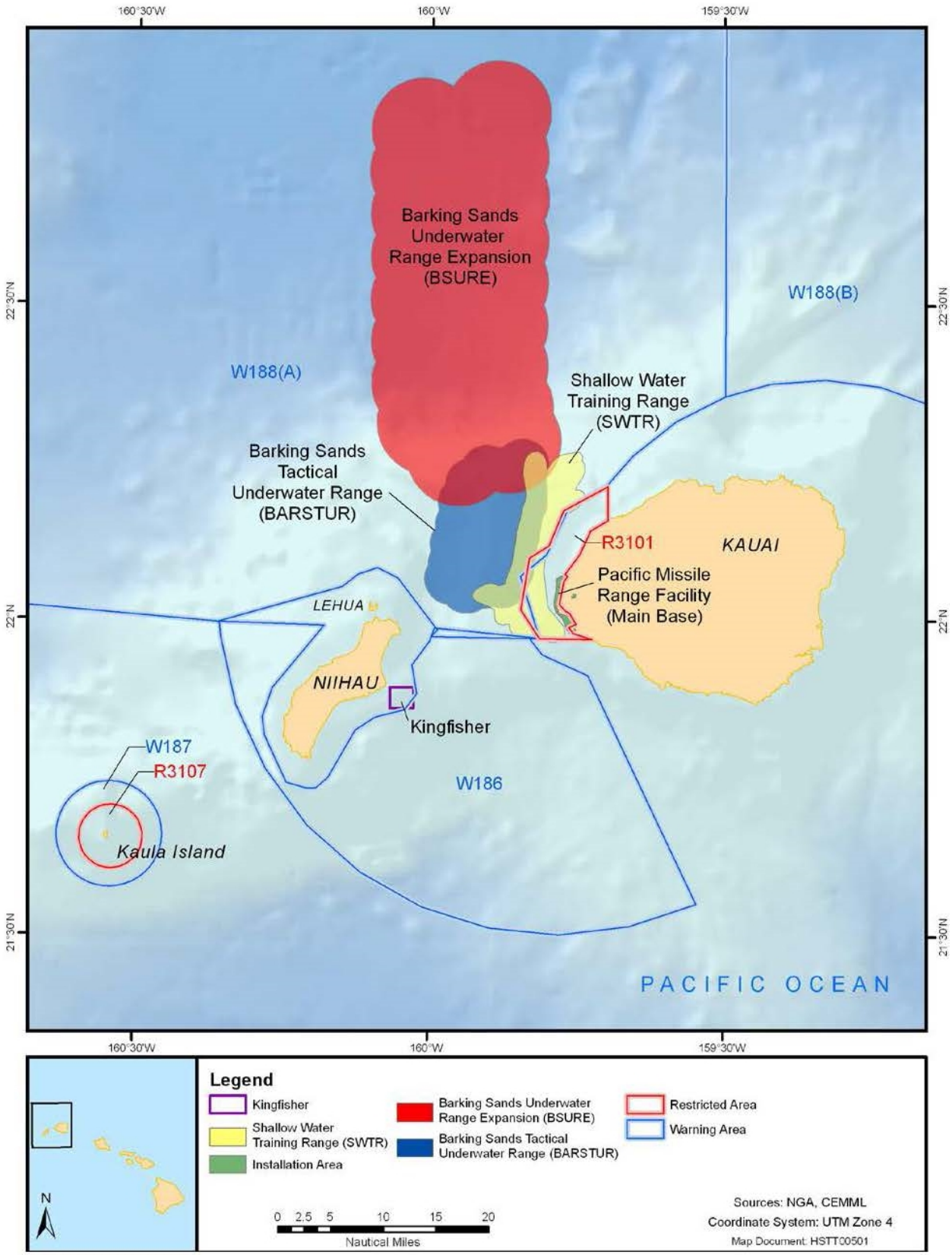

Figure 5. Navy Training Areas around Kauai, specifically the Pacific Missile Range Facility. From DoN (2013a).

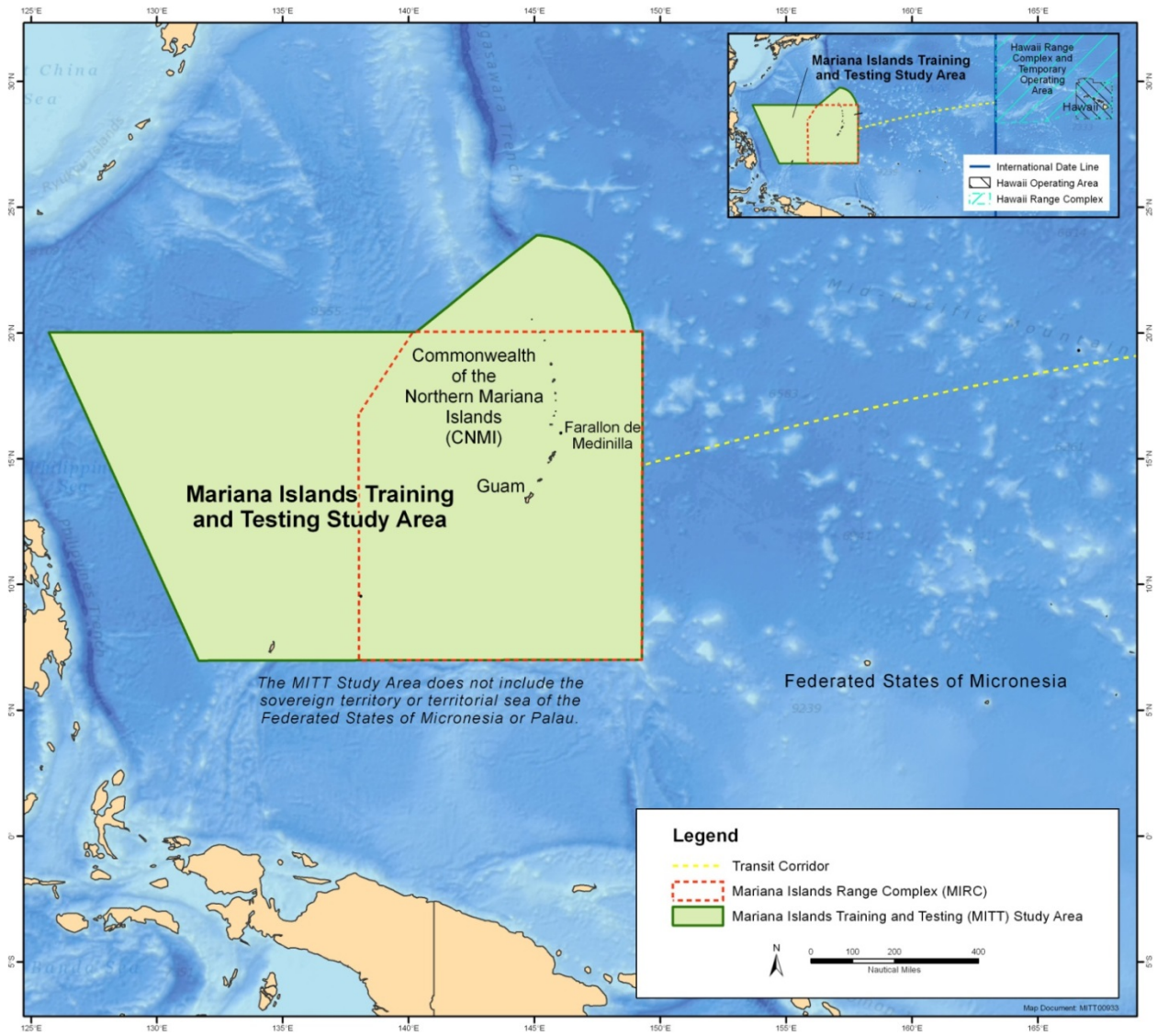

Figure 6. Mariana Islands Training and Testing Study Area. From DoN (2015a).

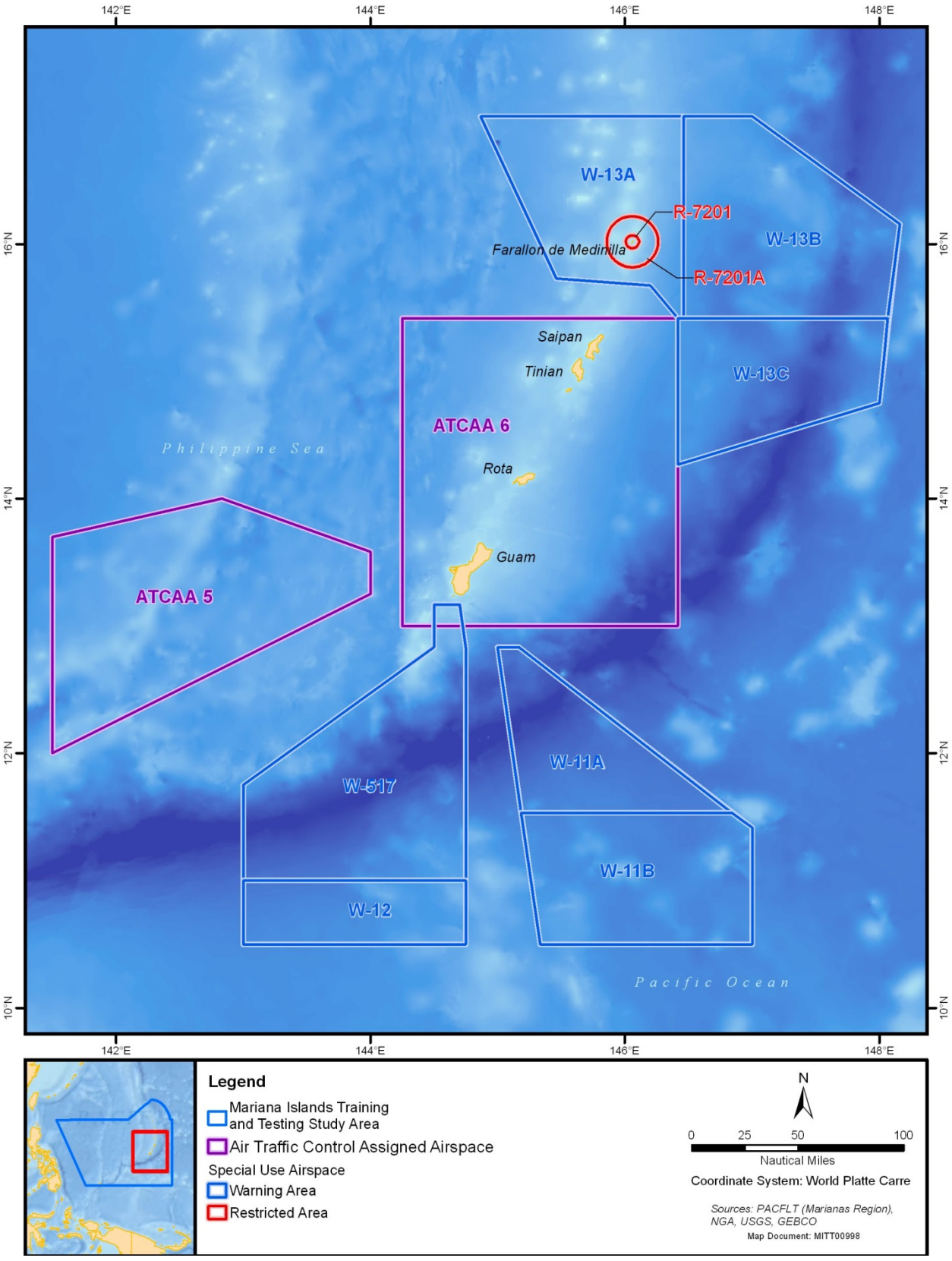

Figure 7. Mariana Islands Range Complex. From DoN (2015a).

NWTT

The NWTT Study Area (DoN 2015b, 2016a) (**Figure 8**) is composed of established maritime operating and warning areas in the eastern North Pacific Ocean region, to include the Strait of Juan de Fuca, Puget Sound, and western Behm Canal in southeastern Alaska. The area includes air and water space within and outside Washington state waters, and air and water space beyond 12 nautical miles off the coast of Oregon and northern California (**Figures 8 and 9**). The Study Area includes four existing range complexes and facilities: the NWTRC, the Keyport Range Complex, Carr Inlet Operations Area, and Southeast Alaska Acoustic Measurement Facility (**Figure 8**). In addition to these range complexes, the Study Area also includes U.S. Navy pier-side locations where sonar maintenance and testing occur as part of overhaul, modernization, maintenance, and repair activities at U.S. Navy piers at Naval Base Kitsap Bremerton, Naval Base Kitsap Bangor, and Naval Station Everett.

GOA TMAA

The GOA TMAA (DoN 2011a) is a temporary area that is established in conjunction with the Federal Aviation Administration for up to 21 days per year from April to October as needed to support the Northern Edge exercise. The TMAA is a surface, undersea space and airspace maneuver area within the GOA for ships, submarines, and aircraft to conduct required training activities. As depicted in **Figure 10**, the TMAA is a polygon that roughly resembles a rectangle oriented from northwest to southeast, approximately 300 nautical miles (nm) (560 kilometers [km]) in length by 150 nm (280 km) in width, located south of Prince William Sound and east of Kodiak Island. With the exception of Cape Cleare on Montague Island located over 12 nm (22 km) from the northern point of the TMAA, the nearest shoreline (Kenai Peninsula) is located approximately 24 nm (44 km) north of the TMAA's northern boundary. The approximate middle of the TMAA is located 140 nm (260 km) offshore.

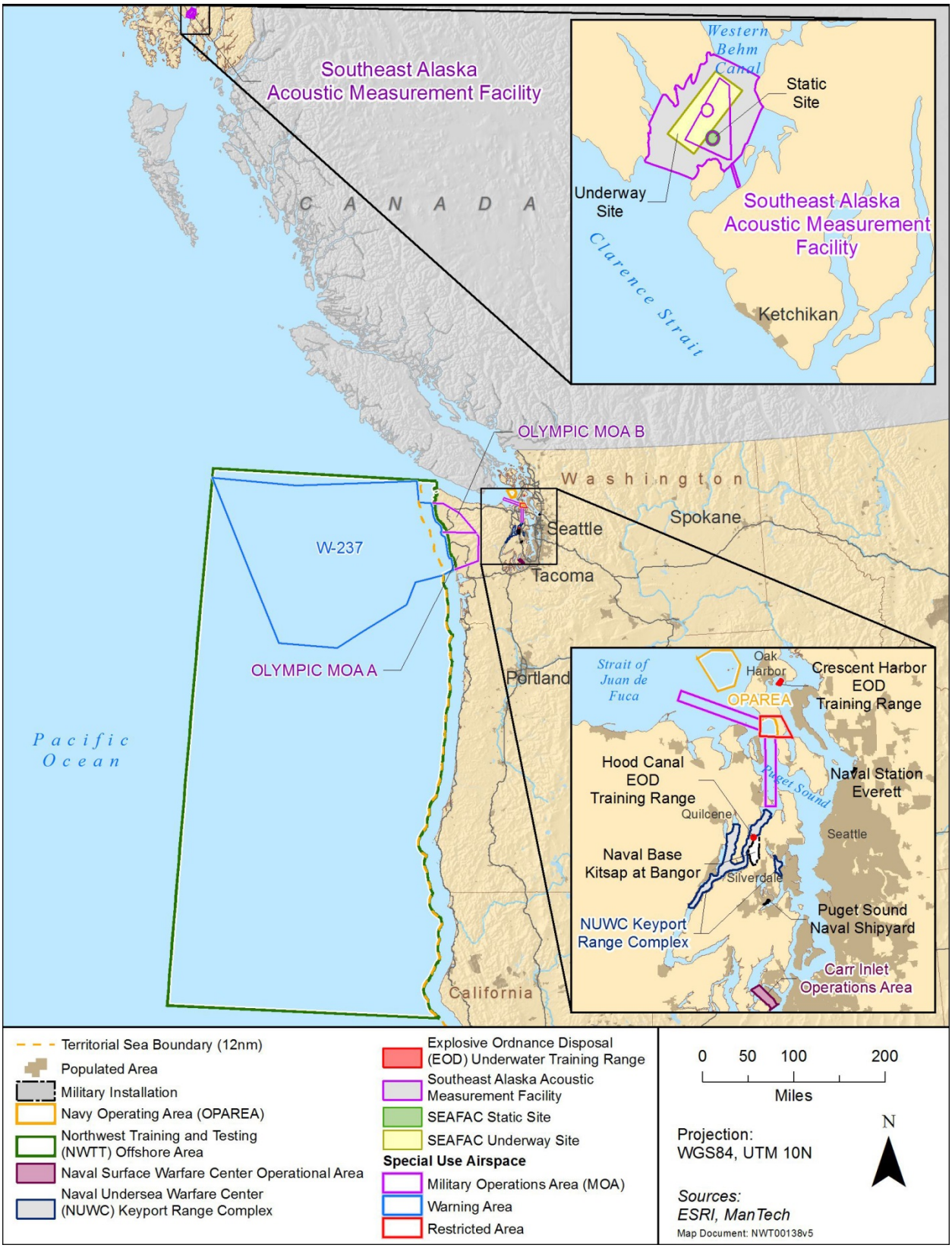

Figure 8. Northwest Training and Testing Study Area. From DoN (2015b).

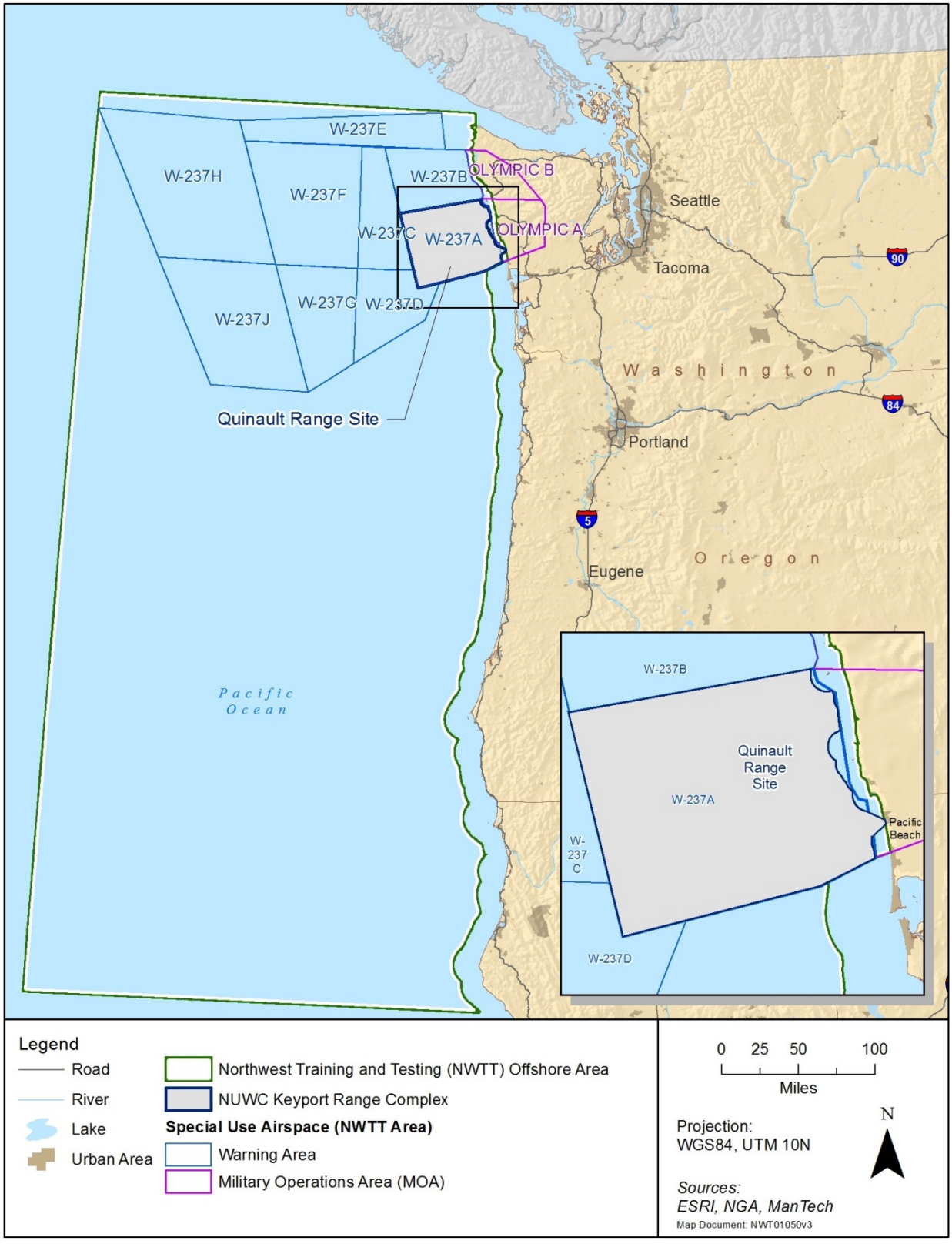

Figure 9. Offshore Area of the Northwest Training and Testing Study Area. From DoN (2015b).

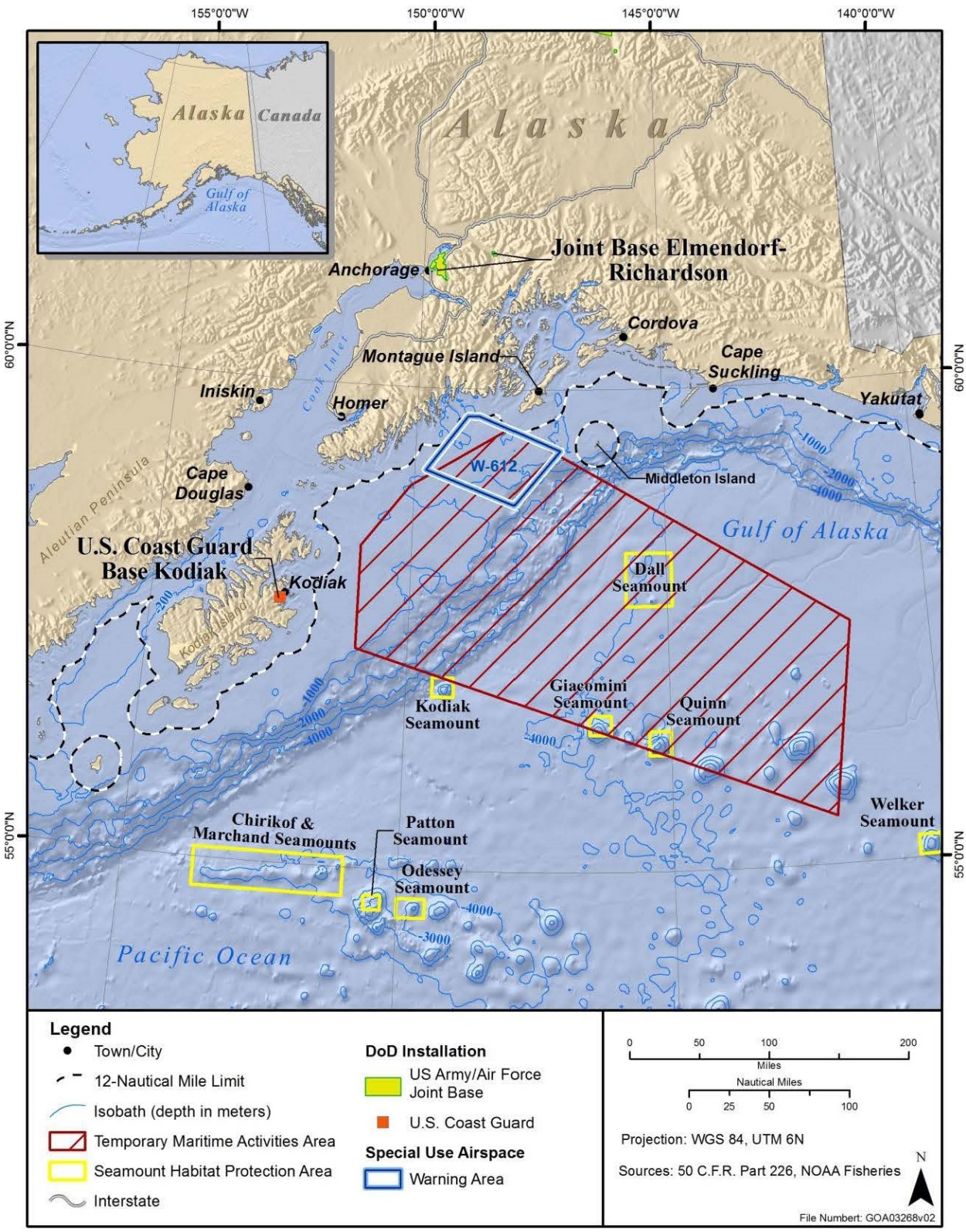

Figure 10. Gulf of Alaska Temporary Maritime Activities Area. From DoN (2016a).

1.2 Integrated Comprehensive Monitoring Program and Strategic Planning Process

Integrated Comprehensive Monitoring Program

The U.S. Navy's Integrated Comprehensive Monitoring Program (ICMP) (DoN 2010b) is intended to coordinate monitoring efforts across all training ranges and testing areas and to allocate the most appropriate level and type of effort for each range complex based on a set of standardized objectives, and in acknowledgement of regional expertise and resource availability. The ICMP is designed to be flexible, scalable, and adaptable through the adaptive management and strategic planning processes to periodically assess progress and reevaluate objectives. Although the ICMP does not specify actual monitoring field work or projects, it does establish top-level goals that have been developed in coordination with NMFS. As the ICMP is implemented, detailed and specific studies are developed that support these top-level monitoring goals. In essence, the ICMP directs that monitoring activities relating to the effects of U.S. Navy training and testing activities on marine species should be designed to accomplish one or more top-level goals.

Monitoring addresses the ICMP top-level goals through a collection of specific regional and ocean basin studies based on scientific objectives. Quantitative metrics of monitoring effort (e.g., 20 days of aerial surveys) are not to be a specific requirement. The adaptive management process and reporting requirements serve as the basis for evaluating performance and compliance, primarily considering the quality of the work and results produced, as well as peer review and publications, and public dissemination of information, reports and data. Details of the current ICMP are available online at http://www.navymarinespeciesmonitoring.us/.

Strategic Planning Process, Scientific Advisory Group, and the Conceptual Framework Categories

The most recent revision of the ICMP resulted in the addition of the Strategic Planning Process for Marine Species Monitoring (Chief of Naval Operations 2013), which establishes the guidelines and processes necessary to develop, evaluate, and fund individual monitoring projects based on objective, scientific study questions. The process is informed by the conceptual framework that was developed in consultation with the Scientific Advisory Group (SAG) (DoN 2011b). This conceptual framework is centered on gathering information within the categories of "*occurrence, exposure, response, and consequences"* as a progression of knowledge on marine species and their interaction with U.S. Navy training and testing activities.

Informed by these conceptual framework categories, the Strategic Planning Process for Marine Species Monitoring is used to set Intermediate Scientific Objectives (ISOs) for the ICMP, identify potential species of interest at a regional scale, and evaluate and select specific monitoring projects to fund or continue supporting for a given fiscal year (FY); the current list of thirteen ISOs applied for this monitoring report is included in **Figure 11** (located in **Section 2.1**). This process also addresses relative investments to different range complexes based on goals across all range complexes, and the benefits of leveraging multiple techniques for data acquisition and analysis whenever possible.

Adaptive Management Review

The ICMP is evaluated annually 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 monitoring plan modifications are warranted, in order to address program goals more effectively. Modifications to the ICMP that result from AMR discussions are incorporated by an addendum or revision to the ICMP. As a planning tool, the ICMP is a "living document" that is updated as needed.

1.3 Report Objectives

This report presents NMFS with monitoring results and progress during the period of 1 January 2016 to 31 December 2016 that address the monitoring goals of marine species monitoring in HSTT, MITT, NWTT, and GOA TMAA in accordance with 50 CFR § 218.75(e), § 218.95(e), § 218.145(f), and § 218.125(d). This report is the second annual monitoring report prepared by the U.S. Navy that implements the option in these regulations to prepare a "multi-Range-Complex" report that describes progress of knowledge made with respect to monitoring plan study questions across multiple training and testing ranges, with similar study questions treated together so that progress on each topic may be summarized across multiple ranges (see DoN 2016). These results are intended to iteratively inform future cycles of AMR and application of the Strategic Planning Process. In addition, detailed technical reports for the individual monitoring projects are provided as supporting documents to this report.

2. Marine Species Monitoring in the Pacific

2.1 2016 Monitoring Goals and Implementation

The U.S. Navy training ranges in the Pacific are located in the MITT Study Area, HSTT Study Area, NWTT Study Area, and GOA TMAA. The ranges vary in terms of monitoring goals implemented for protected marine species including marine mammals and sea turtles, in support of each study area's MMPA and ESA requirements (NMFS 2010a, 2010b, 2011a, 2011b, 2011c, 2011d, 2013a, 2013b, 2013c, 2013d, 2013e, 2014a, 2014b, 2014c, 2015a, 2015b, 2015c, 2015d, 2015e, 2015f, 2015h, 2015i, 2016a).

For MITT, HSTT, and NWTT, current monitoring goals are framed in terms of progress made on scientific monitoring questions and ISOs, and shown paired with cumulative accomplishments in **Table 1**. **Table 2** shows the same for GOA TMAA, also with a question-based monitoring goal because the only project for this year was one that also encompassed NWTT. However the accomplishments column for GOA TMAA also includes accomplishments from previous years of monitoring under its original effort-based compliance regime.

Figures 11 and 12 provide an overview of all monitoring projects and goals across all the Pacific ranges. **Figure 11** shows the distribution of monitoring questions and study objectives with respect to monitoring projects and Conceptual Framework Categories (CFCs) (i.e., *occurrence, exposure, response, consequences*), as well as illustrate which ISOs are addressed by each monitoring project. **Figure 12** illustrates the relative number of monitoring questions associated with each CFC, and how this varies by range. Though not shown in **Figure 11**, the effort-based compliance metric for GOA TMAA in 2015 and earlier for deploying passive acoustic monitoring devices to study marine mammal occurrence is included in the tabulation represented in **Figure 12** under *occurrence*. Although the CFC of *consequences* is generally considered to be a complex field of new science best supported by research and development efforts through the Office of Naval Research, rather than by MMPA compliance monitoring, one monitoring question each for HRC and SOCAL was related to population trends of species at Navy ranges. Because of their connection to population trends, though not comparable to the fully-realized modeling of population consequences, these were tabulated in **Figure 12** under *consequences*.

Table 1. Monitoring goals and accomplishments for training ranges in second cycle of five (5) year authorizations (MITT, HRC, SOCAL, and NWTT).

Project (technical report for 2016)	**Conceptual Framework Category**	**Intermediate Scientific Objectives** (numbered as per Figure 11)	**Monitoring Questions**	**Accomplishments**[1]
MITT				
[M1] PIFSC Cetacean Monitoring (Hill et al. 2017) (This project includes "Small-Vessel Visual Surveys" and "Acoustic Analysis of High-frequency Acoustic Recording Package Data")	Occurrence, Exposure	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas. #2: Estimate the distribution, abundance, and density of marine mammals and sea turtles in Navy range complexes, testing ranges, and in specific training and testing areas. #3: Determine what species and populations of marine mammals and ESA-listed species are exposed to Navy training and testing activities. #4: Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur. #5: Establish the baseline behavioral patterns(foraging, diving, etc.) of marine mammals where Navy training and testing activities occur.	• What species of beaked whales and other odontocetes occur in the MITT study area? • Are there locations of greater relative cetacean abundance in the MITT study area? • What is the baseline abundance and population structure of cetaceans that may be exposed to sonar and/or explosives in the MITT study area? • What is the seasonal occurrence and movements of baleen whales in the MITT study area? • What is the exposure of cetaceans and sea turtles to explosives and/or sonar in the MITT study area?	*In 2016:* • Photo processing and analysis was continued to add to existing individual photo-ID catalogs. • Conducted small-vessel visual surveys off Saipan, Tinian, and Aguijan and shore-based observations from elevated stations around Saipan to look for humpback whales in the winter season (March). Biopsy samples collected from humpback whale mothers. • In May and June, small-vessel visual surveys conducted in the waters surrounding Saipan, Tinian, Aguijan, Rota, and Guam. Satellite tags deployed on sperm whales, short-finned pilot whales, and a pantropical spotted dolphin; tags deployed on two sperm whales and a pantropical spotted dolphin for the first time in the Marianas. Dwarf sperm whales encountered for the first time off Guam. Kernel density estimates ongoing. • Acoustic analyses from PIFSC-funded HARPs were ongoing in 2016, with reporting expected in 2017. *In 2015:* • Conducted winter humpback whale surveys from shore and small vessels off Saipan, succeeded in sighting several mother-calf pairs. Collected fluke photographs and biopsies for population studies. • Conducted small- and large-vessel visual summer surveys from Guam to Uracas and off Rota, including biopsy and satellite tagging. One false killer whale tagged at Asuncion traveled well past the Western Mariana Ridge toward the Philippines. Also made first sighting of a Bryde's whale in this survey series. • Used mtDNA, including samples from the Mariana Islands, to describe the regional and local genetic structure in island-associated and pelagic Pacific short-finned pilot whales.'' • Acoustic data from HARPs deployed off Saipan and Tinian during 2013-2015 examined for beaked whale calls: Cuvier's beaked whale, Blainville's beaked whale, and the "Cross Seamount beaked whale" call were detected.

Project (technical report for 2016)	**Conceptual Framework Category**	**Intermediate Scientific Objectives** (numbered as per Figure 11)	**Monitoring Questions**	**Accomplishments**[1]
MITT (continued)				
[M2] Sea Turtle Tagging in the Mariana Islands Training and Testing Study Area (Martin and Jones 2016)	Occurrence, Exposure	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas. #2: Estimate the distribution, abundance, and density of marine mammals and sea turtles in Navy range complexes, testing ranges, and in specific training and testing areas. #3: Determine what species and populations of marine mammals and ESA-listed species are exposed to Navy training and testing activities. #4: Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur. #12: Evaluate trends in distribution and abundance for populations of marine mammals and ESA-listed species that are regularly exposed to sonar and underwater explosives.	• What are the occurrence, habitat use, abundance, and population structure of sea turtles in the MITT study area? • What is the exposure of cetaceans and sea turtles to explosives and/or sonar in the MITT study area? • Are there locations of greater cetacean and/or sea turtle concentration in the MITT study area?	*In 2016*: • Conducted sea turtle tagging surveys in nearshore and coastal waters of Guam, Saipan, and Tinian, including new areas not previously surveyed—Tachungnya Bay in the southwest corner of Tinian, Tinian Harbor, Coral Ocean Point in southeast Saipan, and Agat Bay and Hagatna in Guam. • Captured, satellite tagged, and took blood samples of an adult male green turtle on the west side of Tinian. • From 2013 to 2016: 97 captures of turtles in the MITT study area and 60 satellite tags deployed. • Deployed satellite (temperature-depth and temperature), Inconel, and PIT tags on green and hawksbill turtles; 22 satellite tags were still transmitting as of November 2016, and spatial, dive depth and duration of turtles, and influence of temperature on habitat use analyses are in progress. • First manuscript derived from this Navy/NOAA interagency agreement was published in Frontiers in Marine Science "Five Decades of Marine Megafauna Surveys from Micronesia" (Martin et al. 2016). *In 2015:* • Sea turtle tagging surveys conducted in nearshore and coastal waters of Guam, Saipan, and Tinian, including new areas—the southwest corner of Tinian, Lao Lao Bay in southeast Saipan, and Agat Bay in Guam. • Satellite (temperature-depth and temperature), Inconel, and PIT tags deployed on green and hawksbill turtles.

Project (technical report for 2016)	**Conceptual Framework Category**	**Intermediate Scientific Objectives** (numbered as per Figure 11)	**Monitoring Questions**	**Accomplishments**[1]
HRC				
[H1] PAM of Odontocetes in Puuloa Underwater Detonation Training Range (Shannon et al. 2016)	Occurrence	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas. #3: Determine what species and populations of marine mammals and ESA-listed species are exposed to Navy training and testing activities. #4: Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur. #12: Evaluate trends in distribution and abundance for populations of marine mammals and ESA-listed species that are regularly exposed to sonar and underwater explosives.	• What are the habitat-use patterns of odontocetes in the area of the Puuloa UNDET range?	*In 2014–2016*: • Conducted analysis of passive acoustic data recorded from passive EARs deployed in waters adjacent to the Puuloa UNDET range off the coast of Oahu, Hawaii from 2010 to 2013. • Analyzed over 133,000 files of which 850 contained odontocete whistles: in regards to seasonal correlation, more occurrences were in late summer/early fall; no statistically strong relationship between the hour of day and presence of whistles was found.

Project (technical report for 2016)	**Conceptual Framework Category**	**Intermediate Scientific Objectives** (numbered as per Figure 11)	**Monitoring Questions**	**Accomplishments**[1]
HRC (continued)				
[H2] Behavioral Response of Marine Mammals to Navy Training and Testing at PMRF (Martin et al. 2017)	Occurrence, Exposure, Response	#4: Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur. #6: Establish the regional baseline vocalization behavior, including seasonality and acoustic characteristics of marine mammals where Navy training and testing activities occur. #7: Determine what behaviors can most effectively be assessed for potential response to Navy training and testing activities. #8: Application of passive acoustic tools and techniques for detecting, classifying, and tracking marine mammals[2]. #9: Application of analytic methods to evaluate exposure and/or behavioral response of marine mammals to Navy training and testing activities #10: Evaluate acoustic exposure levels associated with behavioral responses of marine mammals to support development and refinement of acoustic risk functions #11: Evaluate behavioral responses of marine mammals exposed to Navy training and testing activities to support PCoD development and application. #12: Evaluate trends in distibution and abundance for populations of marine mammals and ESA-listed species that are regularly exposed to sonar and underwater explosives. #13: Leverage existing data with newly developed analysis tools and techniques[2].	• What are the occurrence of and estimated received levels of MFAS on 'blackfish' and humpback, minke, sperm, and Blainville's beaked whales within the PMRF instrumented range? • What, if any, are the short-term behavioral responses of 'blackfish' and humpback, minke, sperm, and Blainville's beaked whales when exposed to MFAS/explosions at different levels/conditions at PMRF?	*In 2016:* • Cumulative sound exposure level estimated for 3 minke whales that were localized and tracked at PMRFduring a training event using MFAS • Analyzed beaked whale dives before, during, and after periods of MFAS activity at PMRF in order to identify any changes in foraging behavior • Results of fully automated processing presented for all data collections throughout FY16 in terms of the beaked whale foraging dives per hour and the number of baleen whale and sperm whale passive acoustic localizations on and near the range. • Data for 2007–2010 automatically processed for beaked whales, humpback whales, and sperm whales, and plots of these results are presented. *In 2015:* • Used archived acoustic data collected by PMRF hydrophones in 2011–2013 to assess changes in Blainville's beaked whale dive counts correlated with periods of MFAS use. • Developed and validated an automated beaked whale click detector. • Calculated number of beaked whale foraging dives relative to MFAS use. *In 2014:* • Estimated RLs during an ASW training event for humpback whales and short-finned pilot whales, ranged from 158 to 174 dB re 1 µPa. • Identified decrease in minke whale "boing" call counts in presence of MFAS. • Documented decrease in Blainville's beaked whale foraging dive rates during periods of MFAS transmission.

Project (technical report for 2016)	**Conceptual Framework Category**	**Intermediate Scientific Objectives** (numbered as per Figure 11)	**Monitoring Questions**	**Accomplishments**[1]
HRC (continued)				
[H3] Long-term Trends in Abundance of Marine Mammals at PMRF (Moretti 2017) (This is a joint project with [S2] "Cuvier's Beaked Whale Impact Assessment at SOAR")	Occurrence, Exposure, Response, Consequences	#1: Determine what species and populations of marine mammals and ESA-listed speciesare present in Navy range complexes, testing ranges, and in specific training and testing areas. #8: Application of passive acoustic tools and techniques for detecting, classifying, and tracking marine mammals[2]. #9: Application of analytic methods to evaluate exposure and/or behavioral response of marine mammals to Navy training and testing activities. #12: Evaluate trends in distibution and abundance for populations of marine mammals and ESA-listed species that are regularly exposed to sonar and underwater explosives. #13: Leverage existing data with newly developed analysis tools and techniques[2].	• What are the long-term trends in occurrence of marine mammals (e.g., minke, humpback, fin, Bryde's, Blainville's) on the PMRF range?	*In 2016*: • Beaked whale detection archives from both SSC Pacific and M3R algorithms compared and baseline abundance at PMRF determined. • Packet recorder interface and new disk handling utilities completed; sample rate decimation implemented and undergoing testing. • No indication in a change in the population trend line of beaked whales over the 5-year period, 2010–2014. *In 2015:* • Upgraded hardware/software for M3R Linux-based cluster signal processor at PMRF, which includes a full range of broadband recording and integrated data archives. • Conducted initial analysis of beaked whale detection archives to establish methods and baseline abundance at PMRF and SCORE.
[H4] Aerial Surveys in the HRC during an SCC (Mobley et al. 2017)	Occurrence, Exposure	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas. #3: Determine what species and populations of marine mammals and ESA-listed species are exposed to Navy training and testing activities. #7: Determine what behaviors can most effectively be assessed for potential response to Navy training and testing activities. #11: Evaluate behavioral responses of marine mammals exposed to Navy training and testing activities to support PCoD development and application.	• Are marine mammals (and sea turtles) exposed to MFAS, especially at levels associated with adverse effects? If so, at what levels are they exposed? • If marine mammals (and sea turtles) are exposed to MFAS, what are their behavioral responses to various received levels?	*In 2015–2016:* • In February 2015 and 2016, aerial surveys were conducted on and around the PMRF during a SCC event for purpose of detecting /observing marine mammals and sea turtles exposed to MFAS. • Sighting locations within 1 hr of MFAS transmissions compared against ship locations at the time of transmission in order to estimate RLs during MFAS exposure. • No unusual behavior or signs of distress observed.

Project (technical report for 2016)	**Conceptual Framework Category**	**Intermediate Scientific Objectives** (numbered as per Figure 11)	**Monitoring Questions**	**Accomplishments**[1]
HRC (continued)				
[H5] Navy Civilian Marine Mammal Observers on DDGs (Vars et al. 2016)	Occurrence, Response	#3: Determine what species and populations of marine mammals and ESA-listed species are exposed to Navy training and testing activities. #4: Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur. #11: Evaluate behavioral responses of marine mammals exposed to Navy training and testing activities to support PCoD development and application	• What is the effectiveness of Navy lookouts on Navy surface ships for mitigation and what species are sighted during sonar training events?	*In 2014–2016:* • MMOs embarked on U.S. Navy warships during a total of four training events: one SCC event in 2015 and one in 2016, and one Koa Kai and two SCC events in 2014. • Recorded marine mammal and sea turtle sighting data to determine which species and populations are exposed to U.S. Navy training events.
[H6] Shoreline Survey and Stranding Summary (Deakos et al. 2017)	Occurrence, Response	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas. #11: Evaluate behavioral responses of marine mammals exposed to Navy training and testing activities to support PCoD development and application.	• Do marine mammals strand along shorelines of the Main Hawaiian Islands within one week following Navy training events?	*In 2016*: • Aerial surveys following NTEs conducted along select coastlines of the main Hawaiian Islands to monitor for strandings and to document sightings of marine mammals and sea turtles. • Analyzed marine mammal stranding data collected in the MHI from 2010 to 2014 in the context of Navy training events involving the use of MFAS. *In 2015:* • Compiling data from reported marine mammal strandings in the Hawaiian Islands 2010–2014. • Summarizing sightings and effort from 16 aerial shoreline surveys conducted 2010–2014. • Using aerial survey data to determine the effectiveness of aerial surveys to detect strandings in populated versus remote areas. • Evaluating how long after initial stranding an animal is likely to be detected using aerial monitoring surveys.

Project (technical report for 2016)	**Conceptual Framework Category**	**Intermediate Scientific Objectives** (numbered as per Figure 11)	**Monitoring Questions**	**Accomplishments**[1]
HRC (continued)				
[H7] Cetacean Studies on PMRF (Baird et al. 2016) (*Collected tag telemetry used in Project [H8]*)	Occurrence, Exposure	#4: Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur. #12: Evaluate trends in distribution and abundance for populations of marine mammals and ESA-listed species that are regularly exposed to sonar and underwater explosives.	• What are the spatial-movement and habitat-use patterns (e.g., island-associated or open-ocean, restricted ranges vs. large ranges) of species that are exposed to MFAS, and how do these patterns influence exposure and potential responses?	*In 2016:* • Pantropical spotted dolphins on PMRF sighted for the first time since 2003. • Satellite tags deployed on short-finned pilot whales, rough-toothed dolphins, and one pantropical spotted dolphin. • All tagged rough-toothed dolphins and the bottlenose dolphin (2015) remained associated with the island of Kauai and Niihau. Based on photo-ID, all were part of groups known to be resident to the islands. *In 2015:* • Small-vessel surveys (non-random and non-systematic) conducted prior to a SCC event. • M3R detections aided in locating animals; collected high-resolution photographs for individual photo-ID. • Satellite tags deployed on short-finned pilot whales, bottlenose dolphins, and rough-toothed dolphins. *In 2014:* • A satellite-tag track for a Blainville's beaked whale was the first detailed movement data available for this species around Kauai and Niihau. • An encounter with false killer whales was cued by an acoustic detection from the M3R system.

Project (technical report for 2016)	**Conceptual Framework Category**	**Intermediate Scientific Objectives** (numbered as per Figure 11)	**Monitoring Questions**	**Accomplishments**[1]
HRC (continued)				
[H8] Estimation of Received Levels of MFAS on Marine Mammals at PMRF (Baird et al. 2017)	Occurrence, Exposure	#3: Determine what species and populations of marine mammals and ESA-listed species are exposed to Navy training and testing activities #6: Establish the regional baseline vocalization behavior, including seasonality and acoustic characteristics of marine mammals where Navy training and testing activities occur. #7: Determine what behaviors can most effectively be assessed for potential response to Navy training and testing activities. #8: Application of passive acoustic tools and techniques for detecting, classifying, and tracking marine mammals[2]. #9: Application of analytic methods to evaluate exposure and/or behavioral response of marine mammals to Navy training and testing activities #10: Evaluate acoustic exposure levels associated with behavioral responses of marine mammals to support development and refinement of acoustic risk functions. #12: Evaluate trends in distibution and abundance for populations of marine mammals and ESA-listed species that are regularly exposed to sonar and underwater explosives. #13: Leverage existing data with newly developed analysis tools and techniques[2].	• What is the occurrence and estimated received levels of MFAS on 'blackfish' and rough-toothed dolphins within the PMRF instrumented range?	*In 2016:* • Conducted vessel-based field efforts on three occasions between July 2013 and February 2015 that corresponded with MFAS use during SCCs. • Deployed location-only (SPOT5) or location-dive satellite tags on a false killer whale, short-finned pilot whales, and rough-toothed dolphins. • Estimated MFAS exposure levels for satellite-tagged individuals in February 2011, February 2012 and February 2013.

Project (technical report for 2016)	**Conceptual Framework Category**	**Intermediate Scientific Objectives** (numbered as per Figure 11)	**Monitoring Questions**	**Accomplishments**[1]
SOCAL				
[S1] Cuvier's Beaked Whale, Blue Whale, and Fin Whale Impact Assessments at Non-Instrumented Range Locations in the SOCAL Range Complex (Rice et al. 2017; Širović et al. 2017)	Occurrence, Exposure, Response	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas. #4: Establish the baseline habitat-use and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur. #6: Establish the regional baseline vocalization behavior, including seasonality and acoustic characteristics of marine mammals where Navy training and testing activities occur. #7: Determine what behaviors can most effectively be assessed for potential response to Navy training and testing activities. #8: Application of passive acoustic tools and techniques for detecting, classifying, and tracking marine mammals[2]. #9: Application of analytic methods to evaluate exposure and/or behavioral response of marine mammals to Navy training and testing activities #10: Evaluate acoustic exposure levels associated with behavioral responses of marine mammals to support development and refinement of acoustic risk functions #11: Evaluate behavioral responses by marine mammals exposed to Navy training and testing activities to support PCoD development and application. #13: Leverage existing data with newly developed analysis tools and techniques[2].	• What, if any, are the short-term behavioral and/or vocal responses when exposed to sonar or explosions at different levels or conditions? • Does exposure to sonar or explosives impact the long-term fitness and survival of individuals or the population, species, or stock? (with focus on blue whale, fin whale, humpback whale, Cuvier's beaked whale, and other regional beaked whale species)	*In 2016:* • PAM conducted June 2015–April 2016 to detect marine mammal and anthropogenic sounds using HARPs at three locations within SOCAL (Rice et al. 2017) and from four sites in 2006–2015 (Širović et al. 2017). • Automated algorithms developed and utilized to detect blue and fin whale calls, Cuvier's beaked whales and MFAS pings. • Preparing for future multivariate statistical analyses (including natural and anthropogenic variables) to account for variability in call densities: data preparation 95% complete, and method of resolving range ambiguity being developed. • Differences between recording sites in the occurrence of blue whale B calls and D calls, and fin whale 20 Hz calls were described • Detections of explosions (likely to be "seal bombs" used in fisheries) and MFAS were described. *In 2014–2016:* • Deployed HARPS at three locations in SOCAL to record marine mammal sounds and anthropogenic noise. • Continued refining understanding of fin whale population in SOCAL though analysis of fin whale song patterns identified songs from resident and "transient" (pan-Pacific) populations of fin whales. • Continued detailed analysis on the presence of anthropogenic sources of sound for the study of impact of sonar on blue, fin, and beaked whales. • Continued analyis of seasonal presence of fin, blue, and Cuvier's beaked whales, and the "BW43" beaked whale call (possibly Perrin's beaked whale). • Began new effort to characterize SOCAL regional Cuvier's beaked whale densities based on passive acoustic data.

Project (technical report for 2016)	**Conceptual Framework Category**	**Intermediate Scientific Objectives** (numbered as per Figure 11)	**Monitoring Questions**	**Accomplishments**[1]
SOCAL (continued)				
[S2] Cuvier's Beaked Whale Impact Assessment at SOAR (Schorr et al. 2017; Moretti 2017) (This is a joint project with [H3] "Long-term Trends in Abundance of Marine Mammals")	Occurrence, Exposure, Response, Consequences	#2: Estimate the distribution, abundance, and density of marine mammals and sea turtles in Navy range complexes, testing ranges, and in specific training and testing areas. #4: Establish the baseline habitat-use and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur. #6: Establish the regional baseline vocalization behavior, including seasonality and acoustic characteristics of marine mammals where Navy training and testing activities occur. #7: Determine what behaviors can most effectively be assessed for potential response to Navy training and testing activities. #8: Application of passive acoustic tools and techniques for detecting, classifying, and tracking marine mammals[2]. #9: Application of analytic methods to evaluate exposure and/or behavioral response of marine mammals to Navy training and testing activities #11: Evaluate behavioral responses by marine mammals exposed to U.S. Navy training and testing activities to support PCoD development and application. #12: Evaluate trends in distribution and abundance for populations of marine mammals and ESA-listed species that are regularly exposed to sonar and underwater explosives. #13: Assess existing data sets which could be utilized to address the current objectives	• What are the baseline population demographics, vital rates, and movement patterns for a designated key species in the SOCAL range complex? • What, if any, are the short-term behavioral and/or vocal responses when exposed to sonar or explosions at different levels or conditions? • Does exposure to sonar or explosives impact the long-term fitness and survival of individuals or the population, species or stock? (with initial focus on Cuvier's beaked whales)	*In 2016:* • 27 days of survey effort conducted from January to November 2016 to collect sighting data, photograph, and obtain biopsy samples from Cuvier's beaked whales and fin whales on SOAR. • Survey effort conducted for the first time during February, nearly doubled the previous amount of effort in April. • Updated hardware/software for M3R Linux-based cluster signal processor at SCORE, which includes a full range of broadband recording and integrated data archives; Update scheduled to be installed for the week of 5–10 March 2017. • Detection statistics (Probability of Detection and False Alarms) for M3Rs Auto-Grouper program were derived and correction factors were calculated from beaked whale detections at SOAR. • Initial risk function for Cuvier's beaked whales completed. • Satellite tags placed on Cuvier's beaked whales, fin whales and Risso's dolphins at SCORE. • At SCORE, yearly abundance estimates showed no decline in population over the 5-year period, 2010–2014. *In 2015:* • Completed hardware/software upgrades for a M3R Linux-based cluster signal processor at SCORE, which includes a full range of broadband recording and integrated data archives. *In 2014–2015:* • Ongoing multi-year analysis of Cuvier's beaked and fin whale occurrence in SOCAL. Analyzed beaked whale detections from 2011 to 2014 to establish methods and baseline abundance. Beaked whale density estimation in progress. • Collected sufficient sighting and photo-ID data for Cuvier's beaked whales to begin estimation of key population vital rates for impact analyses.

Project (technical report for 2016)	**Conceptual Framework Category**	**Intermediate Scientific Objectives** (numbered as per Figure 11)	**Monitoring Questions**	**Accomplishments**[1]
SOCAL (continued)				
[S3] Marine Mammal Sightings during CalCOFI Cruises (Debich et al. 2017)	Occurrence	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas. #4: Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur.	• What is the seasonal occurrence and density of cetaceans within the Navy's Southern California Range Complex?	*In 2016:* • Performed visual and acoustic monitoring for cetaceans during 18 CalCOFI cruises from February 2012 to April 2016 in the Southern California Bight to collect distribution, abundnace, and seasonal and inter-annual patterns of density. • 18 species identified and varied by season, 1,027 sonobuoy deployments and 478 towed-array deployments during 334 days at sea and 2,034 observation hr on effort. *In 2015:* • Performed visual and acoustic monitoring for marine mammals aboard CalCOFI cruises in 2014 and 2015. • Platform provides an opportunity to assess the full range of marine mammal species present in SOCAL. • Habitat modeling underway to predict marine mammal presence in the SOCAL. *In 2014:* • Gathered sufficient data for generation of species-specific seasonal densities and abundance trends at finer spatial and temporal scales than standard NMFS U.S. West Coast surveys, which are performed every 3 to 6 years.

Project (technical report for 2016)	**Conceptual Framework Category**	**Intermediate Scientific Objectives** (numbered as per Figure 11)	**Monitoring Questions**	**Accomplishments**[1]
SOCAL (continued)				
[S4/N4] Blue and Fin Whale Tagging and Genetics (Mate et al. 2017) (This project is also a component of NWTT tagging)	Occurrence, Exposure	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas. #3: Determine what species and populations of marine mammals and ESA-listed species are exposed to Navy training and testing activities. #4: Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur. #5: Establish the baseline behavioral patterns(foraging, diving, etc.) of marine mammals where Navy training and testing activities occur.	• What are the movement patterns, occurrence, and residence times of blue and fin whales within Navy training and testing areas along the U.S. West Coast as compared to other areas visited by tagged whales outside of Navy training and testing areas? • What are the residency time/occupancy patterns of blue whales within NMFS-designated Biologically Important Areas (BIAs) for this species along the U.S. West Coast?	*In 2016:* • Instrumented 19 blue, 14 fin, and 2 humpback whales with SPOT6 location-only and DM satellite tags. • Analyzed genetic samples from blue whales and fin whales biopsied to determine sex of the individuals. • Used mtDNA sequences to define haplotypes for stock analysis and to confirm species identification. *In 2015:* • Instrumented blue whales, fin whales, and a blue/fin hybrid whale with SPOT5, and a Bryde's whale with location-only and ADB satellite tags. • Analyzed genetic samples from blue whales and fin whales biopsied in 2014 and 2015 to determine sex of the individuals. • Used mtDNA sequences to define haplotypes for stock analysis and to confirm species identification. *In 2014:* • Instrumented blue whales and fin whales with location-only and ADB satellite tags. • Data from ADB tags revealed strong and consistent diel feeding patterns in blue whales.
NWTT				
[N1] PAM for Marine Mammals in the NWTRC (Wiggins et al. 2017) (In 2016, this project also addressed the monitoring question for GOA TMAA, see project [G1] in **Table 2**, below)	Occurrence, Exposure	#9: Application of analytic methods to evaluate exposure and/or behavioral response of marine mammals to Navy training and testing activities. #13: Leverage existing data with newly developed analysis tools and techniques[2].	• What is the ambient and anthropogenic soundscape in NWTT?	*In 2016:* • Ambient soundscape sound pressure levels re-processed using new and improved techniques, including calculating long (multi-year) spectrograms, sound pressure spectrum level percentiles, and average sound pressure spectrum levels. *In 2015:* • Reported on marine mammal and anthropogenic detections from July 2013 to April 2014, and presented separate report on seasonality of killer whale ecotype calls from January 2011 to April 2014. These technical reports were previously submitted under NWTRC reporting (DoN 2015c). • Began cumulative analysis of HARP passive acoustic data collected from 2004 through 2015 (final report anticipated after June 2016.

Project (technical report for 2016)	**Conceptual Framework Category**	**Intermediate Scientific Objectives** (numbered as per Figure 11)	**Monitoring Questions**	**Accomplishments**[1]
NWTT (continued)				
[N2] Modeling the Offshore Distribution of Southern Resident Killer Whales in the Pacific Northwest (Hanson et al. 2017)	Occurrence	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas. #2: Estimate the distribution, abundance, and density of marine mammals and sea turtles in Navy range complexes, testing ranges, and in specific training and testing areas #3: Determine what species and populations of marine mammals and ESA-listed species are exposed to Navy training and testing activities. #4: Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur. #6: Establish the regional baseline vocalization behavior, including seasonality and acoustic characteristics of marine mammals where Navy training and testing activities occur.	• What are the seasonal and annual occurrence patterns of Southern Resident killer whales relative to offshore Navy training ranges?	*In 2016:* • Deployed satellite tags (SPOT5) on SRKW in Puget Sound and coastal waters of Washington and Oregon between 2012 and 2016; however further SRKW tagging halted indefinitely by NMFS in 2016. • Compiled all locations for satellite-tagged SRKW recorded through 2015; created duration-of-occurrence and state-space models to identify areas of high use and travel corridors. • Detections summarized for most years from fall 2006 through summer 2015 from an enhanced array of passive acoustic recorders deployed off the coasts of California, Oregon, and Washington. • Continued collecting telemetry from SRKW “K33” tagged in December 2015 *In 2015:* • Completed review of acoustic data for 13 EARs recovered along the U.S. West Coast from fall 2014 to summer 2015; vocalizations of killer whales identified and calls used to classify to ecotype. • Conducted small-vessel tagging surveys to deploy tags on SRKW. • Collected photos for purposes of individual photo-ID, as well as samples of prey remains, feces, mucus and regurgitation. • Deployed a SPOT5tag on one SRKW adult male, a member of K pod.
[N3] Marine Mammal Density Surveys in the Pacific Northwest (Inland Puget Sound) (Smultea et al. 2017)	Occurrence	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas. #2: Estimate the distribution, abundance, and density of marine mammals and sea turtles in Navy range complexes, testing ranges, and in specific training and testing areas.	• What is the abundance, distribution, and density of marine mammals in inland waters of Puget Sound?	*In 2016:* Conducted systematic line-transect aerial surveys for marine mammals in eight sub-regions of Puget Sound from 16 to 26 January 2016. • Data and analyses were compared to 5 other survey periods from 2013 to 2015, spanning four seasons (winter, spring, summer, and, fall). • Estimated seasonal in-water density and abundance of marine mammals, particularly harbor porpoise, harbor seals, and sea lions (California and Steller). • Collected high-resolution photographs and video of marine mammal encounters.

Project (technical report for 2016)	**Conceptual Framework Category**	**Intermediate Scientific Objectives** (numbered as per Figure 11)	**Monitoring Questions**	**Accomplishments**[1]
NWTT (continued)				
[N4/S4] Blue and Fin Whale Tagging and Genetics (Mate et al. 2017) (This project is a also a component of SOCAL tagging)	*See project S4/N4 (above, in SOCAL)*			
[N5] Tagging and Behavioral Monitoring of Sea Lions in the Pacific Northwest in Proximity to Navy Facilities	Occurrence	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas. #3: Determine what species and populations of marine mammals and ESA-listed species are exposed to Navy training and testing activities. #4: Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur.	• What is the abundance and habitat use of California sea lions that haul out at Navy facilities and forage in testing and training areas?	*In 2016:* • Deployed satellite-linked time-depth-recording tags on 14 adult male California sea lions from floating traps in Clam Bay near Manchester naval facilities in February 2016. • Collected sea lion behavioral data, including the percentage of time animals haul-out each month on structures and assets near Puget Sound naval installations at Everett, Bremerton, and Bangor. • Identified locations of foraging grounds to better understand foraging behavior of adult male sea lions within the inland waters (U.S. and Canada) and along the outer coast. • Satellite telemetry instruments relayed at-sea locations, haulout locations, and diving data from December through August. *In 2015:* • Deployed satellite-linked time-depth-recording tags on 16 adult male California sea lions from floating traps in Sinclair Inlet near Bremerton Naval facilities. • Collected sea lion behavioral data within inland waters of Washington and British Columbia and offshore along west coast. • Documented percentage of time animals haul-out each month on Navy structures and assets in Puget Sound.

Project (technical report for 2016)	**Conceptual Framework Category**	**Intermediate Scientific Objectives** (numbered as per Figure 11)	**Monitoring Questions**	**Accomplishments**[1]
NWTT (continued)				
[N6] Harbor Seal Density Estimation (Jefferson and Ampela 2016)	Occurrence	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas. #2: Estimate the distribution, abundance, and density of marine mammals and sea turtles in Navy range complexes, testing ranges, and in specific training and testing areas. #12: Evaluate trends in distribution and abundance for populations of marine mammals and ESA-listed species that are regularly exposed to sonar and underwater explosives.	• What is the density of harbor seals in Hood Canal, Washington?	*In 2016:* • Used Navy-funded line-transect aerial survey data (collected from 2013 to 2016 by Smultea Environmental Sciences) from Hood Canal to enable direct estimation of harbor seal in-water density and abundance for six geographic sub-regions of Hood Canal; final results expected in 2017. *In 2015:* • Convened a workshop in October 2015 to assess existing monitoring datasets and chart a way forward to refine existing harbor seal density and abundance estimates in eight geographic subregions within Puget Sound.

[1] As per the regulations implementing monitoring reporting requirements (described in Section 1. Introduction), accomplishments from monitoring in the second cycle of five (5) year authorizations are reported in a cumulative fashion.

[2] Primary Research & Development and DemVal investments for tools and techniques supported by Office of Naval Research Marine Mammal & Biology and Living Marine Resource programs.

Key: ADB = Advanced Dive Behavior; ASW = anti-submarine warfare; CalCOFI = California Cooperative Oceanic Fisheries Investigations; CV = coefficient of variation; dB re 1 µPa = decibels referenced to 1 micro Pascal; DDG= guided missile destroyer; DM = dive monitoring; DoN = Department of the Navy; EAR = Ecological Acoustic Recorder; ESA = Endangered Species Act; GOA TMAA = Gulf of Alaska Temporary Maritime Activities Area; $g(0)$ = trackline detection probability; HARP = High-frequency Acoustic Recording Package; HRC = Hawaii Range Complex; HSTT = Hawaii Southern California Training and Testing; km = kilometer; LIMPET = Low Impact Minimally Percutaneous Electronic Transmitter; M3R = marine mammal monitoring on Navy ranges; MFAS = mid-frequency active sonar; MITT = Mariana Islands Training and Testing; MMO = marine mammal observer; mtDNA = mitochondrial DNA; NMFS = National Marine Fisheries Service; NOAA = National Oceanic and Atmospheric Administration; NTE = Navy Training Events; NWTRC = Northwest Training Range Complex; NWTT = Northwest Testing and Training; PAM = passive acoustic monitoring; PCoD = Population Consequences of Disturbance; photo-ID = photo-identification; PIFSC = Pacific Islands Fisheries Science Center; PIT = Passive Integrated Transponder; PMRF = Pacific Missile Range Facility; SCC = Submarine Commanders Course; SCORE = Southern California Offshore Range; SOAR = Southern California Offshore Antisubmarine Warfare Range; SOCAL = Southern California Range Complex; SPOT = Smart Position and Temperature; SSC Pacific = Space and Naval Warfare Systems Pacific; SRKW = southern resident killer whale; UNDET = Underwater Detonation; U.S. = United States.

Table 2. Monitoring goals and accomplishments for training ranges in first cycle of 5- year authorizations (GOA TMAA).

Project	Conceptual Framework Category	Corresponding Intermediate Scientific Objectives	Monitoring Question	Accomplishments
GOA TMAA				
[G1] PAM of Marine Mammals in the Gulf of Alaska Temporary Maritime Activities Area using Bottom-Mounted Devices (Wiggins et al. 2017) (In 2016, this project also addressed the monitoring question in NWTT, see project [N1] above)	Occurrence. Exposure, Response	#9: Application of analytic methods to evaluate exposure and/or behavioral response of marine mammals to Navy training and testing activities. #13: Leverage existing data with newly developed analysis tools and techniques[1].	*In 2016:* • What is the ambient and anthropogenic soundscape in GOA? *In 2015:* Monitoring effort metric: • Deploy underwater glider within the northern Gulf of Alaska. • Maintain passive acoustic data collection from two HARPs.	*In 2016:* • Ambient soundscape sound pressure levels re-processed using new and improved techniques, including calculating long (multi-year) spectrograms, sound pressure spectrum level percentiles, and average sound pressure spectrum levels. *In 2015:* • Deployed and recovered two HARPs within GOA TMAA. • In 2015, concluded monitoring from two HARPs for presence of marine mammals in GOA TMAA, with a particular focus on endangered species and beaked whales. • In 2015, report on data analysis from five GOA TMAA HARPs from April 2014 to May 2015 with particular focus on endangered species and beaked whales. (Rice et al. 2015; previously submitted with GOA TMAA Year-5 annual report).

[1]Primary Research & Development and DemVal investments for tools and techniques supported by Office of Naval Research Marine Mammal & Biology and Living Marine Resource programs.

Key: GOA TMMA = Gulf of Alaska Temporary Maritime Activities Area; ESA = Endangered Species Act; HARP = high-frequency acoustic recording package; NWTT = Northwest Training and Testing; PAM = passive acoustic monitoring.

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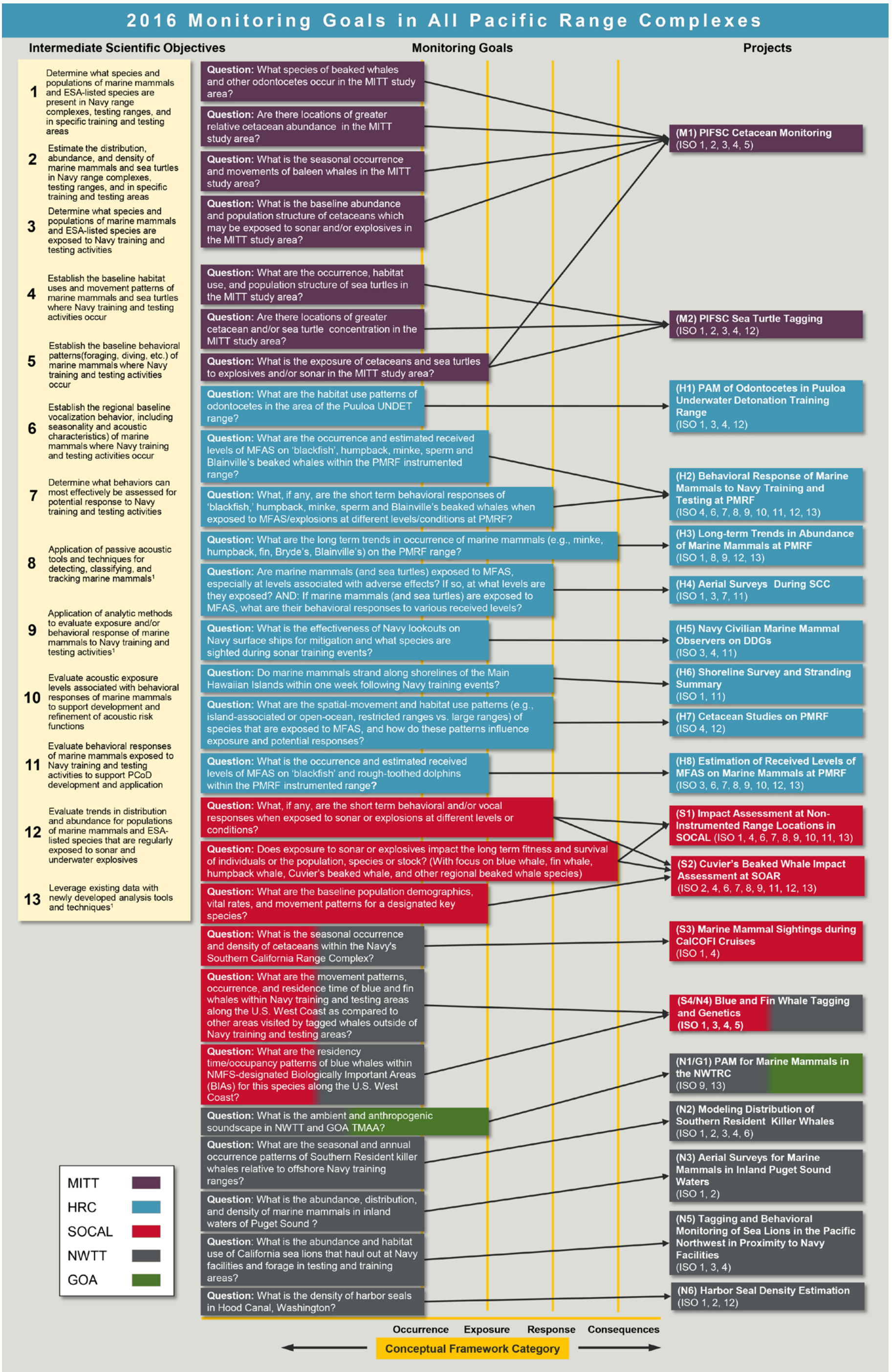

Figure 11. 2016 Monitoring goals in all Pacific range complexes. [1]Primary research-and-development and demonstration-validation investments for tools and techniques supported by ONR Marine Mammal & Biology and Living Marine Resource programs.

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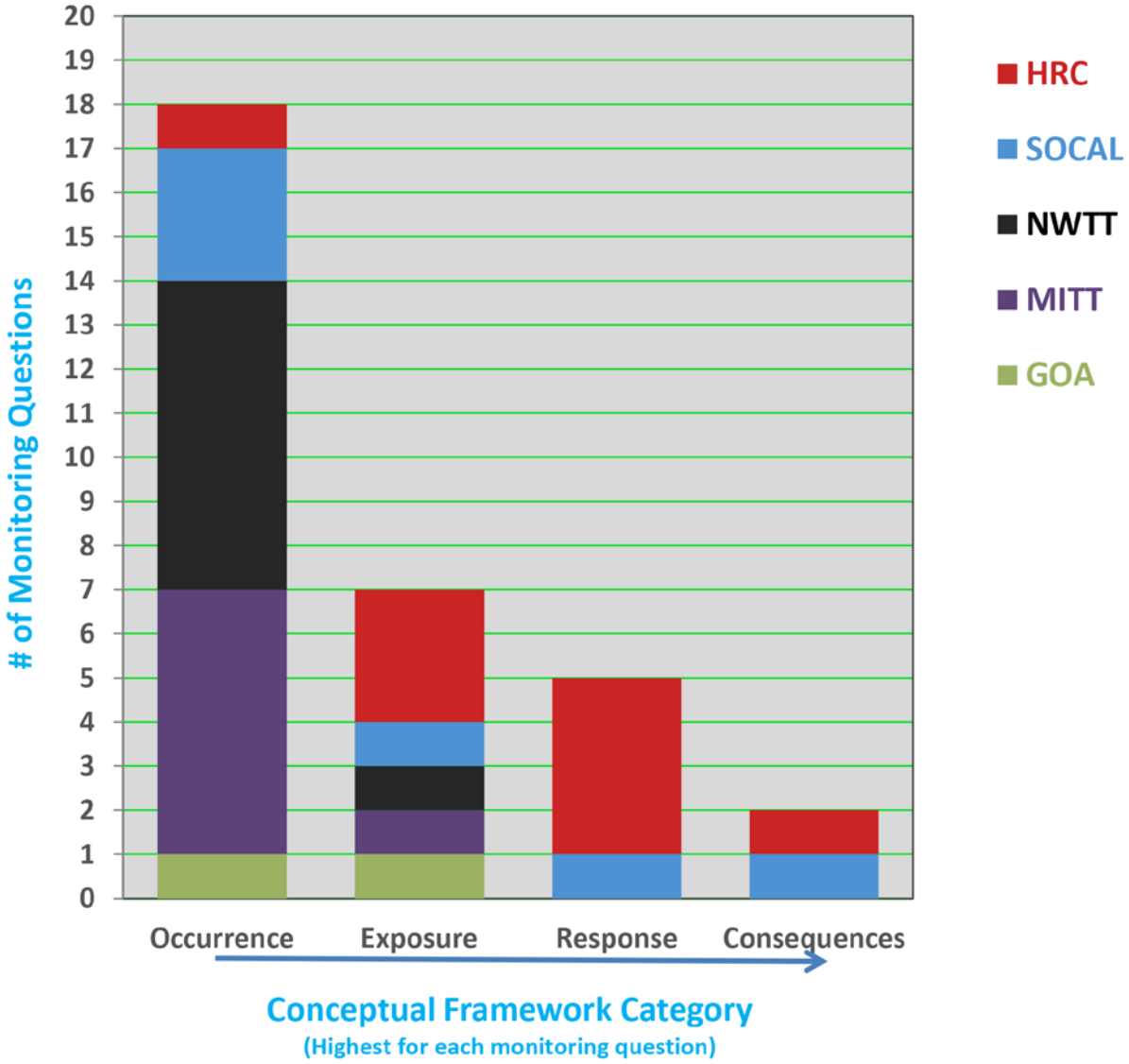

Figure 12. Number of monitoring questions and goals in all Pacific range complexes that address the four progressive Conceptual Framework Categories for monitoring knowledge outlined by the Scientific Advisory Group. Additional Navy funded effort under *Response* (not represented here) has been conducted in SOCAL under the ONR Marine Mammal & Biology and Living Marine Resource programs.

2.1.1 Timeline of Monitoring Efforts

In this sub-section, a graphical timeline of monitoring projects is presented for each range, covering the 2016 monitoring year. The timeline includes monitoring projects as well as notable items (e.g., results and outcomes). The timeline graphic is followed by a description of each monitoring project; the corresponding monitoring project in the timeline can be identified by the numbered code at the beginning of the project title, which begins with a one-letter abbreviation of the range/study area (e.g., M=MITT; H=HRC; S=SOCAL; N=NWTT; G=GOA TMAA).

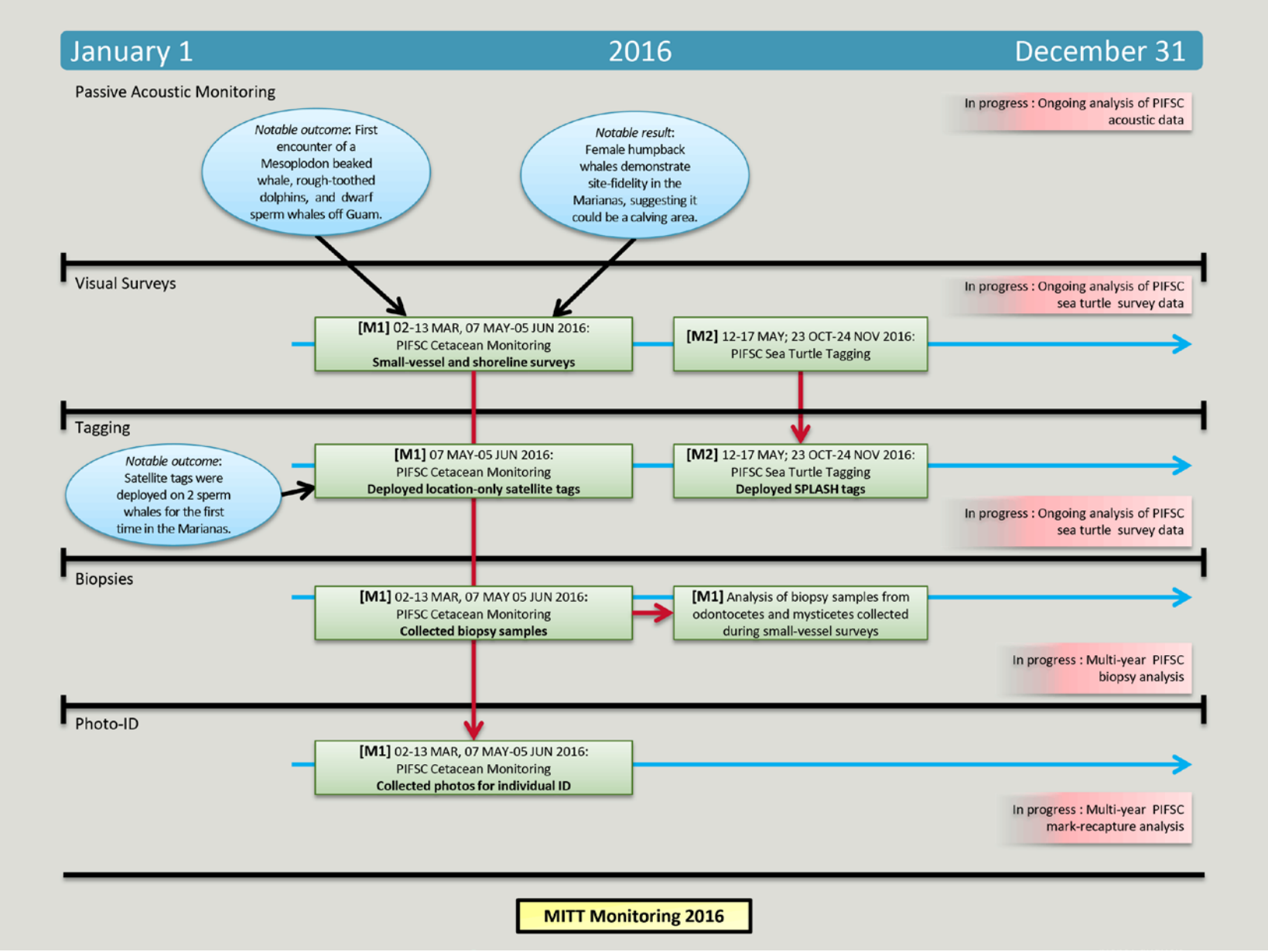

Figure 13. Timeline of 2016 projects in the Mariana Islands Training and Testing Study Area.

MITT

The MITT Study Area is depicted in **Figure 6**. A timeline of all U.S. Pacific Fleet-funded monitoring tasks implemented in the MITT in 2016 is illustrated in **Figure 13**. Detailed project summaries follow below.

[M1] Cetacean Monitoring in the Mariana Islands Range Complex, 2016 [Hill et al. 2017]

During 2-13 March 2016, Pacific Islands Fisheries Science Center (PIFSC) Cetacean Research Program (CRP) conducted a winter season survey effort to search for humpback whales. The vessel survey component was conducted on small vessels (<12 meters [m] in length) for cetaceans during 2–13 March 2016 off Saipan, Tinian, and Aguijan. On 8 March 2016, the survey team split into three groups to conduct shore-based observations around Saipan and Tinian shore-based visual surveys. In the event of sightings from the shore, the small-vessel survey team was positioned to be ready attempt photography, biopsy, and satellite tagging.

Summer season visual surveys were conducted from small vessels (<8 m in length) in the waters surrounding Saipan, Tinian, Aguijan, Rota, and Guam on 24 days during 7 May–5 June 2016. Survey effort was designed to cover representative habitat within the study area, and did not conform to systematic (i.e., line-transect) methods. Vessel tracks were spread out from day to day to ensure broad survey coverage over a wide range of depths and were also dictated by weather and sea conditions. All cetacean groups encountered were approached for species confirmation, group-size estimates, photo-identification (photo-ID), and biopsy sampling including sloughed skin (for assessment of genetic population structure) when possible, and Wildlife Computers (WC) Smart Position and Temperature (SPOT)-5 location-only satellite tags were deployed on individuals of certain species to investigate their movements. Opportunistic passive acoustic recordings were collected using a dipping hydrophone (Compact Acoustic Recording Buoy [CARB]) that was deployed from the small vessel and remained free floating while the survey team conducted photo-ID and biopsy sampling operations. Multi-year mark-recapture photo-ID and biopsy analyses are ongoing.

[M2] Sea Turtle Tagging in the Mariana Islands Training and Testing (MITT) [Martin and Jones 2016]

In October and November 2016, dedicated sea turtle surveys were conducted from small vessels in the nearshore and coastal waters of Guam, Saipan, and Tinian by PIFSC Marine Turtle Biology and Assessment Program in a collaborative effort with the U.S. Pacific Fleet, Naval Base Guam, Guam Division of Aquatic and Wildlife Resources, Guam Office of Law Enforcement, the Apra Harbor Patrol, and CNMI Department of Lands and Natural Resources. Survey locations included new areas not previously surveyed by this team—the southwest corner of Tinian (Tachungnya Bay and Tinian Harbor), Coral Ocean Point in southeast Saipan, Tanapag Lagoon on the west side of Saipan, and Agat Marina south to Cocos Island and Hagåtña Marina in Guam. When green (*Chelonia mydas)* and hawksbill (*Eretmochelys imbricata)* turtles were encountered, they were captured by hand while snorkeling or diving, and instrumented with metal Inconel tags or 'flipper tags' and with Passive Integrated Transponder (PIT) tags in order to characterize sea turtle movements and habitat use in the MITT. Skin samples were obtained for DNA and stable isotope analysis. Straight carapace length (SCL) and turtle mass were measured and turtles of appropriate SCL (see Jones et al. 2013) were

outfitted with a satellite tag (WC SPLASH/SPOT tags with GPS FastLoc technology, temperature, and depth). Turtle tracks were created using all available GPS locations. The kernel interpolation with barriers (KIWB) method was selected over traditional kernel density estimation due to its ability to account for land barriers for nearshore marine species (Sprogis et al. 2016). Using the KIWB estimate, 50 and 95 percent volume contour polygons were plotted to describe the core area and home range, respectively.

In 2016, cetacean observations were also recorded during surveys and transit periods. Analysis of the location data for habitat-use analysis includes a cumulative analysis from the 2013, 2014, 2015, and 2016 monitoring field efforts (Martin and Jones 2016). Tissue sample analyses from past-season surveys are ongoing, and will inform population structure of sea turtles in the MITT. As of the writing of this report, many of the tags are still transmitting and results will be documented in subsequent reports.

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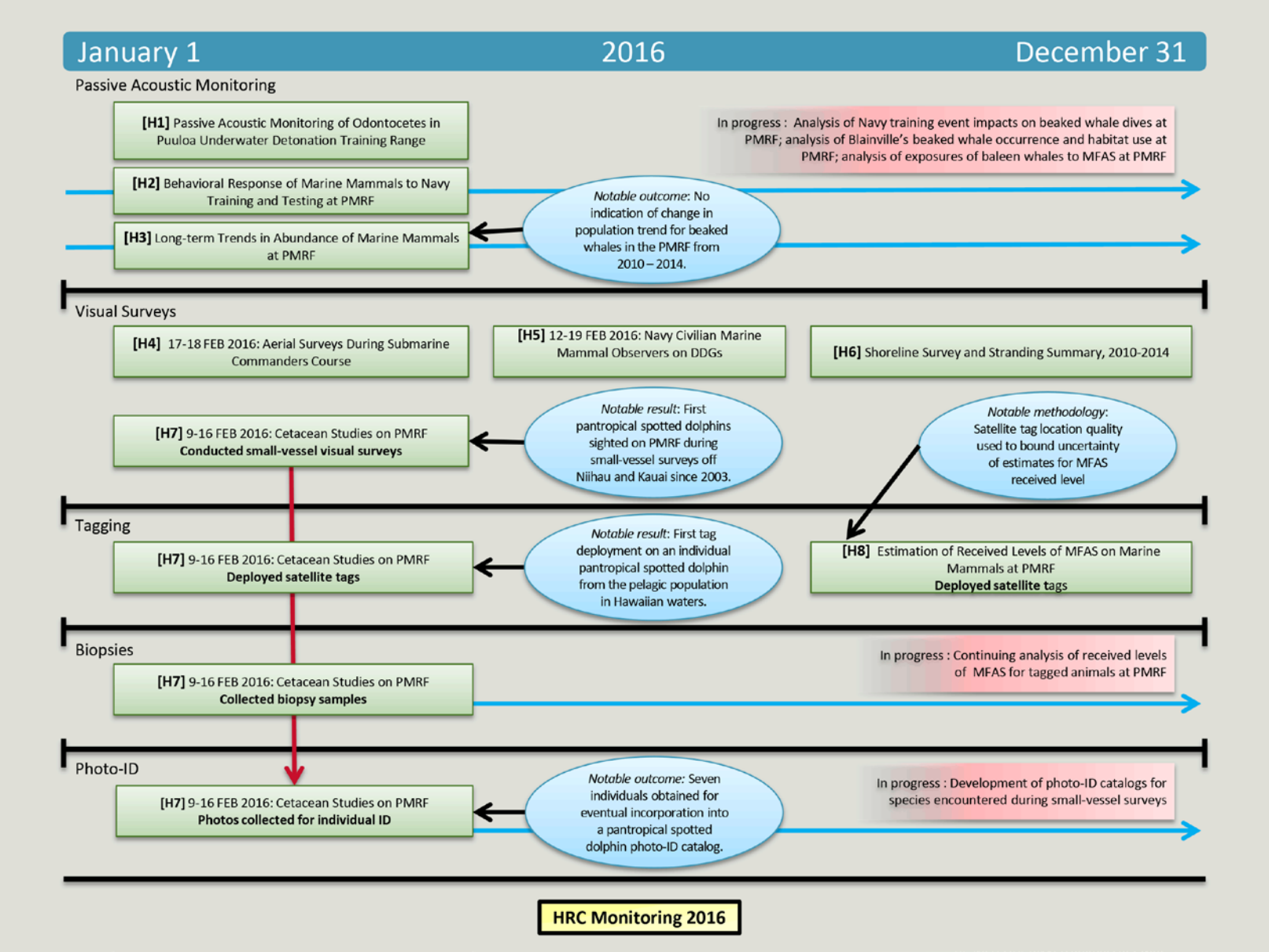

Figure 14. Timeline of 2016 projects in the Hawaii Range Complex.

HSTT

The HSTT Study Area is depicted in **Figure 1**. Monitoring in HRC and SOCAL is presented individually in the immediately following sections.

HRC

The HRC is shown in **Figure 2.** A timeline of all U.S. Pacific Fleet-funded monitoring tasks implemented in the HRC in 2016 is illustrated in **Figure 14**. It should be noted that for three of these HRC tasks, field work and data collection occurred prior to 2016, but data analysis occurred within the 2016 reporting period. Detailed project summaries follow below.

[H1] Passive Acoustic Monitoring of Odontocetes in the Vicinity of Puuloa Underwater Detonation Training Range, Hawaii Range Complex Oahu [Shannon et al. 2016]

From 2010 to 2013, passive Ecological Acoustic Recorders (EARs) were deployed in waters adjacent to the Puuloa UNDET range off the coast of Oahu (**Figures 4 and 15**). The EARs recorded on a duty cycle of 30 seconds every 5 minutes (min) at a sampling rate of 40 kilohertz (kHz). Naval Facilities Engineering and Expeditionary Warfare Center (NAVFAC EXWC) was tasked with conducting a thorough investigation and analysis of passive acoustic data as a second analysis of the dataset after a previous effort to develop an automated detector of odontocete whistles proved unsuccessful due to the high biotic and abiotic noise typical of a shallow-water environment. Shannon et al. (2016) is a continuation of that effort. Manual examination of the files of interest was conducted visually and aurally by human researchers. Because the aim of this study was to understand odontocete habitat usage in the range during times coinciding with UNDETs, only files recorded during operating hours at the range were reviewed manually. A generalized linear model was run in *R* (a software environment for statistical computing and graphics, https://www.r-project.org/) using month, hour, and location (east or west) and their interactions, with presence or absence of whistles as the binomial dependent variable. This work leveraged additional support from NAVFAC EXWC's Marine Resource Assessment Diving Services (MRADS) and the Hawaii Institute of Marine Biology's Marine Mammal Research Program.

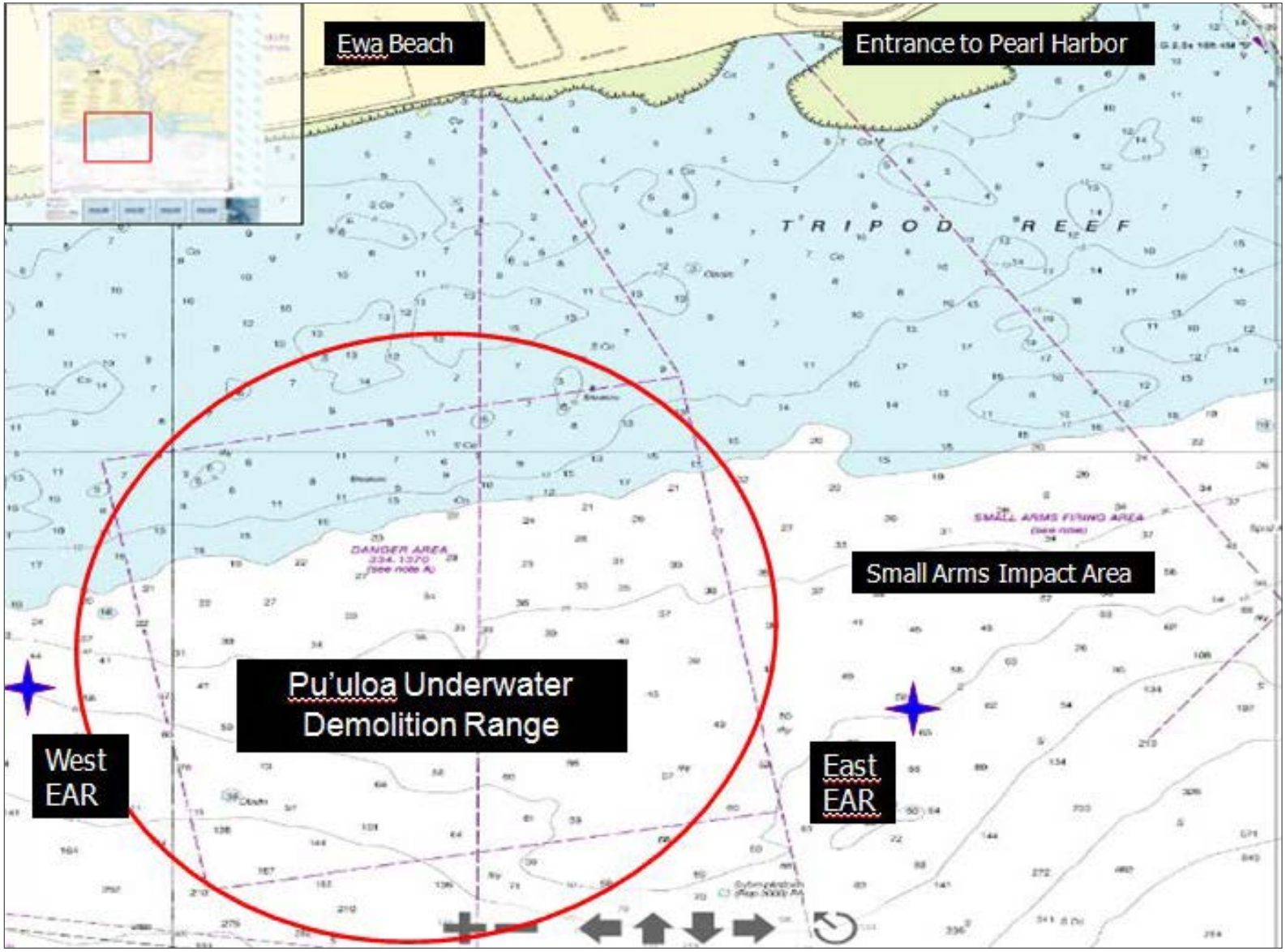

Figure 15. Puuloa Underwater Detonation/Demolition Range (Purple dashed square danger area) west of the mouth of Pearl Harbor, with approximate locations of Ecological Acoustic Recorders (EARs) annotated. Source is DMA Chart 19366. From: Shannon et al. 2016 [Project H1]

[H2] SSC Pacific FY16 Annual Report on PMRF Marine Mammal Monitoring [Martin et al. 2017]

In FY 2016, the Space and Naval Warfare Systems Center Pacific (SSC Pacific) Detection, Classification, Localization, Tracking, and Density Estimate (DCLTDE) Laboratory automatically processed data recorded on bottom-mounted hydrophones at the PMRF (**Figure 5**) to detect and localize several species of marine mammals and estimate RLs from MFAS transmissions. This ongoing passive acoustic monitoring (PAM) effort has focused on passive acoustic data collection and cataloging in addition to the baseline occurrence, habitat use, and density estimation of marine mammals at PMRF. In addition, this effort has focused on evaluating the occurrence, exposure, and response of marine mammals relative to Submarine Commanders Course (SCC). Estimation of marine mammal exposures from MFAS and possible subsequent behavioral reactions has been performed by analyzing data collected before, during, and after SCC training events held biannually in February and August.

Automated processing has progressed over the past several years such that when hydrophone data arrive at the DCLTDE lab, they are automatically processed for detecting and localizing marine mammal calls from fin (*Balaenoptera physalus*), sei (*Balaenoptera borealis*), Bryde's (*Balaenoptera edeni*), minke (*Balaenoptera acutorostrata*), and sperm whales (*Physeter macrocephalus*), as well as Blainville's (*Mesoplodon densirostris*) and other beaked whales with frequency-modulated (FM) echolocation clicks (e.g., Cuvier's beaked whale [*Ziphius cavirostris*] foraging clicks and Cross Seamount beaked whale type clicks) and a newly developed killer whale (*Orcinus orca*) high-FM vocalization detector. In addition, MFAS detections are automatically processed and localized for exposure analysis efforts. Beaked whale dive groups are automatically detected and localized to the nearest hydrophone locations. Killer whales are automatically detected and future efforts will attempt to localize whales to the nearest hydrophone location, similar to beaked whales. All other species are localized as individuals when possible.

Presence, occurrence, and relative abundance of species automatically processed were presented as a quick look for all available acoustic data recordings since the prior annual report (Martin et al. 2015). At the time of this report, all included data from FY16 spanned from 28 August 2015 to 7 September 2016, while more recent data were still at PMRF.

A test-case analysis of MFAS exposures was conducted by comparing estimated RLs and potential behavioral responses for minke whales that were automatically localized and semi-automatically tracked using MATLAB algorithms, with kinematic processes tuned for the species' call rates and swim speeds. Animal-received exposures to multiple MFAS transmissions were expressed as a cumulative sound exposure level (CSEL), using the sonar equation for propagation modeling.

A comparison of automatically detected Blainville's beaked whale dives was conducted between subsets of data (from March 2011, July 2011, January 2012, and February 2014) recorded by Naval Undersea Warfare Center (NUWC) and SSC Pacific. These detections were then combined and used to estimate density, demonstrating that combining the results from different methodologies provides a more complete picture. Finally, an analysis of individual group

responses by Blainville's beaked whales to U.S. Navy training activity and sonar was summarized.

[H3] Long-term Passive Acoustic Monitoring of Cetaceans at PMRF and SCORE [Moretti 2017]

The goal of this study is to understand the effects of military training events and exercises on local cetacean populations. For each of the major U.S. Navy instrumented ranges in the Pacific (PMRF, Southern California Offshore Antisubmarine Warfare Range [SOAR]) (**Figures 3 and 5**), the initial goal of NUWC Division Newport is to provide a Marine Mammal Monitoring on Navy Ranges (M3R) system that can be run with minimal operator intervention to collect passive acoustic detection archives on a nearly continuous basis (see also project [S2]). These archive files provide an electronic record of marine mammal acoustic activity, and sonar activity, as well as marine mammal localization data from multiple algorithms. As algorithms become available and are incorporated into the system, algorithm-specific reports can be seamlessly integrated into the archives to provide a time-synchronous history of events.

An initial risk function for Cuvier's beaked whales using the method described for Blainville's beaked whales at the Atlantic Undersea Test and Evaluation Center (AUTEC) was completed as a proof-of-concept. This was the first application of passive acoustic methods to the derivation of a Cuvier's beaked whale risk function. The Risk Function estimates the probability of foraging dive disturbance as a function of sonar root-mean-squared received level (RL_{rms}). The method is presently being validated with data from a calibrated source, which was deployed from the R/V *Sally Ride* in January 2017 at the Southern California Offshore Range (SCORE).

Detection statistics (Probability of Detection and False Alarms) for M3R's Auto-Grouper program were derived and correction factors were calculated from beaked whale detections at SOAR. This effort also validated archived data products using raw data and calculated a density estimate of Cuvier's beaked whales.

Satellite tags were placed on both Cuvier's beaked whales and fin whales at SCORE, the results of which are provided in a report from Marine Ecology and Telemetry Research (MarEcoTel) (Schorr et al. 2017).

FY16 goals include making data available and applied to the study of the effect of sonar on marine mammals. For example, prior and on-going studies have established that beaked whales are displaced when exposed to MFAS. The data suggest that they increase their time submerged and ascend to the surface away from the source. By combining passive acoustic localization of the animals and precise location of sonar sources, a risk function for behavioral disruption of Blainville's beaked whales at AUTEC was developed. In 2016, a risk function model for behavioral disruption was adapted for use with Cuvier's beaked whale at SCORE and cross-validation with Blainville's beaked whale data from PMRF is underway. The results are being made available to a separate effort to develop a Population Consequences of Disturbance (PCoD) model to estimate the cumulative effect of repeated sonar exposure at a population level for Cuvier's beaked whales at SCORE.

[H4] Aerial Survey Monitoring for Marine Mammals and Sea Turtles in the Hawaii Range Complex in Conjunction with a Navy Training Event: SCC [Mobley et al. 2017]

Aerial surveys were conducted on and around the PMRF (**Figures 5 and 16**) for the purpose of detecting and observing marine mammals and sea turtles exposed to MFAS during a Navy training exercise held in February 2016. Survey effort was spent flying elliptical orbits in advance of a Navy warship as it participated in the exercise. Sightings made in close proximity of the ship and judged suitable to track for an extended period were selected for a focal follow for extended behavioral observations and videography. Aerial survey data relative to the SCC event was summarized by HDR and Marine Mammal Research Consultants. Animals sighting records were reviewed by the SSC Pacific and compared with PMRF data products provided following the training event in order to perform estimates of MFAS received level at these animals. Transmission loss was estimated using the propagation model Peregrine and bathymetry from the NOAA Coastal Relief model.

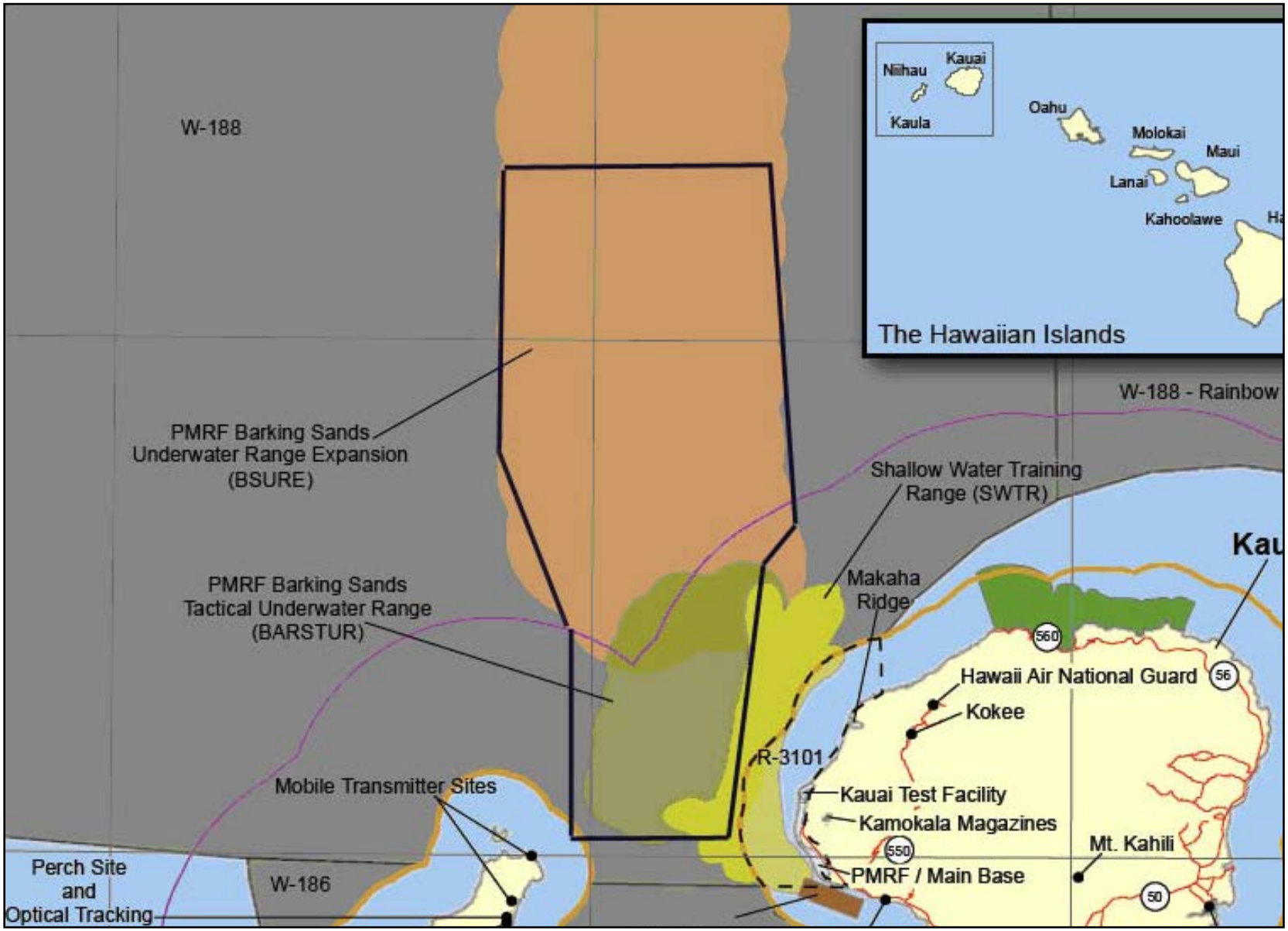

Figure 16. Location of the aerial survey monitoring area (black box = area for ship follows) in and near the U.S. Navy PMRF west and northwest of Kauai, Hawaii. [Project H4]

[H5] Final Cruise Report, Marine Species Monitoring & Lookout Effectiveness Study, Submarine Commanders Course, February 2016, Hawaii Range Complex [Vars et al. 2016]

Marine mammal observers (MMOs) embarked on a U.S. Navy vessel during a SCC held in February 2016. MMOs followed a prescribed protocol to collect data that will be pooled with other embarks for future analysis of the effectiveness of U.S. Navy lookouts. In addition, MMOs recorded marine mammal and sea turtle sightings in order help determine the species and populations relative to U.S. Navy training events in the HRC.

[H6] Aerial Shoreline Surveys for Marine Mammals and Sea Turtles in the Hawaii Range Complex, Conducted after Navy Training Events. Five-Year Summary Report 2010–2014 [Deakos et al. 2017]

Aerial surveys 2010-2014 made along shorelines after U.S. Navy training events (NTEs) to search for stranded marine mammals were summarized by HDR. Because of the lack of any sightings of strandings over this span, HDR and Hawaii Pacific University investigated local stranding network records to determine whether the baseline stranding rate was consistent with this aerial survey result of no strandings detected. Also the local stranding network data were used to investigate whether there was any detectable difference in the number of strandings recorded before as compared to during-and-after the same NTEs for which the above aerial surveys had been performed.

[H7] Odontocete Studies on the Pacific Missile Range Facility in February 2016: Satellite-tagging, Photo-identification, and Passive Acoustic Monitoring [Baird et al. 2016]

A joint marine mammal monitoring project by CRC and SSC Pacific in February 2016 on and around PMRF was carried out utilizing combined vessel-based field efforts and PAM. Surveys were conducted in conjunction with the M3R real-time PAM system located at the PMRF range (Moretti 2017). M3R detections helped to locate animals for satellite-tag deployment, and visual observations provided validation of acoustic detections. The goal was to obtain information on spatial movements and habitat-use patterns of cetaceans that are exposed to MFAS on and around PMRF before, during, and after a NTE; using data obtained from satellite tags (see Baird et al. 2017). (Note: although tags are deployed prior to the training event, the tags have the potential to remain attached to the animal for several weeks; therefore, recovered data may overlap in space and time with training events, and be utilized for Project [H8], below.)

[H8] Impact of MFAS to Odontocetes during SCC, 2013–2015 [Baird et al. 2017]

In an effort to assess both exposure and responses to MFAS, data were used from 20 satellite tags deployed on odontocetes prior to three SCCs held on PMRF between July 2013 and February 2015 (Baird et al. 2017). Details on field methods are available in Baird et al. (2016). Tags used were either location-only (WC SPOT5) or location-dive (WC Mk10A) tags in the Low Impact Minimally Percutaneous Electronic Transmitter (LIMPET) configuration. MFAS use during each SCC was compared with movement patterns of tagged animals.

The methods for estimating MFAS exposure levels for satellite- tagged individuals for the period February 2011 through 2013 were previously described (Baird et al. 2014). The methods utilized here were similar in several areas, with improvements in the area of incorporating an estimate for the animal location accuracy along with utilizing a different propagation model, which allowed

batch mode processing. Together these two factors allowed a statistical representation of the estimated MFAS exposure levels for satellite-tagged individuals, which provided insight into the bounds of uncertainty for each estimated RL.

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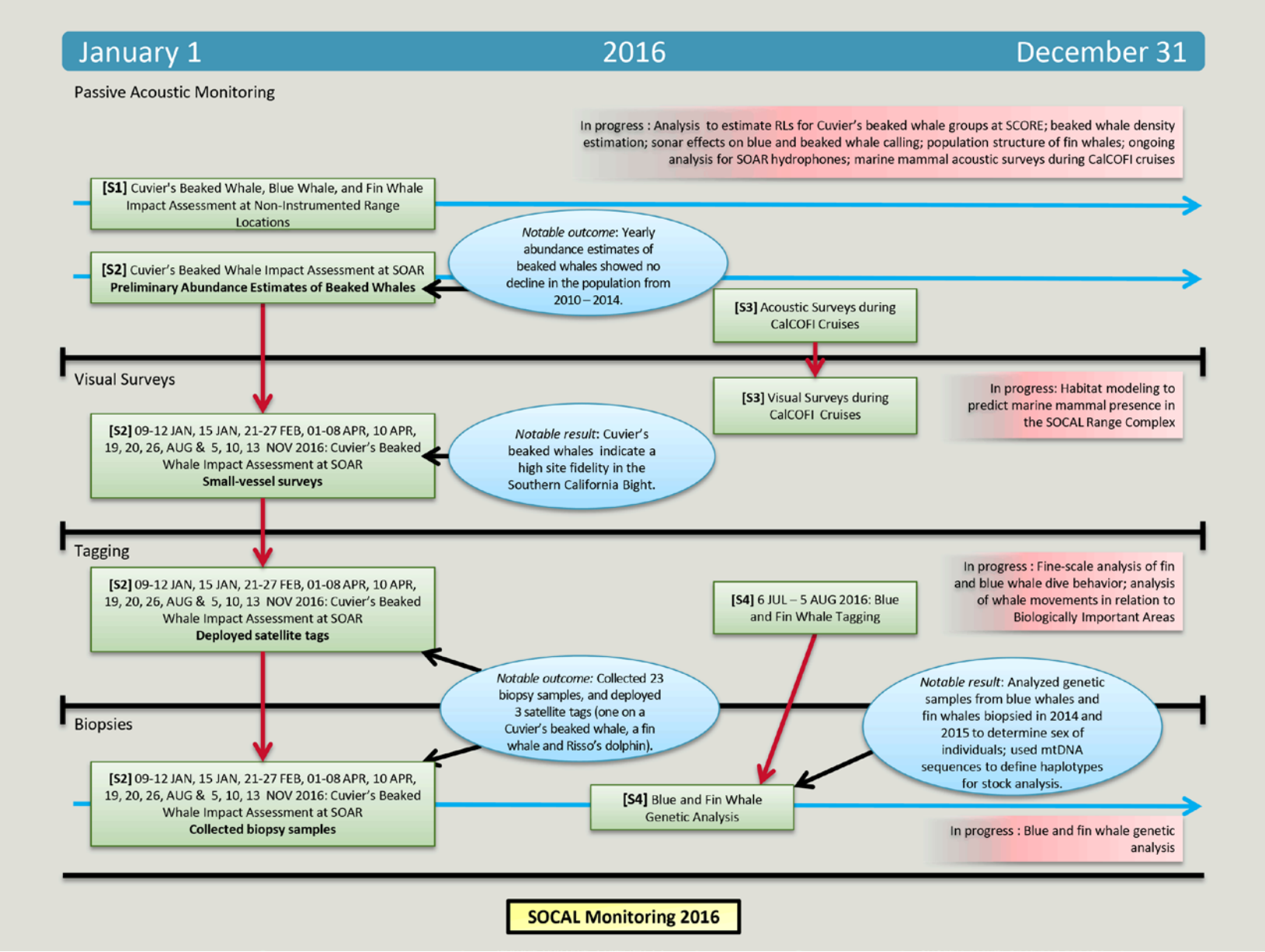

Figure 17. Timeline of 2016 projects in the Southern California Range Complex.

SOCAL

SOCAL is depicted in **Figure 3**. A timeline of all U.S. Pacific Fleet-funded monitoring tasks implemented in the SOCAL in 2016 is illustrated in **Figure 17**. Detailed project summaries follow below.

[S1] Passive Acoustic Monitoring and Data Analysis in SOCAL [Rice et al. 2017, Širović et al. 2017]

The University of California San Diego's Scripps Institution of Oceanography (SIO) in La Jolla, California, and SSC Pacific are collaborating to study potential impacts of sonar exposure and other anthropogenic noise on marine mammal presence and acoustic behavior near naval training areas. The range of work conducted under this effort includes analyses of whale calls and echolocation clicks (of particular interest are blue whales [*Balaenoptera musculus*], fin whales, and Cuvier's beaked whales); collection of anthropogenic signals (including sonar, shipping noise, etc.); impact of MFAS on whale calling behavior; beaked whale population density; and fin whale population structure.

Broadband PAM data have been collected in the SOCAL region since 2006 using High-frequency Acoustic Recording Packages (HARPs) that record sounds from 10 Hertz (Hz) up to 160 kHz and are capable of approximately 300 days of continuous data storage. Recording over a broad frequency range of 10 Hz to 100 kHz allows detection of mysticetes, odontocetes, and anthropogenic sounds.

All analyses are conducted using automated detectors for whale and anthropogenic sound sources. Analysis focuses on blue, fin, and Cuvier's beaked whales. In addition, signals from Blainville's and Stejneger's (*Mesoplodon stejnegeri*) beaked whales are analyzed. Other beaked whale signals screened for include FM pulses known as BW40, BW43, and BW70, which may belong to Hubbs' (*M. carlhubbsi*), Perrin's (*M. perrini*), and pygmy (*M. peruvianus*) beaked whales, respectively. Individual blue whale B calls and beaked whale echolocation clicks, as well as MFAS and explosion occurrence and levels are detected automatically using computer algorithms. Presence of fin whale 20-Hz calls is detected using an energy detection method and is reported as fin whale acoustic index.

Rice et al. (2017) analyzed data collected during June 2015 to April 2016 from HARPs deployed at three locations: west of San Clemente Island (1,000-m depth, site H), southwest of San Clemente Island (1,200-m depth, site N), and west of La Jolla, California (500-m depth, site P) (**Figure 18**).

Širović et al. (2017) are in the final stages of the process of detecting and classifying the acoustic signals needed to perform the analysis on the impact of mid-frequency active sonar on blue whale and beaked whale calling behavior. The basis for the effort is previously collected PAM data from four HARP deployment sites in the years 2006 to 2015. Four sites (designated E, H, N, and P) (**Figure 18**; Site E not shown in figure because not currently deployed) were chosen for the MFAS impact analysis based on numbers of MFAS detections. Previous ONR-funded work showed that blue whale calls are regularly detected at these sites using PAM, and these HARPs are within primary habitat for Cuvier's beaked whales in SOCAL. Algorithms were modified and utilized to detect calls from fin whales, blue whales (B and D calls), and Cuvier's

beaked whales and MFAS pings. These data-preparation efforts are currently approximately 95 percent complete for detecting and classifying the acoustic signals needed to perform the analysis on the impact of MFAS on blue whale and beaked whale calling behavior. In parallel, a method for resolving range ambiguity to detected calls is being developed. Multivariate statistical analyses to account for variability in call densities, including natural and anthropogenic variables, are planned for 2017.

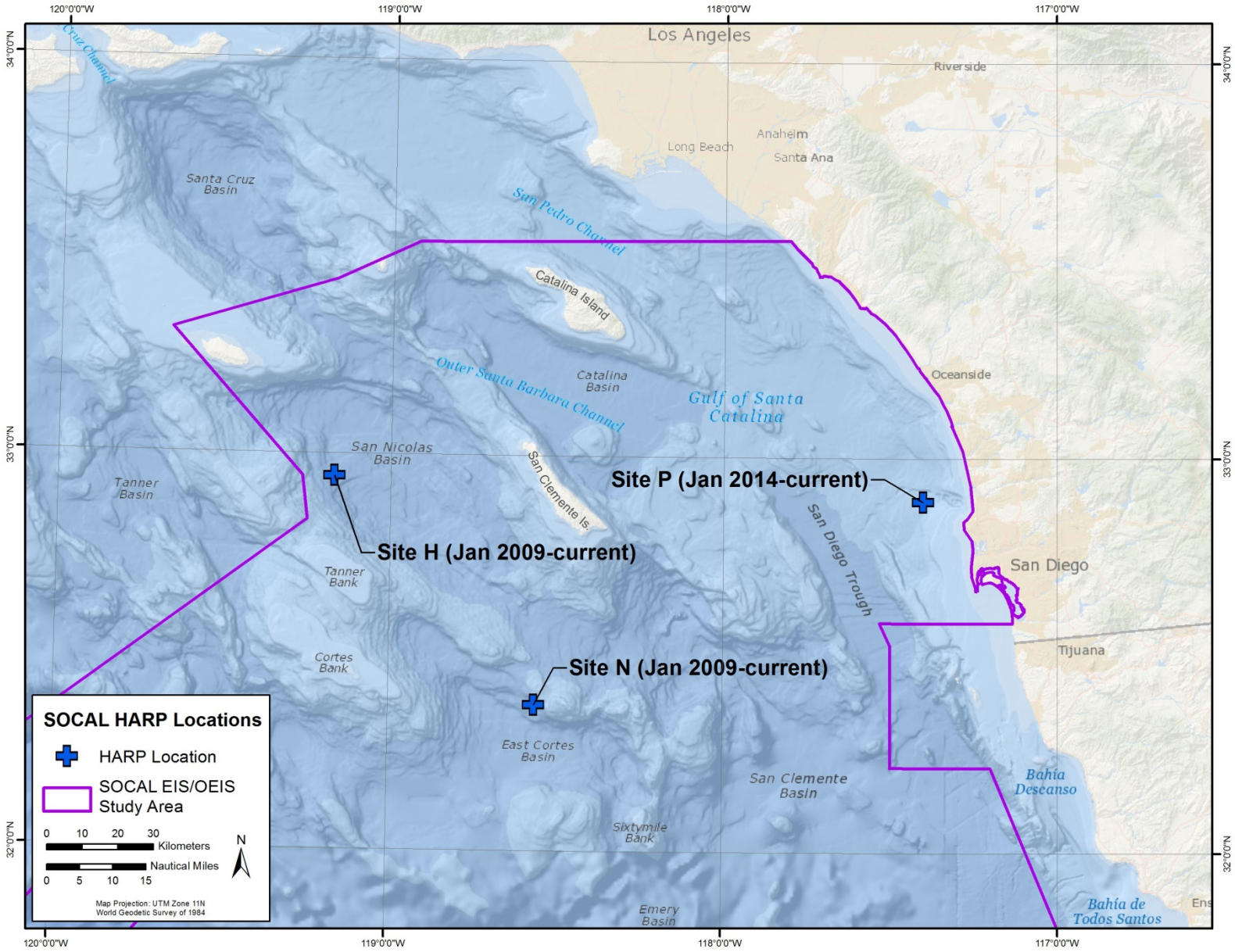

Figure 18. High-frequency Acoustic Recording Packages currently deployed in the Southern California Range Complex. [Project S1]

[S2] Cuvier's Beaked Whale Impact Assessment at the Southern California Offshore Antisubmarine Warfare Range (SOAR) [Schorr et al. 2017]

As part of an ongoing study of the distribution and demographics of several marine mammal species within SOCAL, MarEcoTel conducted 27 days of survey effort from 7 January to 13 November 2016, specifically focusing on the SOAR (**Figure 19**). The primary goal of the surveys was sighting, photographing, and collecting biopsy samples from Cuvier's beaked whales and fin whales.

Staff from the NUWC M3R program would monitor hydrophones from the Range Operations Center on North Island in San Diego and direct a rigid-hulled inflatable boat (RHIB) via radio or satellite phone into areas where marine mammal vocalizations were detected. While the RHIB could be directed towards any vocalizations for visual verification, they were preferentially directed to those likely to be beaked whales when conditions were suitable for working with these species (typically winds at Beaufort 3 or less). In general, detections classified as small odontocetes were bypassed in favor of those from beaked or baleen whales. Photographs were taken for species verification where questionable, and for individual identification for species where this methodology is being employed during this study or by collaborators (beaked, fin, blue, humpback, minke, Bryde's, and killer whales; bottlenose [*Tursiops truncatus*] and Risso's dolphins [*Grampus griseus*]). Remote tissue biopsies were collected from species of interest both to this study (beaked and fin whales), and also on behalf of collaborators at the Southwest Fisheries Science Center (SWFSC) for use ongoing assessments of offshore populations and stress hormone analyses. Finally, a limited number of satellite tags (LIMPET SPLASH10-A design) were deployed; as this effort was focused more on population monitoring that is better supported by photo-ID and biopsy data.

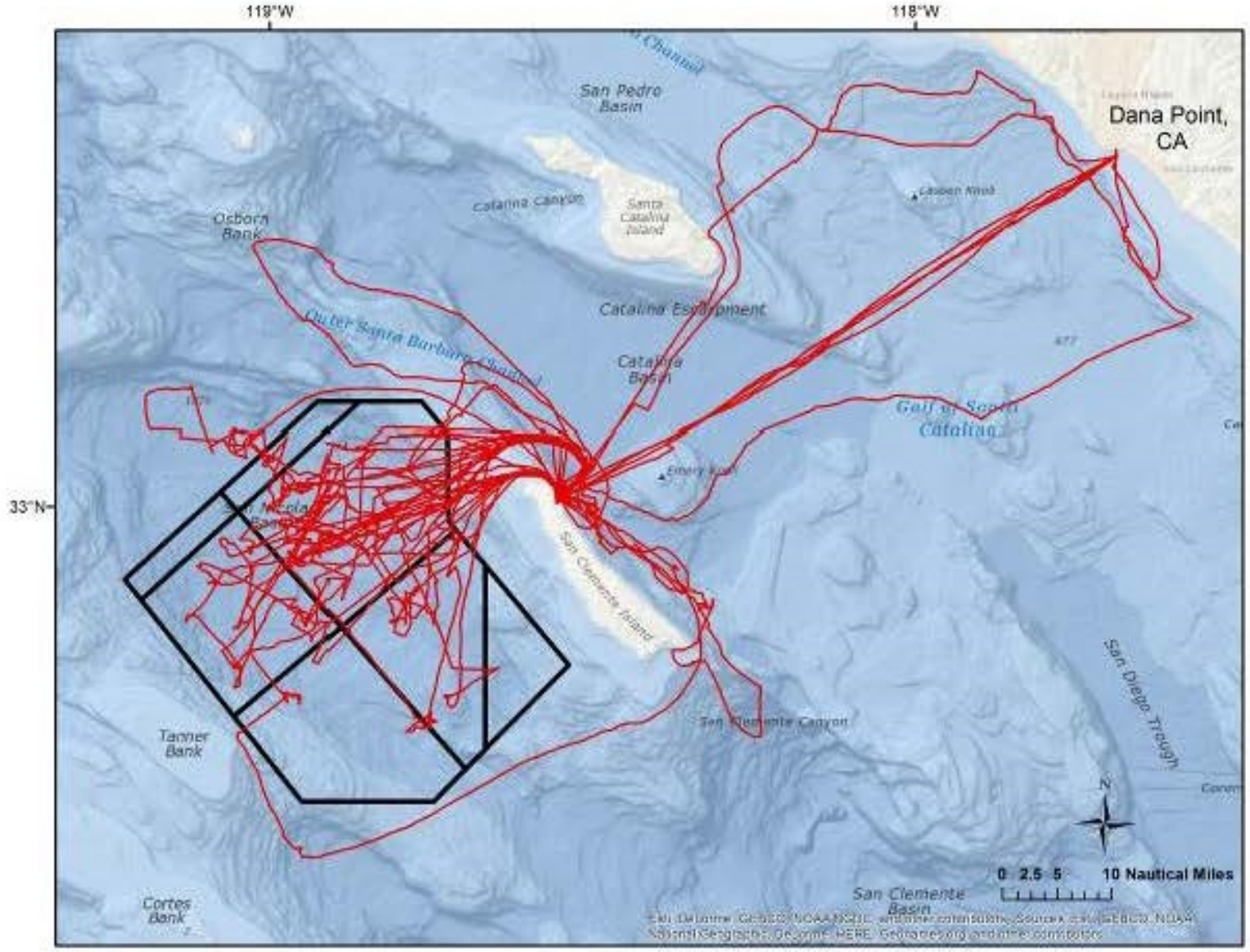

Figure 19. Vessel track lines from surveys conducted January 2016 through November 2016. Black lines west of San Clemente Island depict the Southern California Offshore Antisubmarine Warfare Range (SOAR) range boundaries. From: Schorr et al. 2017 [Project S2]

[S3] Marine Mammal Surveys on CalCOFI Cruises [Debich et al. 2017]

The California Cooperative Oceanic Fisheries Investigations (CalCOFI) cruises, a joint agency field effort, have been conducted off southern California for over 62 years, and represent the only continuous, seasonal marine mammal information available for southern California. More information on the overall history of the CalCOFI program is available at: http://www.calcofi.net/.Beginning in 2004, the Chief of Naval Operations Environmental Readiness Division funded the collection of marine mammal visual and passive acoustic data during regularly scheduled CalCOFI cruises, which occur four times per year. U.S. Pacific Fleet specifically funded marine mammal data collection in 2013, 2014, 2015, and continuing from 2016 through 2018. The CalCOFI marine mammal efforts represent one of the few cool-water (i.e., winter, spring) vessel surveys in the region, with the exception of the U.S. Pacific Fleet's aerial surveys that have also sampled during cool-water periods (e.g., Smultea and Bacon 2012, 2013). Each CalCOFI cruise consists of sampling the same survey tracklines including coverage offshore (>100 nm). Visual and acoustic data are used to characterize spatial and temporal distribution patterns, seasonal and inter-annual patterns of density, and abundance of cetaceans in the Southern California Bight. Through collaboration with SIO and NMFS, these data are being used to develop predictive marine mammal habitat models for southern California, including the SOCAL Range Complex (e.g., Becker et al. 2016).

[S4] Blue & Fin Whale Tagging and Analysis in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas [Mate et al. 2017]

Oregon State University's Marine Mammal Institute conducted a third year of effort (see Mate et al. 2015, 2016) to tag blue and fin whales in the offshore areas of SOCAL. The focus of these studies was to collect information on long-range movement and occurrence patterns within NMFS-designated Biologically Important Areas (BIAs) (Ferguson et al. 2015; Calambokidis et al. 2015), as well details of individual animal use of U.S. Navy testing and training areas and subareas in terms of residence time. This includes movements in and through SOCAL, NWTT, and Naval Air Systems Command's Point Mugu Sea Range (herein referred to as Pt Mugu). In addition, foraging and dive behaviors for blue and fin whales were also obtained (Mate et al. 2017). Two types of satellite-monitored radio tags were deployed on blue and fin whales—location-only and intermediate-duration dive-monitoring (DM) tags—to provide both long-term tracking information to generate metrics to define home ranges and core areas and shorter-term, fine-scale dive profile information, respectively. The new technology of DM tags incorporated depth and tri-axial accelerometer sensors into the traditional location only-tag design, enabling a relative measure of foraging effort, and its changes over time, to be obtained via satellite, without the need to recover the tags. Genetic analyses to determine sex, mitochondrial haplotypic composition, nuclear microsatellite loci composition, individual identification, population structure, and interspecific introgressive hybridization are in progress on tissue samples collected from blue and fin whales during U.S. Navy-funded monitoring efforts in 2014, 2015, and 2016.

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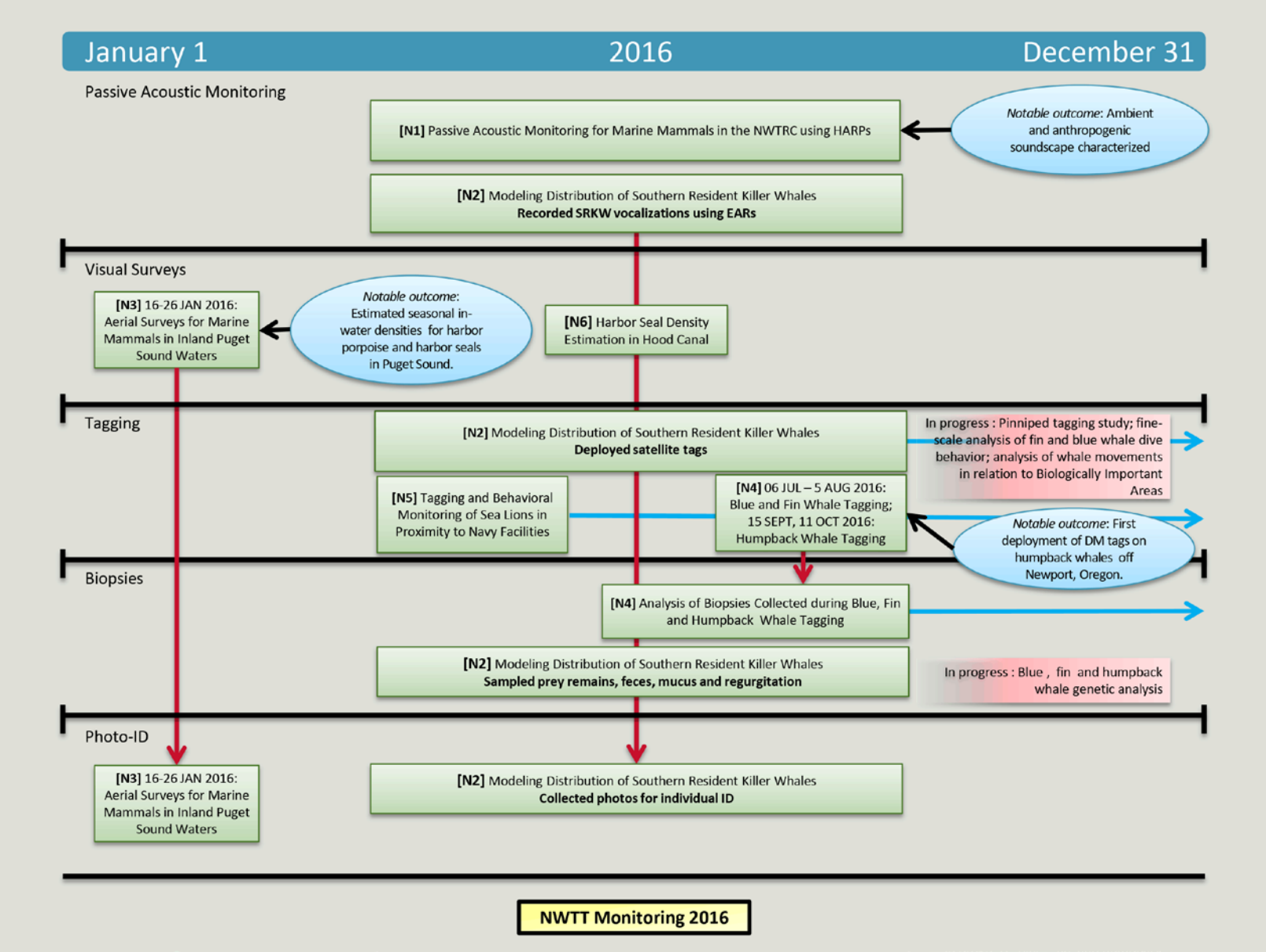

Figure 20. Timeline of 2016 projects in the Northwest Training and Testing Study Area.

NWTT

The NWTT Study Area including offshore areas is depicted in **Figures 7 and 8**. A timeline of all U.S. Pacific Fleet-funded monitoring tasks implemented in the NWTT in 2016 is illustrated in **Figure 20**. For three of these NWTT projects, field work and data collection occurred prior to 2016, but data analysis occurred within the 2016 reporting period. Detailed project summaries follow below.

[N1] Passive Acoustic Monitoring for Marine Mammals in the Northwest Training Range Complex [Wiggins et al. 2017]

PAM using HARPs has been conducted in the NWTRC since 2004 by SIO and funded by U.S. Pacific Fleet. Wiggins et al. (2017) report on analyses of data spanning 10 years starting in September 2004 and ending in May 2014 and using three sites in the NWTRC: one on the shelf (CE) and two on the slope of Quinault Canyon covering different periods (QCA and QCB) (**Figure 21**). This work builds on previous similar analyses (Širović et al. 2011, 2012; Kerosky et al. 2013b; Debich et al. 2014; Trickey et al. 2015).The ambient soundscape (including whales) sound pressure levels (SPLs) were re-processed using new and improved techniques, including calculating long (multi-year) spectrograms, sound pressure spectrum level percentiles, and average sound pressure spectrum levels over the recording periods. Detections of anthropogenic sources included broadband ship, MFAS, low-frequency active sonar (LFAS) and explosions.

This work is similar to that completed for GOA TMAA, refer to **Project G1**.

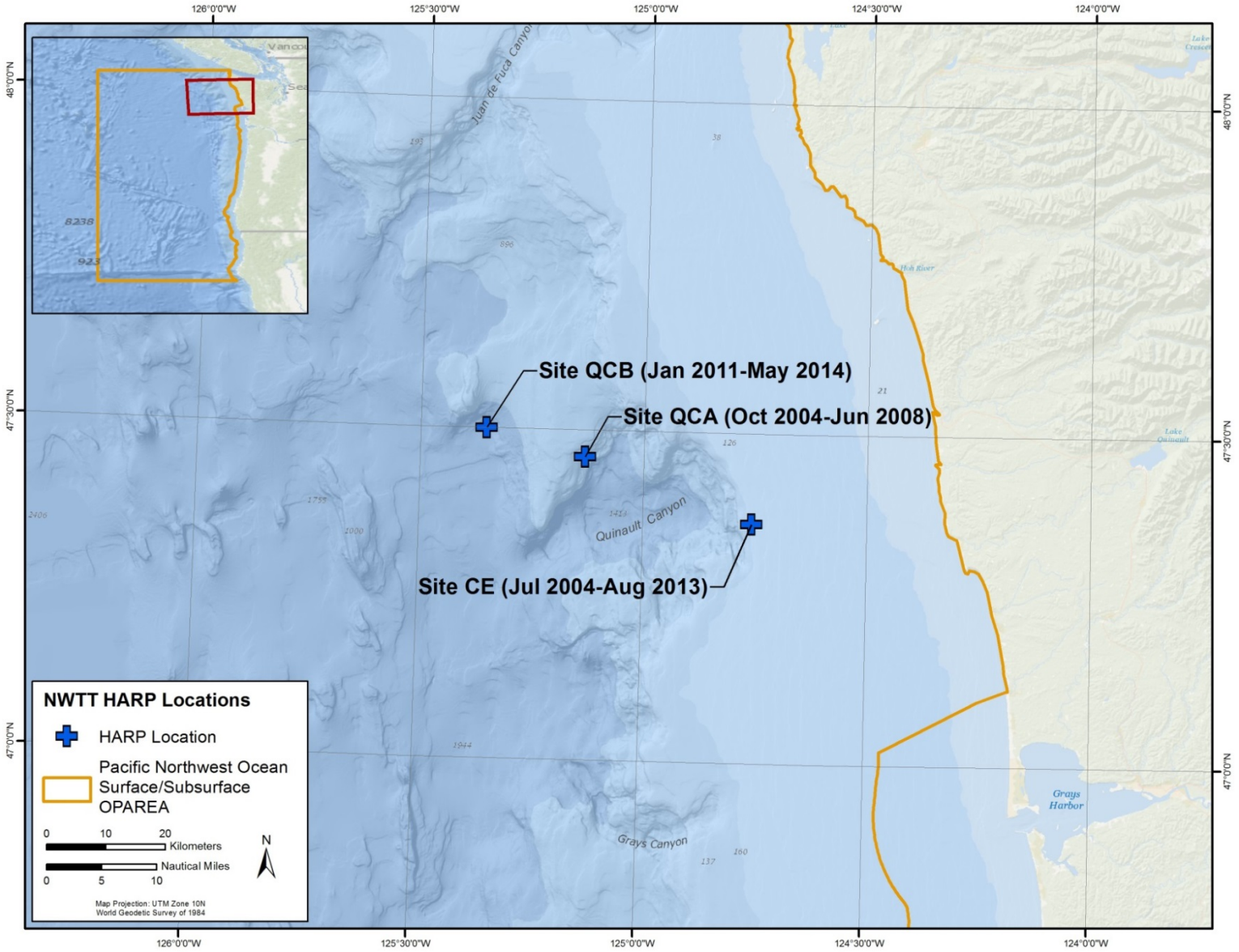

Figure 21. High-frequency Acoustic Recording Packages previously deployed in the Northwest Training and Testing Study Area. [Project N1]

[N2] Modeling Offshore Distribution of Southern Resident Killer Whales [Hanson et al. 2017]

This project leverages existing work funded by the U.S. Navy and NMFS (specifically, the Northwest Fisheries Science Center). The spatial distribution of endangered Southern Resident killer whales (SRKW) was studied using deployed autonomous passive acoustic devices (EARs), satellite-tracked tags, and spatial habitat modeling. Satellite-linked tags (WC SPOT5) deployed on SRKW in Puget Sound or in the coastal waters of Washington and Oregon between 2012 and 2016 were analyzed to assess the movements and occurrence of the SRKW in the winter. EARs, deployed in areas thought to be frequently used by the SRKW (off the coast of California, Oregon, and Washington), including waters encompassing the U.S. Navy's NWTRC Area W237 and the Olympic Military Operations Area (MOA), were used to assess their seasonal occurrence in these areas (**Figure 22**).

All locations for satellite-tagged killer whales up through 2015 were compiled and duration-of-occurrence and state-space models were created to identify areas of high use and travel corridors. In addition, detections of stereotypic calls of SRKW collected from the EARS were summarized for most years since the fall of 2006 thorough the summer of 2015.The probability of detection and identification were estimated based on a review of vocalization activity and from the state-space model comparing the satellite-linked locations with acoustic recorder detections. State-space models of SRKWs seasonal and annual probability of occurrence off the Washington coast were developed. Analyses included travel speed, depth of occurrence, and distance from shore in coastal waters, as well as occurrence within the NWTRC.

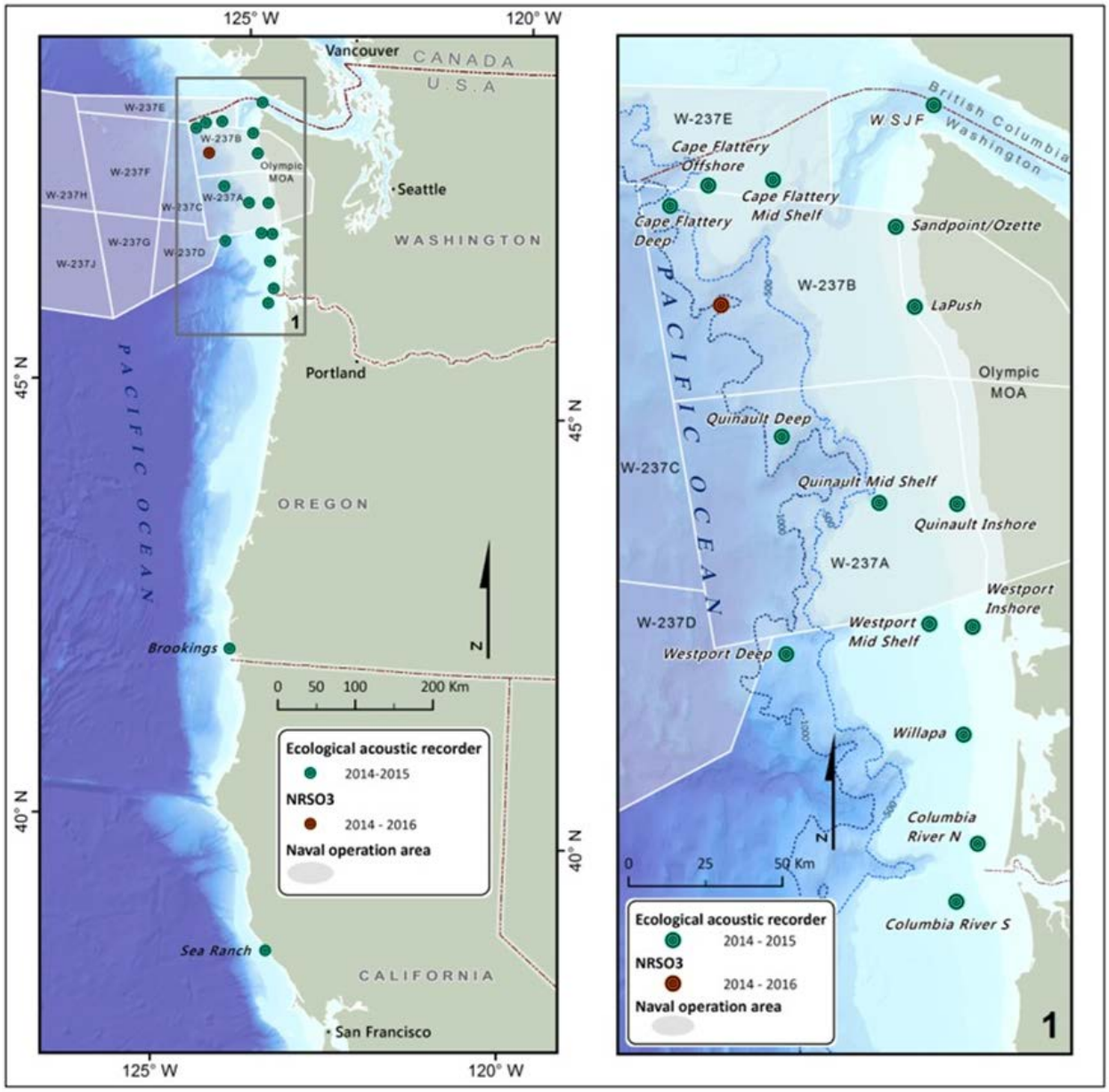

Figure 22. Locations of Ecological Acoustic Recorders (EARS) deployed beginning in the fall of 2014. From: Hanson et al. 2017 [Project N2]

[N3] Marine Mammal Aerial Surveys Conducted in the Inland Puget Sound Waters of Washington, Summer 2013–Winter 2016 [Smultea et al. 2017]

The U.S. Navy has funded systematic line-transect aerial surveys over eight sub-regions of inland Puget Sound waters in the NWTT Study Area since 2013. From 2013 through January 2016, surveys were flown by Smultea Environmental Sciences and Clymene Enterprises, during six separate survey periods spanning four seasons, using fixed-wing aircraft to collect data to estimate seasonal in-water densities and abundance of marine mammals particularly harbor porpoise (*Phocoena phocoena*) and harbor seals (*Phoca vitulina*). Distribution, habitat use, and behavior of each observed species were documented. Density and abundance estimates were calculated following conventional distance-sampling methods using DISTANCE 6.2 software. Surveys were divided into eight survey blocks (i.e., sub-regions) developed by the U.S. Navy and NMFS (**Figure 23**). Occurrence and distribution data were recorded for each of these sub-regions, and when possible, in-water density and abundance estimates were derived for these areas as well. Sightings data were used to estimate in-water density and abundance of harbor seals, harbor porpoise, and sea lions (California [*Zalophus californianus*] and Steller [*Eumatopias jubatus*] combined). Sample size was sufficient for only these four species to estimate density and abundance.

Inclement weather conditions prevented aerial surveys from being conducted in winter months in 2015. In order to address this data deficiency, an aerial survey was conducted during 16 to 26 January 2016 in order to collect information in this typically data-poor seasonal period. Data were incorporated with the previous results and analyses (Smultea et al. 2015).

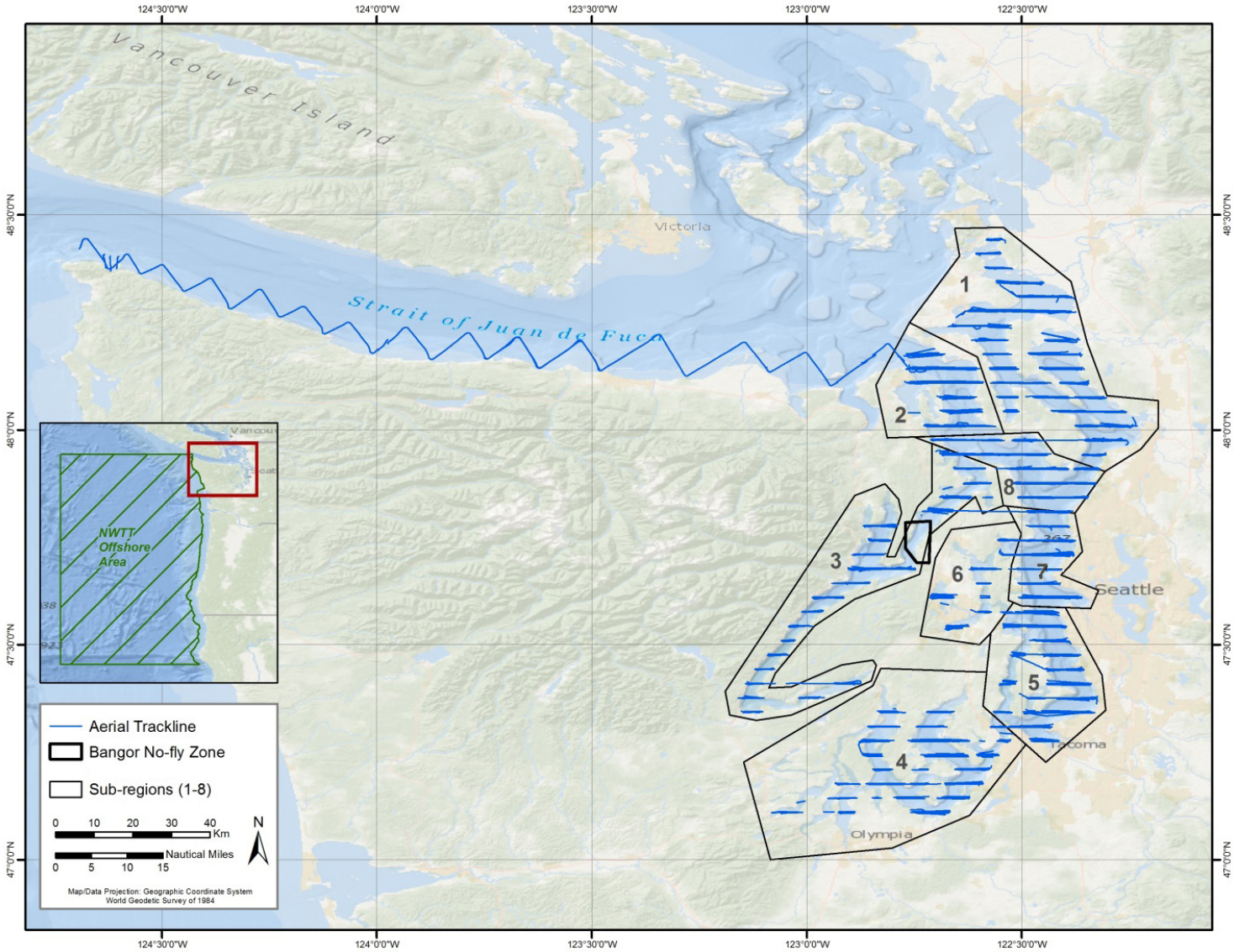

Figure 23. Systematic, on-effort tracklines for Puget Sound aerial surveys 2013–2016, including opportunistic effort in the Strait of Juan de Fuca. Also shown are the eight pre-defined sub-regions (1=East Whidbey, 2=Admiralty Inlet, 3=Hood Canal, 4=Southern Puget Sound, 5=Vashon, 6=Bainbridge, 7=Seattle, and 8=South Whidbey), and the no-fly zone at Naval Base Kitsap at Bangor. From: Smultea et al. 2017 [Project N3]

[N4] Baleen (Blue & Fin) Whale Tagging and Analysis in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas [Mate et al. 2017]

This is the same project noted earlier in the description of **Project S4**. Oregon State University's Marine Mammal Institute continued the previous year's efforts (see Mate et al. 2015, 2016) to tag blue, fin, and humpback whales. In 2016 Oregon State University's Marine Mammal Institute obtained permission from the U.S. Navy to deploy DM tags on humpback whales off Newport, Oregon. In cases where tagged animals traveled to the NWTT Study Area, the results are applied to NWTT monitoring.

[N5] Tagging and Behavioral Monitoring of Sea Lions in the Pacific Northwest in Proximity to Navy Facilities

Researchers from NMFS (National Marine Mammal Laboratory and Alaska Fisheries Science Center) in collaboration with Washington Department of Fish & Wildlife (WDFW) and funded by U.S. Pacific Fleet, are collecting sea lion behavioral data, including the percentage of time animals haul-out each month on structures and assets near Puget Sound naval facilities at Everett, Bremerton, and Bangor. Two floats were anchored in place in spring/summer 2014; traps were later installed on the floats to allow the agencies the ability to capture adult male California sea lions and instrument some of these individuals with satellite-linked time-depth recorders to assess the proportion of time animals are hauled out versus in the water and potentially exposed to underwater stressors from U.S. Navy activities. This in turn will improve the U.S. Navy's understanding of how many sea lions might be impacted by a given naval activity. Currently, density estimates assume that 100 percent of the population is in the water at all times and therefore, exposed to underwater acoustic stressors during U.S. Navy Acoustic Effects Model (NAEMO) modeling runs. The end objective was for NMFS and WDFW to determine the "correction factor" which would "correct" the in-water density estimates to more accurately reflect the amount of time spent in the water vs the amount of time hauled out, based on their behavior (i.e., tag wet [animal in-water] or tag dry [animal hauled out]).

An additional goal of the tagging effort was to identify the location and temporal use of foraging grounds and better understand foraging behavior of adult male sea lions within the inland and offshore waters of the NWTT Study Area. Preliminary results were presented in the 2015 NWTRC Annual Monitoring Report (DoN 2015d). Data analyses are still underway; results will be presented in a future report. Spatial analysis of the tagging data provides important information on California sea lion movements through inland and offshore waters, and more specifically, sea lion occurrence in Navy training areas. The data will later be used by the U.S. Navy to understand the spatial and temporal occurrence of California sea lions further offshore, and how density of California sea lions changes by distance from the coastline and haulout locations. Tagging results revealed that adult male California sea lions did not stay more than a few days at any given location and then were on the move again, and did not venture very far offshore.

[N6] Harbor Seal Density Estimation [Jefferson and Ampela 2016]

In order to evaluate impacts and estimate exposure to U.S. Navy activities that may cause acoustic disturbance, analyses were conducted to estimate abundance and in-water densities for the harbor seal in various regions of Hood Canal, Washington. Analyses consisted of reviewing existing line-transect aerial and vessel-based monitoring survey data to produce and refine estimates of abundance, distribution, and density (by season and sub-region [**Figure 24**])

with variances. This project is a collaboration between Clymene Enterprises, HDR, NMFS-Alaska Fisheries Science Center (National Marine Mammal Laboratory), and WDFW.

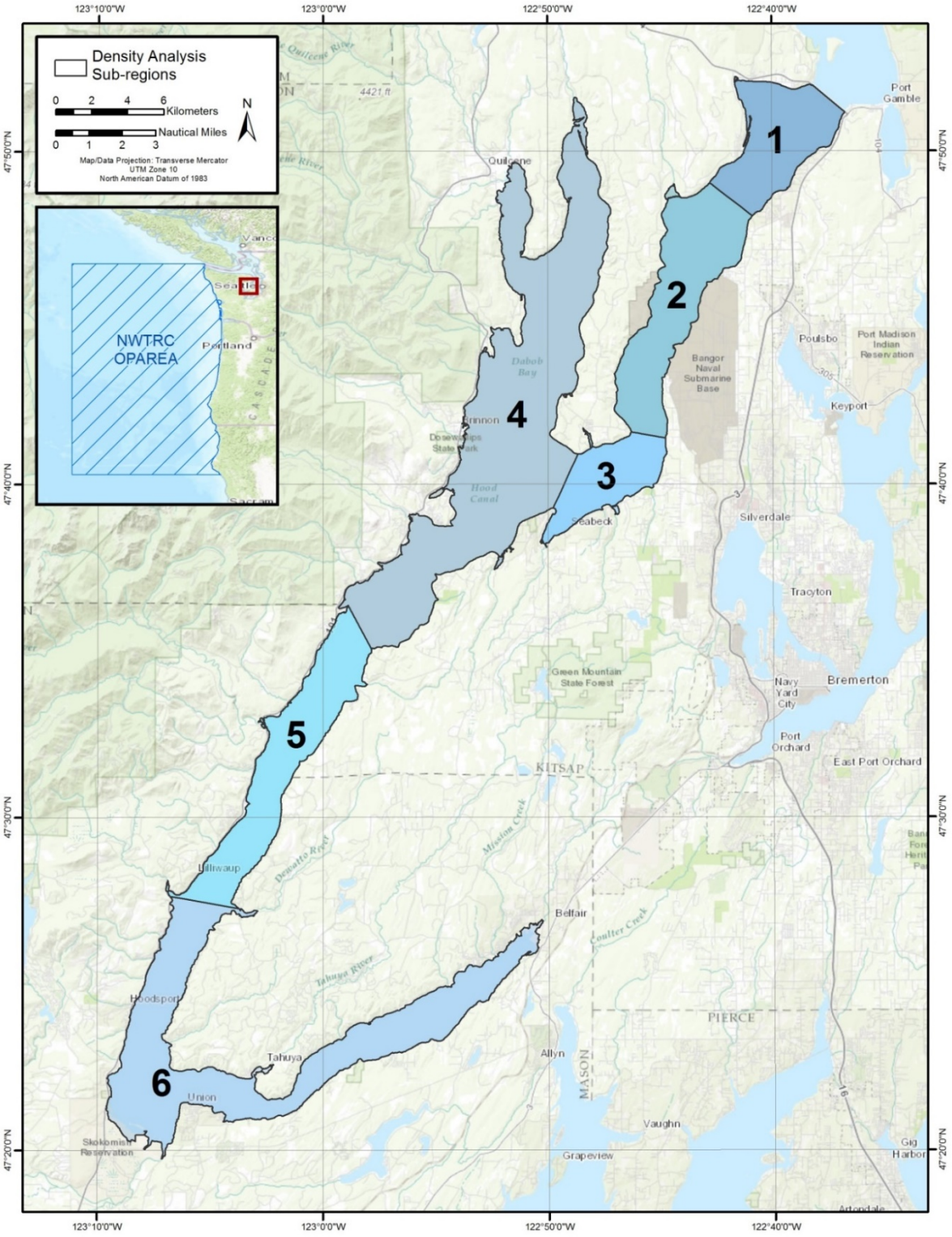

Figure 24. Density analysis sub-regions (6 analytical sub-regions). Sub-region 1: Hood Canal Bridge to Navigation Marker #8 and Marker #9, Sub-region 2: From Area 1 to Hazel Point to Marker #11, Sub-region 3: From Area 2 to Oak Harbor (Marker #12) to Misery Point (Marker #15), Sub-region 4: From Area 3 to Trident Head (green Marker #9 to Teku Point), Sub-region 5: From Area 4 to Lilliwaup Bay to Duwato Bay, Sub-region 6: From Area 5 around the Great Bend to Belfair. Navigational markers correspond to those of National Oceanic and Atmospheric Administration chart 18476. [Project N6]

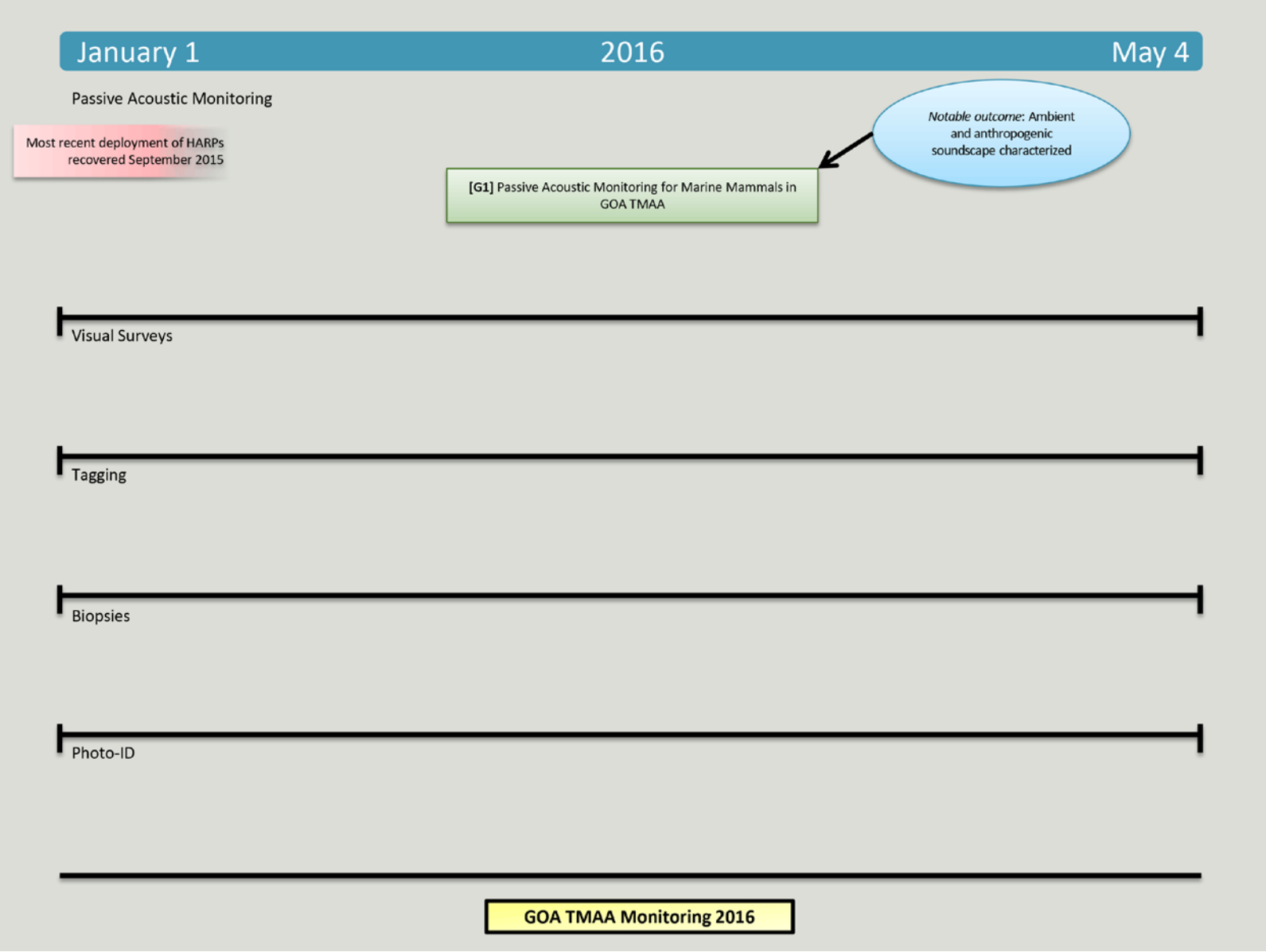

Figure 25. Timeline of 2016 Gulf of Alaska Temporary Maritime Activities Area monitoring projects. The Letter of Authorization (NMFS 2013d) for GOA TMAA was effective through 4 May 2016.

GOA TMAA

The GOA TMAA is depicted in **Figure 9**. A timeline of all U.S. Pacific Fleet-funded monitoring tasks implemented in the GOA TMAA in 2016 is illustrated in **Figure 25**. It should be noted that for the GOA TMAA project, field work and data collection occurred prior to 2016, but data analysis occurred within the 2016 reporting period. Detailed project summaries follow below.

[G1] Passive Acoustic Monitoring of Marine Mammals in GOA TMAA using Bottom-Mounted Devices [Wiggins et al. 2017]

U.S. Navy-funded HARP deployments by SIO have been taking place since 2011 in the GOA TMAA, using two to five HARPs (Baumann-Pickering et al. 2012; Debich et al. 2013, 2014; Rice et al. 2015). Wiggins et al. (2017) report on analyses of data spanning four years starting in the July 2011 and ending in September 2015 using five deployment locations: two on the continental shelf (KO and CA), one on the continental slope (CB) and two on seamounts (QN and PT) (**Figure 26**). The ambient soundscape (including sounds generated by whales) SPLs were re-processed using new and improved techniques, including calculating long (multi-year) spectrograms, sound pressure spectrum level percentiles, and average sound pressure spectrum levels over the recording periods. Detections of anthropogenic sources included broadband ship, MFAS, LFAS, and explosions.

This project is similar to work completed for the NWTRC, refer to **Project N1**.

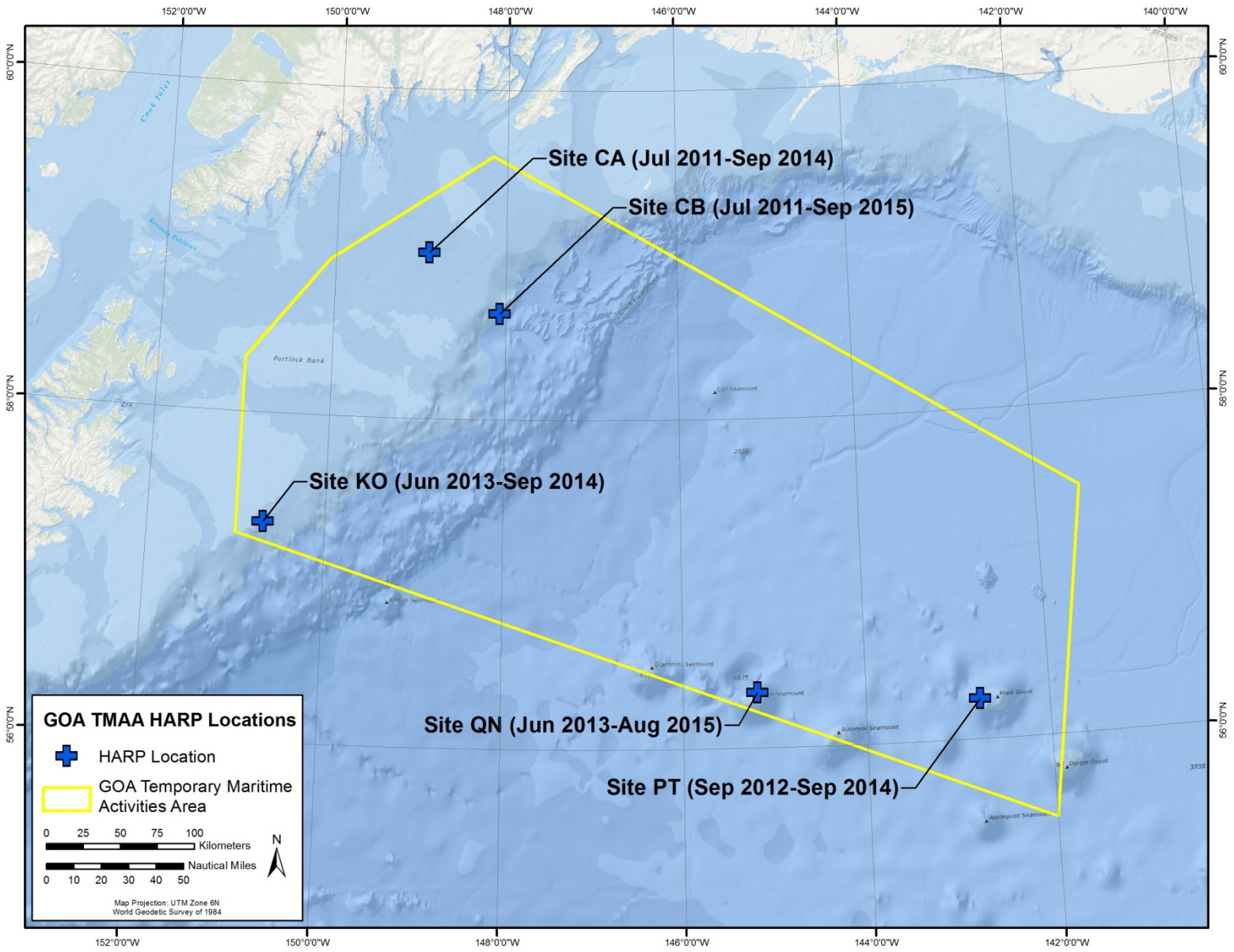

Figure 26. High-frequency Acoustic Recording Packages previously deployed in the Gulf of Alaska Temporary Maritime Activities Area (GOA TMAA). [Project G1]

2.2 Results

Cumulative results and key conclusions from the Pacific monitoring projects are summarized below. Project results are organized by Conceptual Framework Category (CFC): *occurrence*, *exposure*, *response*, and *consequences*; then by monitoring questions or objectives and the projects that address these. Within each CFC, the regions are presented sequentially, as MITT, HSTT (HRC and SOCAL), NWTT, and GOA TMAA. During this monitoring year, only two project results addressed the fourth CFC, the issue of population *consequences*.

2.2.1 Conceptual Framework Category 1. Occurrence

The following sections summarize progress made this monitoring year on addressing the conceptual framework category of *occurrence* of protected marine species in the four Pacific training and testing study areas: MITT, HSTT (HRC and SOCAL), NWTT, and GOA TMAA. Progress is treated by monitoring questions and objectives related to *occurrence*, and within this grouping will be ordered by range complex.

In 2016, substantial progress was made with respect to improving knowledge of the *occurrence* of protected marine species throughout the U.S. Navy's training and testing study areas. Multiple monitoring projects have resulted in estimation of density and abundance, spatial distribution, movement patterns, and habitat use of protected marine species. Several projects ([S2] and [S5]) noted the effects of the strong 2015–2016 El Niño event on species sightings. Considerable information about species occurrence is now available from U.S. Navy-funded monitoring efforts across all four study areas (MITT, HSTT, NWTT, and GOA TMAA). Residency time and occupancy patterns of marine species have also been addressed by monitoring projects falling within this CFC. The knowledge gained in this category provides the U.S. Navy with starting points to estimate potential takes of protected marine species from anthropogenic activities.

2.2.1.1 MONITORING QUESTION: WHAT SPECIES OF BEAKED WHALES AND OTHER ODONTOCETES OCCUR IN THE MITT STUDY AREA?; AND,

MONTORING QUESTION: ARE THERE LOCATIONS OF GREATER RELATIVE CETACEAN ABUNDANCE IN THE MITT STUDY AREA? [PROJECT M1]

In March 2016, shore-based visual surveys were conducted from elevated stations around Saipan to look for humpback whales. No humpback whales were seen during those surveys.

During small-vessel surveys performed in 2016 off Saipan, Tinian, Aguijan, Rota, and Guam, observers recorded bottlenose dolphins, spinner dolphins (*Stenella longirostris*), pantropical spotted dolphins (*Stenella attenuata*), rough-toothed dolphins (*Steno bredanensis*), short-finned pilot whales, sperm whales, dwarf sperm whales (*Kogia sima*), and *Mesoplodon* beaked whales (Hill et al. 2017). Other species observed included green and hawksbill turtles. In May and June 2016, during small-vessel visual surveys, two encounters occurred with *Mesoplodon* beaked whales in the waters surrounding Rota and Guam (**Figure 27**). This was the first sighting of a beaked whale (or any cetacean species) at Galvez Banks (Guam) during PIFSC CRP's small-

vessel surveys. During similar surveys performed in 2015, the cetacean species encountered were humpback whale, bottlenose dolphin, and pygmy killer whale (*Feresa attenuata*).

In 2016, satellite tags were deployed on sperm whales, short-finned pilot whales, and a pantropical spotted dolphin (**Figures 28a-c**); the latter two species had never before been tagged in the Marianas. While the tagged sperm whales ranged widely, tagged short-finned pilot whale tracks were concentrated in the nearshore areas off Guam. Satellite tag locations from 2016 are currently being analyzed together with those from 2013–2014 to investigate areas of heaviest use by short-finned pilot whales. Preliminary data suggest that the northwest side of Guam is an important area for these whales.

Although questions about specific locations of greater relative cetacean abundance have not been addressed yet as part of this project, habitat use (depth and distance from shore) and encounter rates reveal varying patterns for species occurring around Guam, Rota, Saipan, Tinian, and Aguijan. Patterns of habitat use by some odontocetes (e.g., spinner dolphins, pantropical spotted dolphins, bottlenose dolphins, short-finned pilot whales) evident from the summer visual surveys were similar to those observed in previous years.

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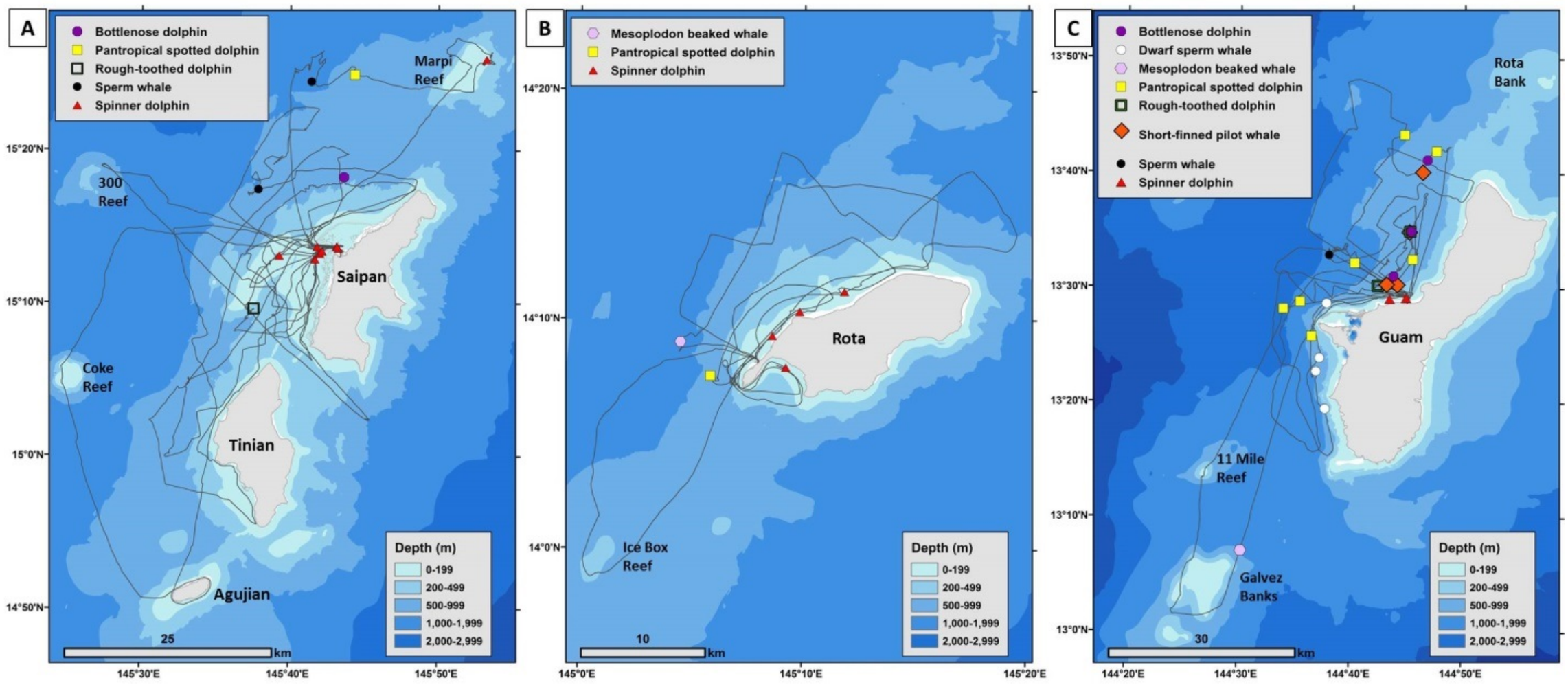

Figure 27: Tracklines and cetacean encounter locations during the 2016 PIFSC CRP Marianas summer (May–June) small-vessel surveys off Saipan, Tinian, and Aguijan (A), Rota (B), and Guam (C). Hill et al. 2017 [Project M1

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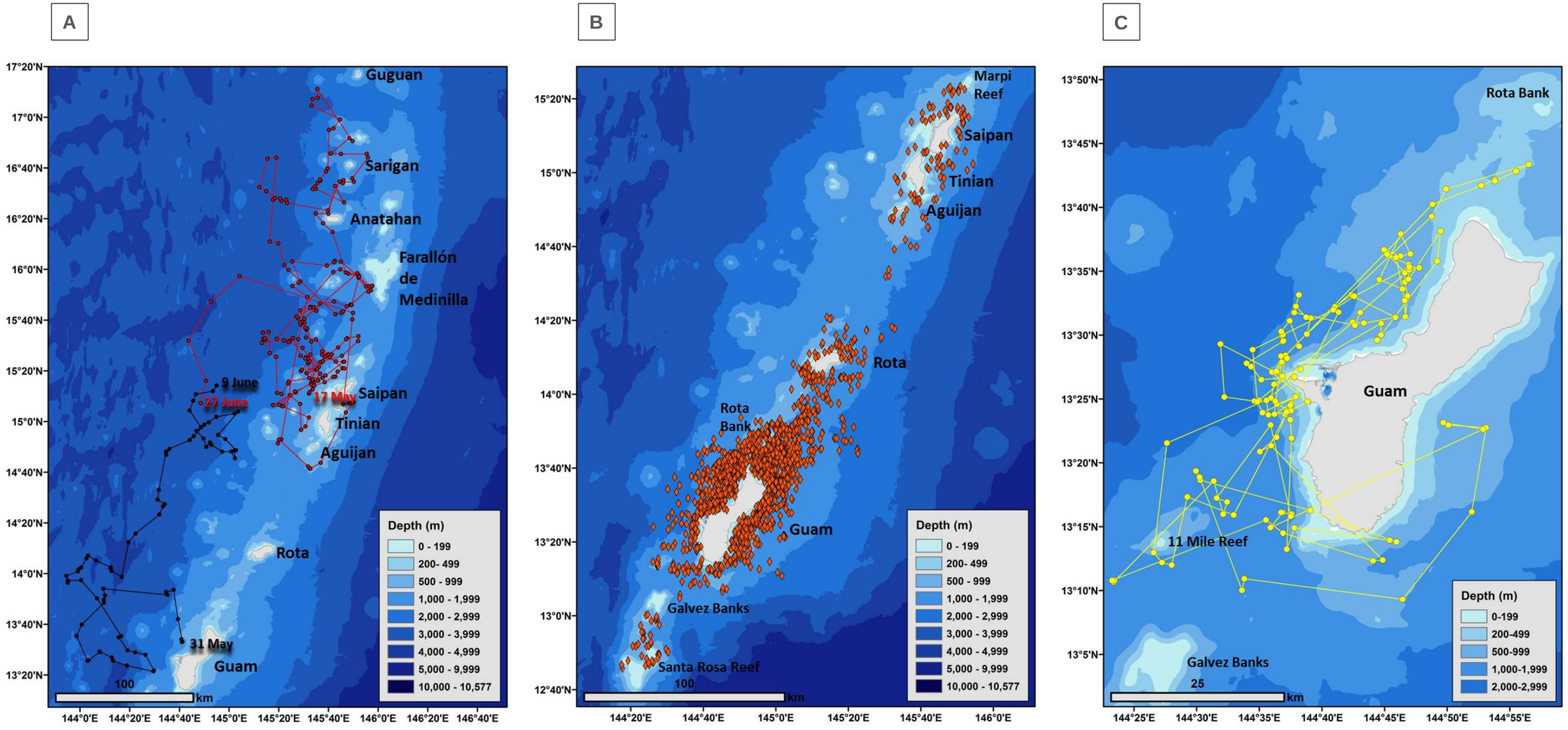

Figure 28: Filtered locations and tracks for satellite tags deployed: (A) on sperm whales off Saipan (17 May) and Guam (31 May), tag durations were 41.8 d and 9.7 d respectively; (B) on short-finned pilot whales off Guam between 29 May and 5 June, tag durations ranged 6.8-79.9; (C) on a pantropical spotted dolphin off Guam (3 June), tag duration was 11.4 d. From: Hill et al. 2017 [Project M1]

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2.2.1.2 MONITORING QUESTION: WHAT IS THE SEASONAL OCCURRENCE OF BALEEN WHALES AROUND GUAM, SAIPAN, TINIAN, AND ROTA? [PROJECT M1]

Shore-based and small-vessel surveys conducted in March 2016 coincided with the known seasonal occurrence of humpback whales off Saipan and Tinian (Hill et al. 2017). Humpback whales were encountered seven times off Saipan during the small-vessel surveys, and sightings included five mother-calf pairs (calves being young-of-the-year, including a neonate), with one same-day re-sight. Four mother-calf pairs were also observed in 2015, and five such pairs were observed in 2016. No sightings of humpback whales were made during the shore-based surveys. Photo-ID revealed that one of the mothers also was sighted in 2007, indicating site fidelity for some individuals (Hill et al. 2016). Further photo-ID matching with Western Pacific humpback whale photo-ID catalogs is ongoing.

Despite these mother-calf pair sightings, encounter rates of humpback whales were overall low during the 2015 and 2016 small-vessel surveys. This, along with the lack of sightings during the shore-based observations, may be a reflection of low numbers of whales using the area during the survey period. No other baleen whales were observed in 2016. In 2015, the first Bryde's whale was encountered during small-vessel surveys around the southernmost islands of the Mariana Archipelago (Hill et al. 2016).

2.2.1.3 MONITORING QUESTION: WHAT ARE THE OCCURRENCE, HABITAT USE, ABUNDANCE, AND POPULATION STRUCTURE OF SEA TURTLES IN THE MITT STUDY AREA? [PROJECT M2]

In concert with regional partners, PIFSC CPR conducted marine turtle surveys and in-water captures of green turtles and hawksbill turtles for 6 days in fall 2016 (Martin and Jones 2016). New model WC SPLASH 297A tags (a smaller GPS Fastloc tag than previously used) were deployed on 16 sea turtles. The smaller tag size permits deployment on turtles with SCL >40 cm, rather than being limited to SCL >50 cm, which allows for more individuals of different ages to be sampled.

Over the course of this multi-year project (2013–2016), 288 turtles were encountered. Of a total of 191 observations, 61 percent were identified as green turtles, 4 percent as hawksbill turtles, and 35 percent as "unknown" species but either green or hawksbill turtles. The demographic data for green and hawksbill turtle captured from 2013 to 2016 are typical for turtles throughout the Marianas Archipelago. Sea turtles recruit to the nearshore waters of the Mariana Islands around 34 to 36 cm SCL and depart to adult foraging and nesting grounds around 78 to 81 cm SCL. The growth rate analysis from the capture-mark-recapture data estimates residency time of 17 years (13–28, 95% CI) from recruitment to maturity.

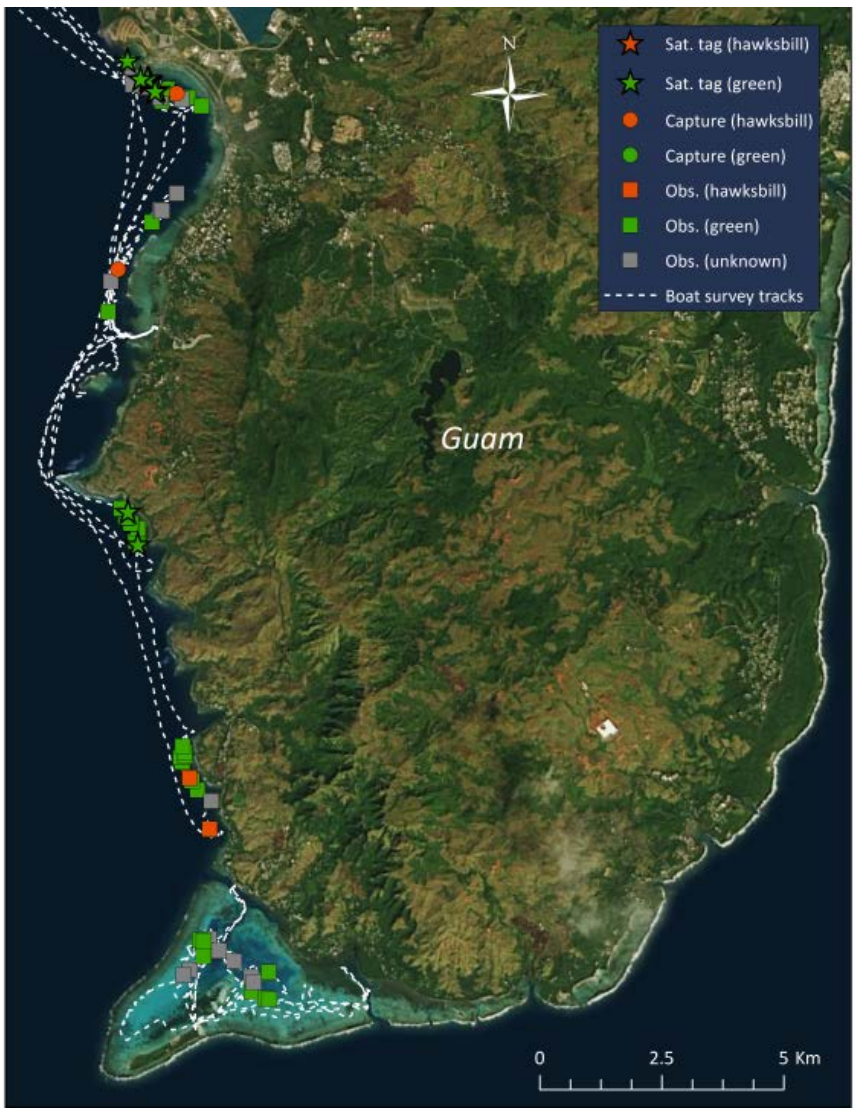
2.2.1.4 MONITORING QUESTION: ARE THERE LOCATIONS OF GREATER CETACEAN AND/OR SEA TURTLE CONCENTRATION IN THE MITT STUDY AREA? [PROJECT M2]

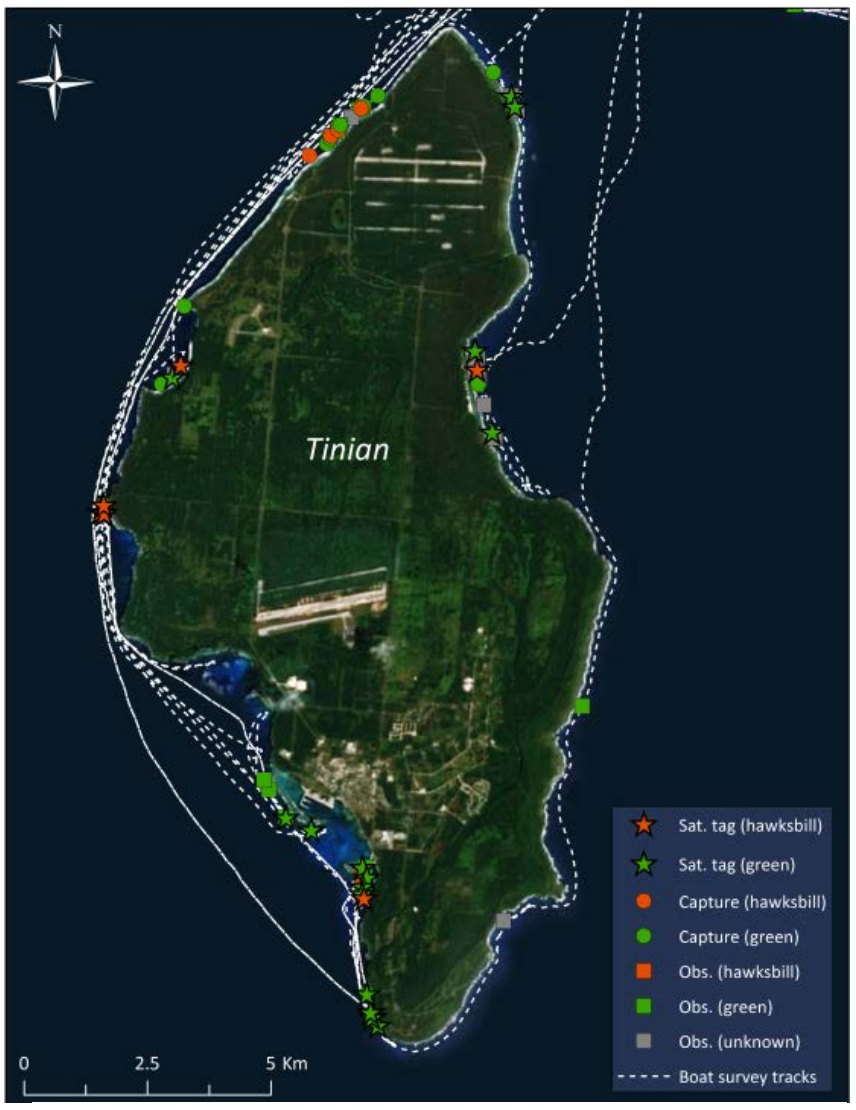
Martin and Jones (2016) noted that the following areas appear to have high turtle density: (1) in Guam, the waters inside Apra Harbor near San Luis, Gab Gab, out to Spanish Steps including Dadi and Tipalao beaches outside of the harbor, as well as Cocos Lagoon and Achang Bay (Martin et al. 2016) (**Figure 29**); (2) in Saipan, the area stretching from the Balisa Channel to

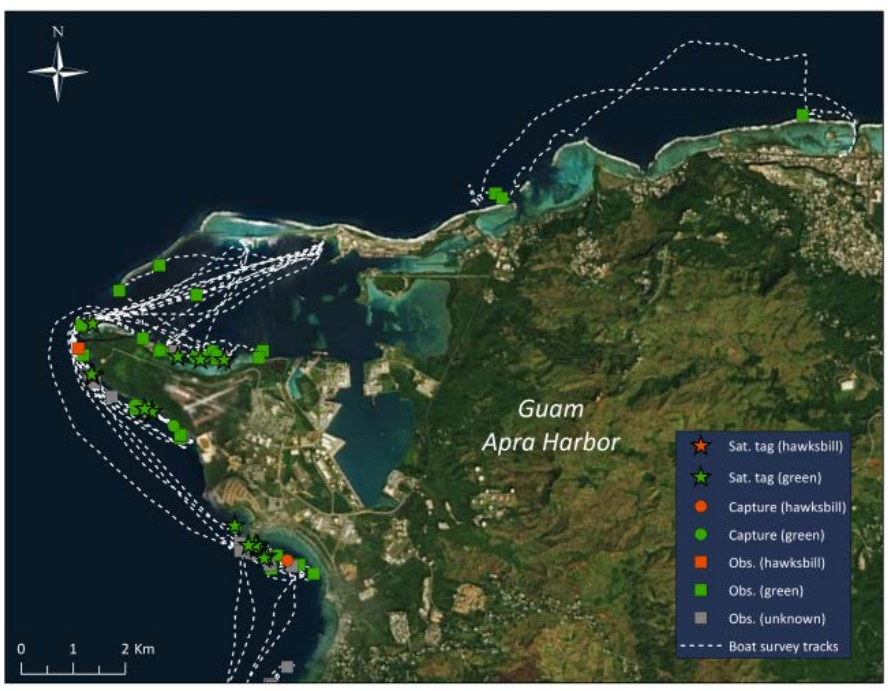
Managaha Island, as well as Lao Lao Bay (**Figure 29**); and (3) the west coast of Tinian (**Figure 29**). These areas are primarily dominated by patch reef communities where turtles both forage and rest.

The turtles in this study were all caught in the water, rather than while nesting, and are members of the resident population of Guam, Tinian, and Saipan. Turtles in this demographic are juveniles that recruit to these islands at a straight carapace length of 34-37 cm, and after growth eventually depart to adult foraging and nesting grounds at about 78-81 cm. Larger adult females that arrive to nest at Guam, Tinian, and Saipan are members of a different population that previously spent their juvenile life stage at a location elsewhere.

Kernel interpolation with barriers (KIWB) estimates revealed high site fidelity and limited movements for both green and hawksbill turtles while residents of Guam, Tinian, and Saipan. While the majority of tagged turtles remained within a 1 to 3 square kilometer (km^2) area for the entire life of the tag, several long-range movements were recorded. These data indicate there is some diversity in nearshore habitat use and movements around the Mariana Islands and beyond.







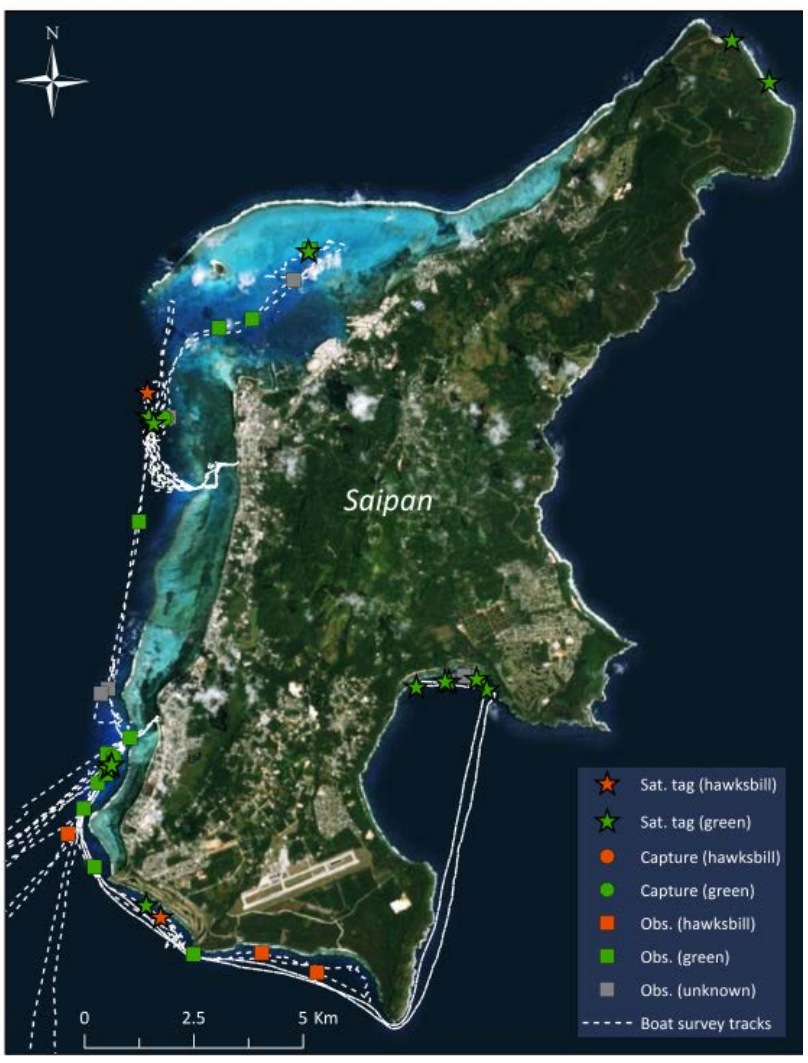


Figure 29. Sea turtle surveys, sightings, captures, and taggings in MIRC, 2013–2016. Symbols differentiate turtle species and types of encounters (observation only, capture without satellite tag, and capture with satellite tag deployment). Boat survey tracks depict vessel movement on survey days. In southwest Guam from Cocos Lagoon (south) to Dadi Beach (north) (top left); around Tinian (top right); in the Apra Harbor area of Guam from Dadi Beach (southwest) to Hagåtña (northeast) (bottom left); around Saipan (bottom right). Survey tracks associated with the satellite tags deployed along the northern shore of Saipan are not available, but the boat surveyed the area between the two capture sites. From: Martin and Jones 2016 [Project M2]

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2.2.1.5 MONITORING QUESTION: WHAT ARE THE BASELINE POPULATION DEMOGRAPHICS, VITAL RATES, AND MOVEMENT PATTERNS FOR DESIGNATED KEY SPECIES IN THE SOUTHERN CALIFORNIA RANGE COMPLEX? [PROJECT S2]

During 27 days of survey effort performed from January through November 2016 at SOAR, observers encountered 12 groups (32 individuals) of Cuvier's beaked whales (Schorr et al. 2017) (**Figure 30**). The majority of sightings occurred in November 2016. A Cuvier's beaked whale tagged on SOAR in January 2016 was tracked for 40 days, during which 84 percent of location estimates were within the SOAR boundary, and all location estimates were within SOCAL (**Figure 31**). Fin whale sightings were noticeably low in 2016, with only 11 sightings on the SCORE range (**Figure 30**). It is possible that the low number of encounters was related to the strong 2015–2016 El Niño event. The tag on the tagged fin whale transmitted uplinks for more than 23 days but locations were not successfully generated due to surfacing behavior of the whale with regard to tag placement on the fin; Kalman filtering will be attempted to generate locations. Also this year a Risso's dolphin was tagged and tracked for over 11 days over 833 km, with ninety-eight percent of all location estimates within the SOCAL range, and 25.7% occurring within the boundaries of SOAR.

Photo-ID and telemetry data collected over the course of this multi-year project indicate that fin whales and Cuvier's beaked whales encountered off southern California tend to remain off southern California, undergoing seasonal distribution shifts but remaining largely within a fairly limited latitudinal range (Falcone and Schorr 2014; Schorr et al. 2017). Mark-recapture abundance estimates from photo-ID data suggest that both species have local populations in the low hundreds (Falcone and Schorr 2014). Both photo-ID and telemetry data suggest that Cuvier's beaked whales exhibit a degree of basin-specific site fidelity within the Southern California Bight (Falcone and Schorr 2014; Schorr et al. 2017).

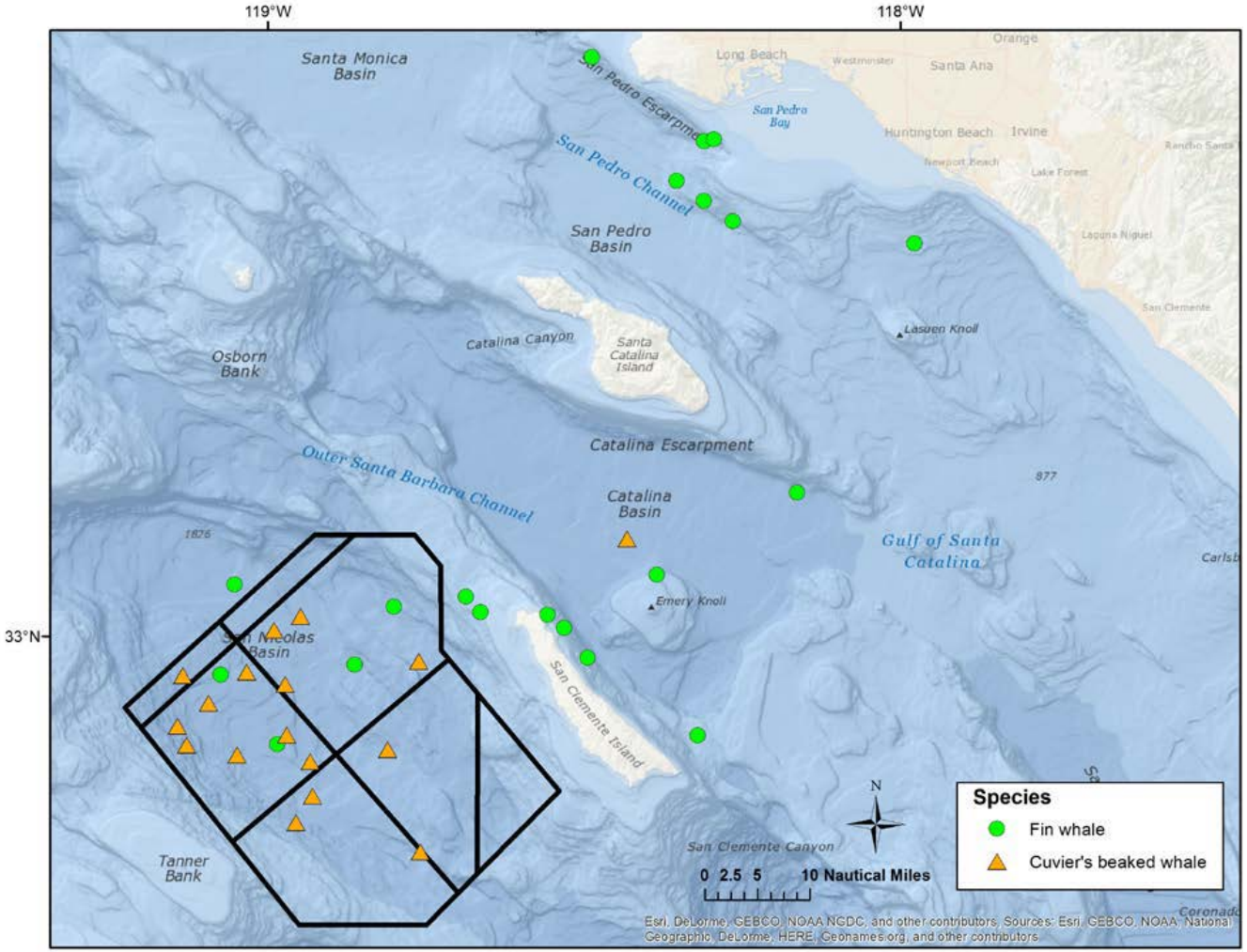

Figure 30. Sighting locations for Cuvier's beaked whales and fin whales during field efforts associated with this project during 2016. The black lines indicate SOAR. From: Schorr et al. 2017 [Project S2]

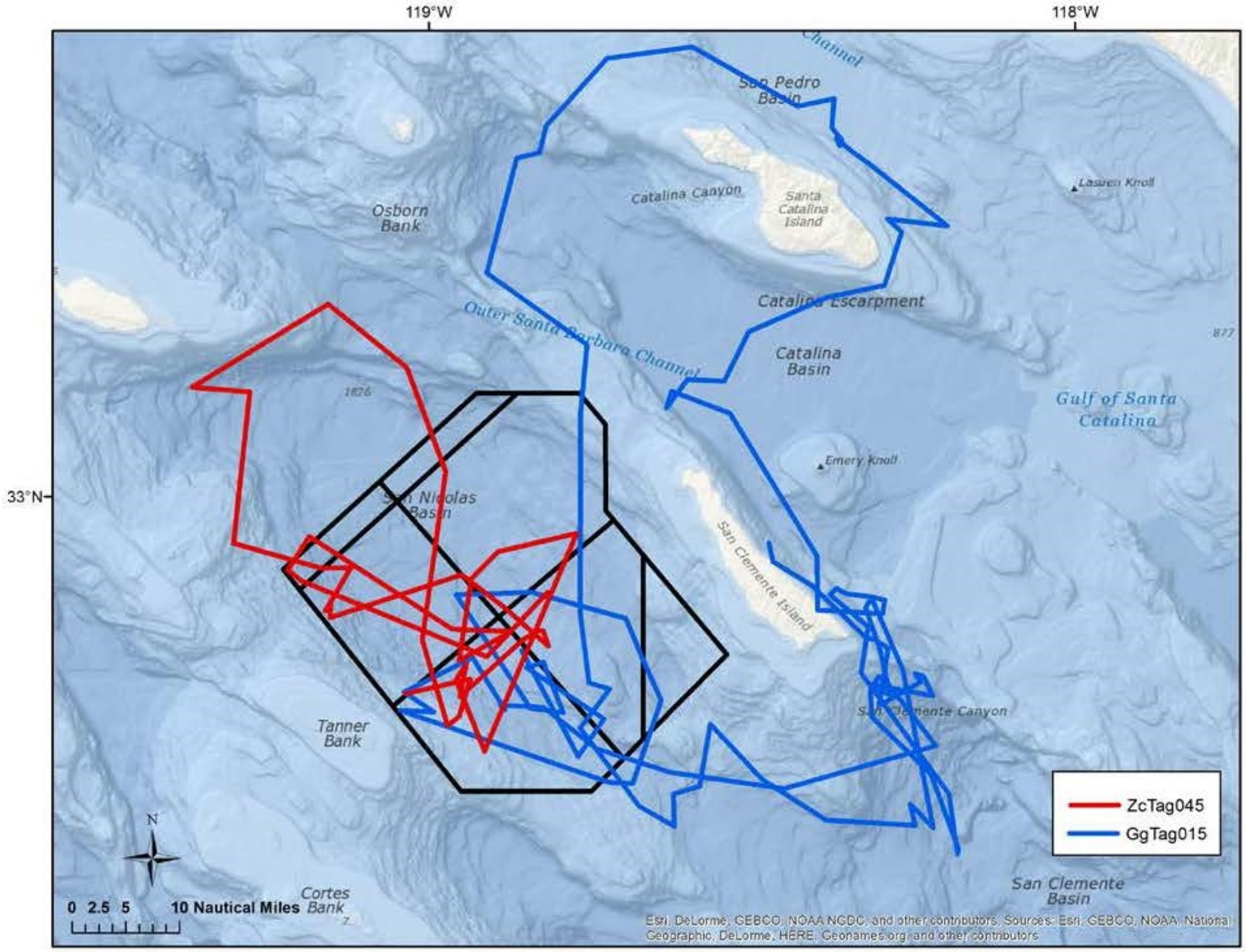

Figure 31. Tracks of a Cuvier's beaked whale (red line) and Risso's dolphin (blue line) instrumented with satellite-tracked tags in 2016. The black line indicates the boundary of the Southern California Anti-Submarine Warfare Range (SOAR). From: Schorr et al. 2017 [Project S2].

2.2.1.6 MONITORING QUESTION: WHAT IS THE SEASONAL OCCURRENCE AND DENSITY OF CETACEANS WITHIN THE NAVY'S SOUTHERN CALIFORNIA RANGE COMPLEX? [PROJECT S3]

Two CalCOFI cruises were conducted in 2016: a winter survey (7 January–29 January 2016) and a spring survey (29 March–22 April 2016) (Debich et al. 2017). During these cruises five species of mysticetes whales were sighted, as well as 10 taxa of odontocetes. Species encountered in 2016 were roughly similar to those seen in previous years of this multi-year project (2012–2016), with several exceptions. Short-finned pilot whales were detected for the first time in recent years in 2015, but they were not detected in 2016. Also, the sporadically-sighted (one sighting only in 2015) killer whale was not detected in 2016. Over the entire project 2012-2016, sightings encompassed twelve odontocete species (long-beaked and short-beaked common dolphins, Risso's dolphins, short-finned pilot whales, northern right whale dolphins, Pacific white-sided dolphins, killer whales, Dall's porpoises, sperm whales, striped dolphins, bottlenose dolphins, and Cuvier's beaked whales) and five baleen whale species (minke, blue, fin, gray, and humpback whales).

Data from 2012–2016 indicate that marine mammal species diversity varied by season. Overall, winter cruises had the highest species diversity for both mysticetes and odontocetes. Mysticete species diversity gradually declined across winter and spring cruises from 2012 to 2015 and then increased in 2016. Variations of odontocete species diversity were somewhat similar to that of the mysticetes. Mysticete and odontocete diversity increased during fall cruises during 2012–2014 but there was a substantial decrease in species diversity during the fall cruise 2015. During winter and spring cruises, most baleen whale sightings occurred within approximately 370 km of the shoreline. During summer and fall cruises baleen whales were sighted primarily along the continental slope and in offshore waters. The exception was the fall 2015 cruise when baleen whales were sighted primarily in the coastal areas of Southern California Bight. During this cruise total sightings were also significantly lower. The timing of the inshore presence and reduced number of sightings of baleen whales during the fall 2015 cruise corresponds to the peak of the strong 2015–2016 El Niño event. No cetacean density estimates were derived as part of this work.

2.2.1.7 MONITORING QUESTION: WHAT ARE THE MOVEMENT PATTERNS, OCCURRENCE, AND RESIDENCE TIMES OF BLUE AND FIN WHALES WITHIN NAVY TRAINING AND TESTING AREAS ALONG THE U.S. WEST COAST AS COMPARED TO OTHER AREAS VISITED BY TAGGED WHALES OUTSIDE OF NAVY TRAINING AND TESTING AREAS? [PROJECT S4/N4]

In 2016, researchers deployed 19 tags on blue whales (11 off southern California and 8 off central California), 14 tags on fin whales in 2016, and 2 tags on humpback whales (off Oregon) (Mate et al. 2017). For individual tagged blue whales, the maximum distance from shore ranged from 37 to 416 km (median = 87 km). Most blue whales tagged off southern California remained in southern or central California waters. Most of the locations for these whales were over the continental slope or offshore banks or seamounts. Six blue whales spent extensive periods of time (from 7 to102 d) at the western end of the Santa Barbara Channel, from Santa Rosa Island to Point Conception, with the majority of locations to the west of San Miguel Island. Locations of blue whales tagged off central California were concentrated in several areas along the California

and southern Oregon coast, with the Gulf of the Farallones and Cordell Bank being the most heavily used, followed by the area around Point Arena and off Fort Bragg, as well as the area off Pigeon Point. For individual tagged fin whales, the maximum distance from shore ranged from 40 to 265 km. Locations ranged from San Nicolas Island in southern California to Hecate Strait in British Columbia, Canada. Most locations were concentrated along the central California coast between Monterey Bay and Point Reyes. The majority of locations occurred over the continental slope and deeper offshore waters.

The most heavily used U.S. Navy training area by tagged blue whales was Pt Mugu (**Figure 32**). None of the tagged blue whales were tracked within W237 of NWTRC, or within the GOA TMAA. Tagging locations occurred in Pt Mugu during all 5 months in which blue whales were tracked (July–November), during 4 months in SOCAL (July, August, September, and October) (**Figure 32**), and during 3 months in NWTRC (September–November) (**Figure 33**). Compared to the northward distribution of blue whales around the northern Channel Islands, there were fewer tracks and less time spent foraging and transiting in the Navy's SOCAL.

Researchers found relatively little use by fin whales of U.S. Navy training areas as compared with prior years; this trend was likely driven by the shorter tracking periods than in previous years. Pt Mugu was the most heavily used naval training range by fin whales tagged in 2016 (**Figure 34**). Locations in Pt Mugu occurred in 3 of 5 months whales were tracked (August–October) (**Figure 34**). Only one fin whale had locations within the NWTRC and W237 training areas (**Figure 35**). None of the tagged fin whales were tracked within SOCAL or the GOA TMAA.

This project has been ongoing since 2014. In 2015, Argos-monitored satellite radio tags were attached to 22 blue whales, 11 fin whales, 1 blue/fin hybrid, and 1 Bryde's whale. All tags were deployed off southern California between Mugu Canyon and the west coast of San Miguel Island. In 2014, 24 blue whales and 6 fin whales were tagged between Mugu Canyon (west of Malibu) and San Diego. A total of 65 satellite radio tags was deployed on blue whales and 31 fin whales off California from 2014 through 2016 (Mate et al. 2015, 2016, 2017). Interannual comparisons and cumulative results will be detailed in the final report for this project, expected in summer 2017.

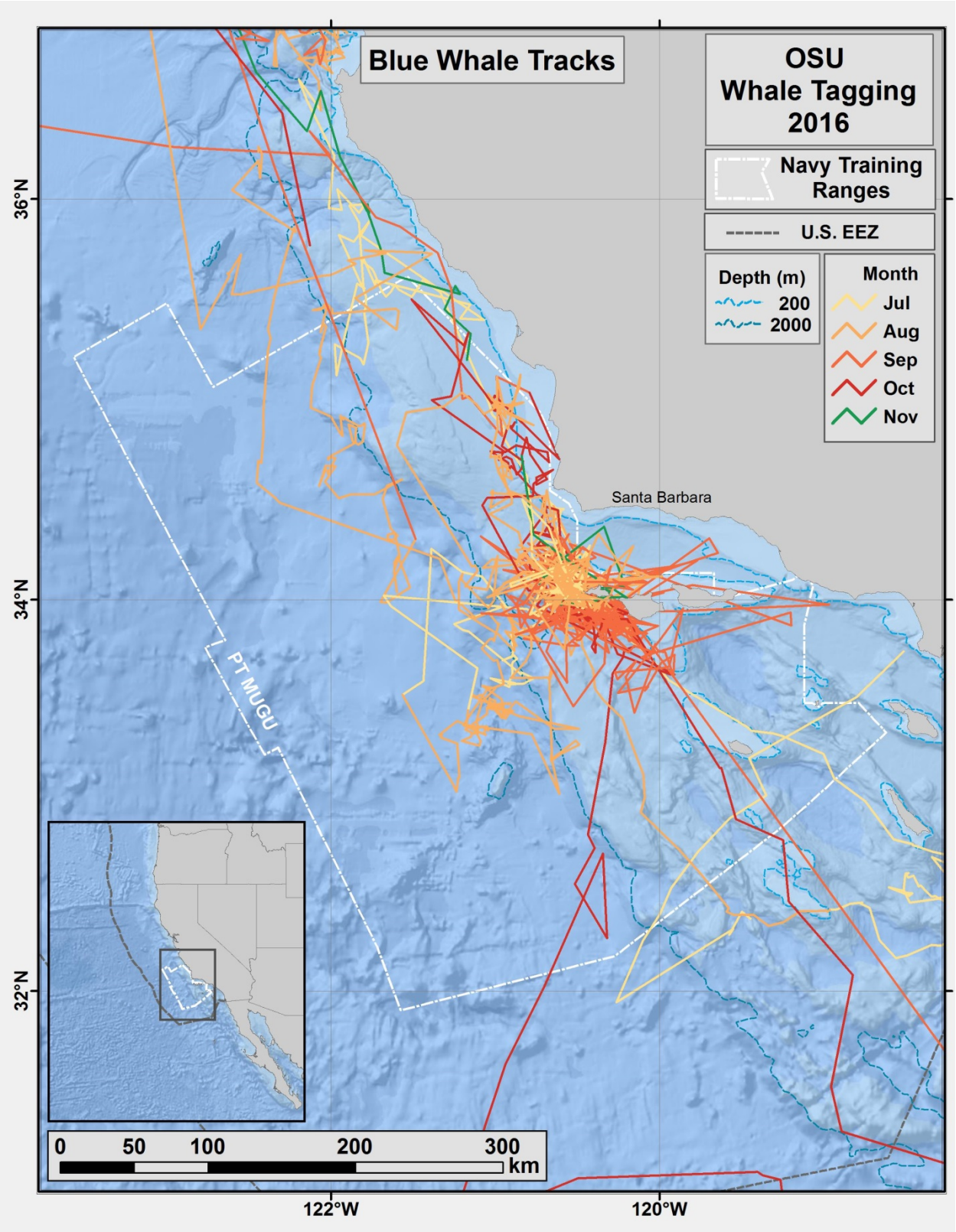

Figure 32. Satellite-monitored radio tracks for blue whales tagged off southern and central California in July and August 2016 (11 LO tags, 8 DM tags). From: Mate et al. 2017 [Project S4]

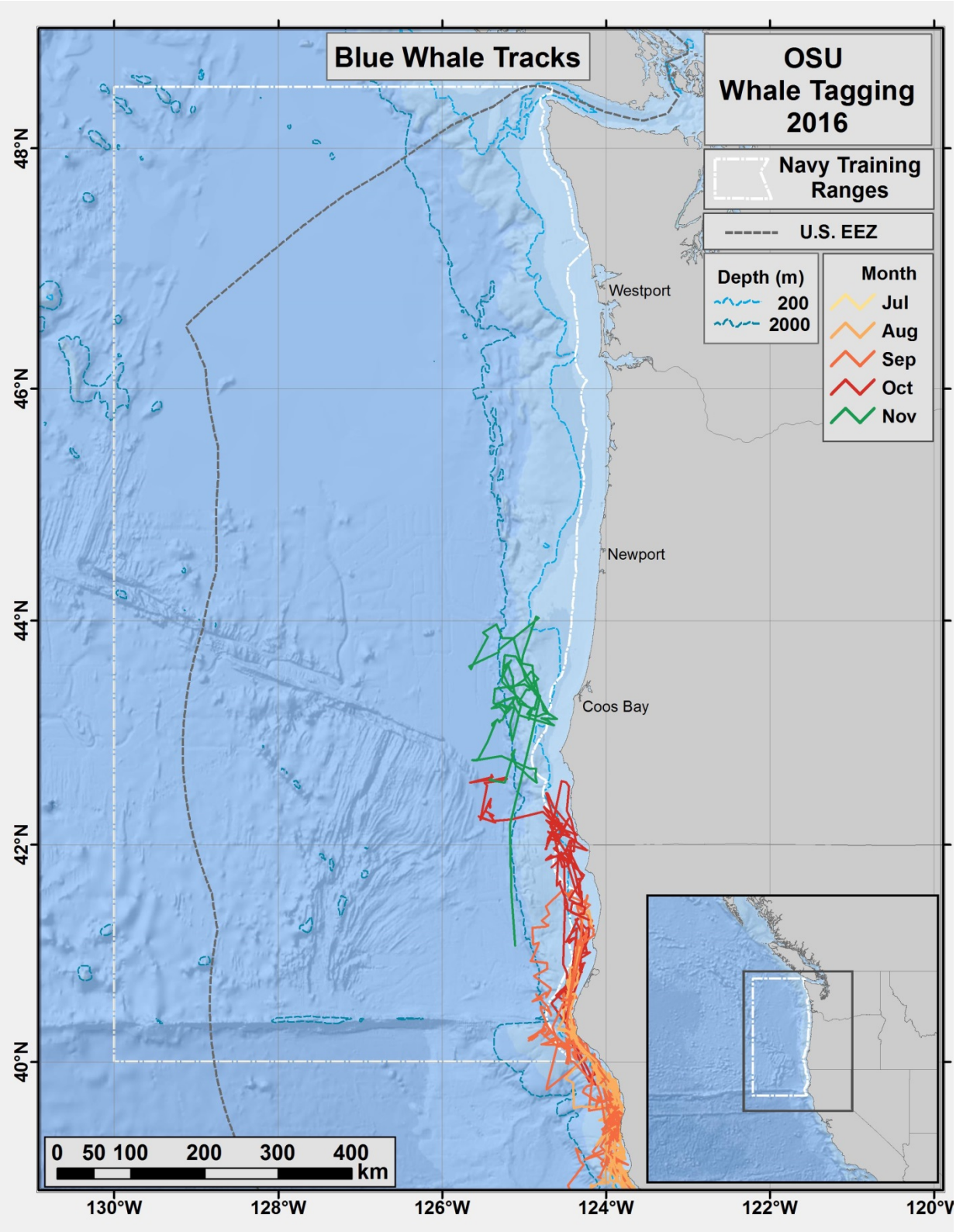

Figure 33. Satellite-monitored radio tracks in NWTRC for blue whales tagged off southern and central California in July and August 2016 (3 location-only tags). From: Mate et al. 2017 [Project N4]

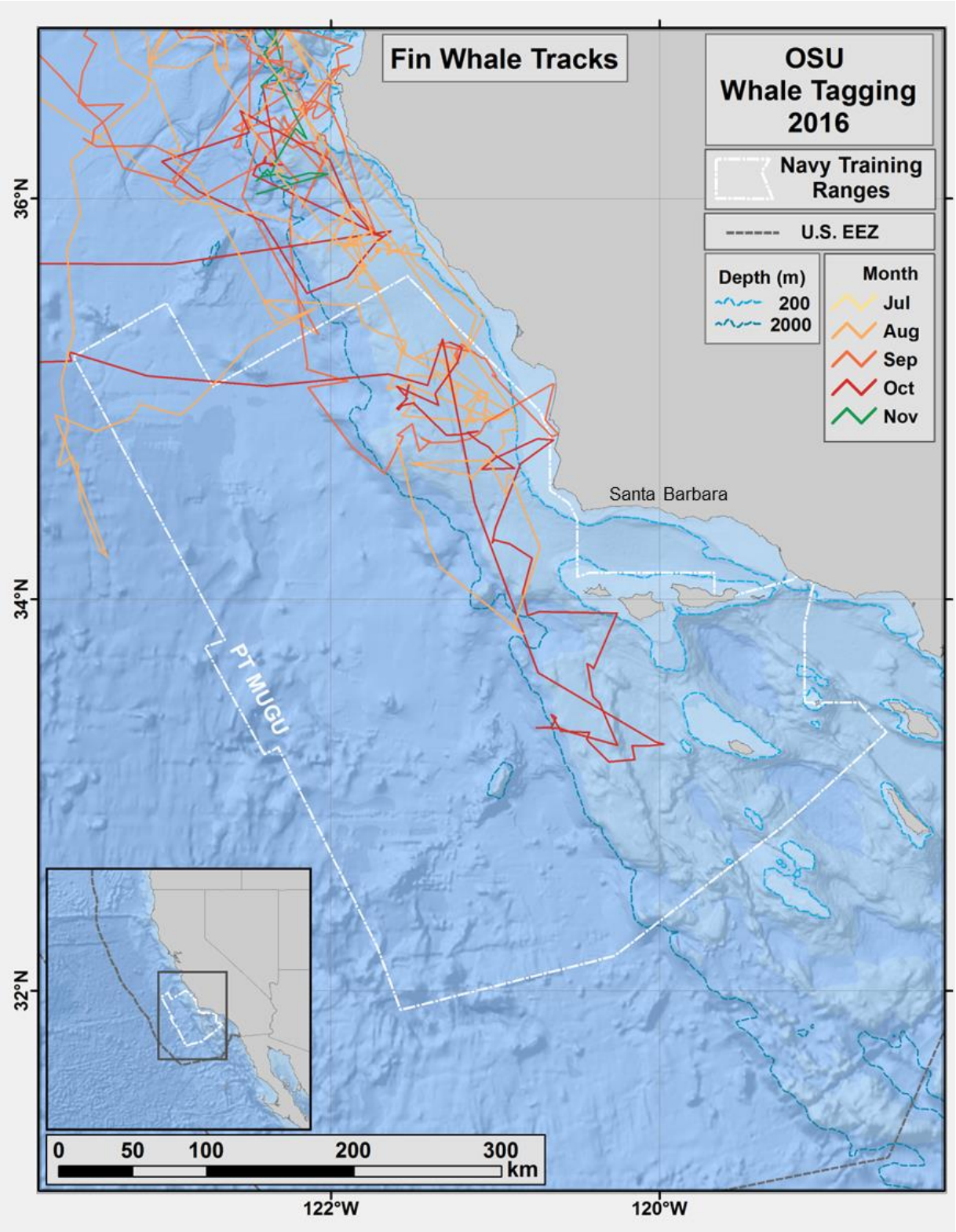

Figure 34. Satellite-monitored radio tracks in Pt Mugu for fin whales tagged off central California in July and August 2016 (1 location-only tag, 2 DM tags). From: Mate et al. 2017 [Project S4]

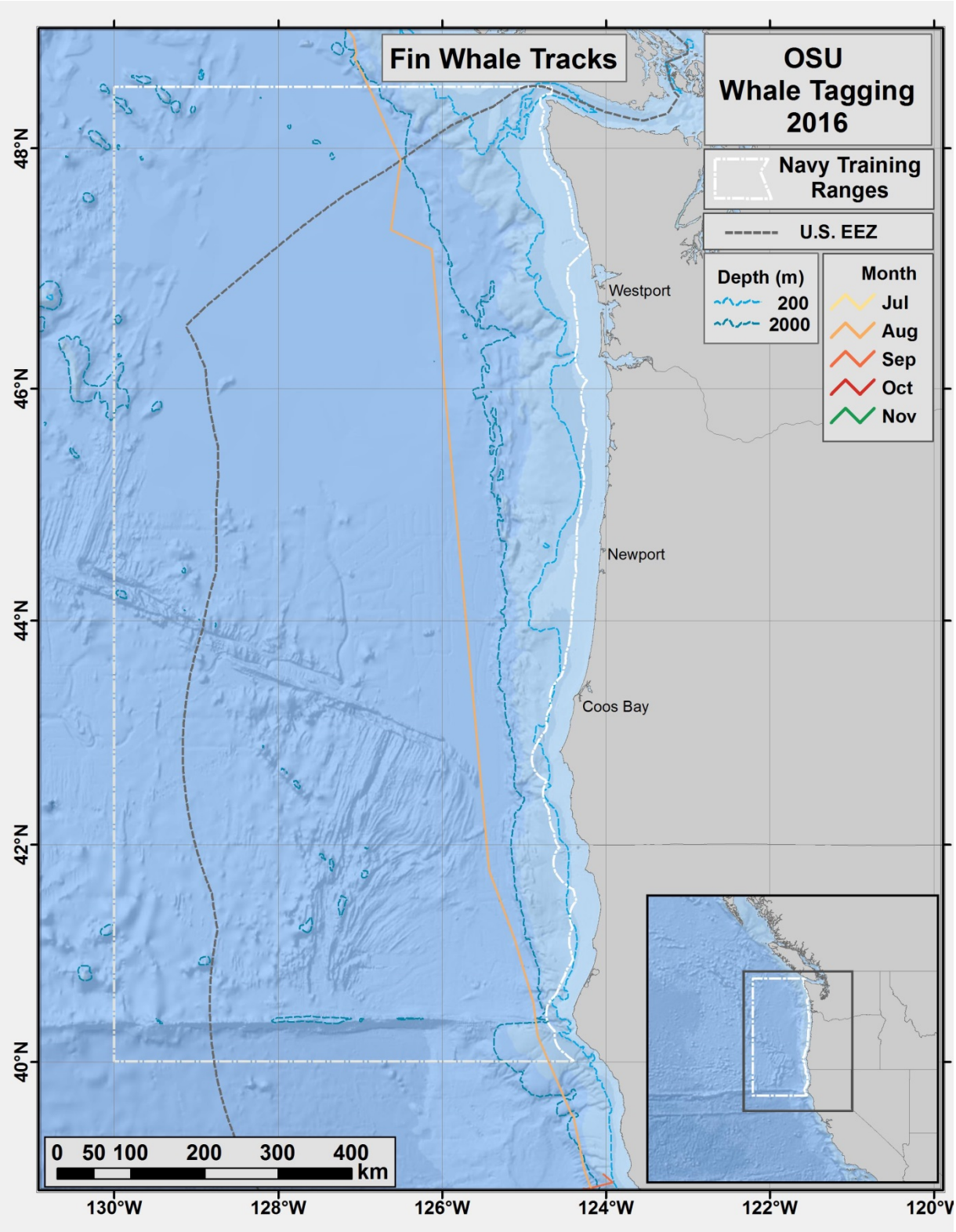

Figure 35. Satellite-monitored radio tracks in NWTRC for a fin whale (Tag# 23030) tagged off central California in July 2016 (DM tag). From: Mate et al. 2017 [Project N4]

2.2.1.8 MONITORING QUESTION: WHAT ARE THE RESIDENCY TIME/OCCUPANCY PATTERNS OF BLUE WHALES WITHIN NMFS-DESIGNATED BIOLOGICALLY IMPORTANT AREAS (BIAs) FOR THIS SPECIES ALONG THE U.S. WEST COAST? [PROJECT S4/N4]

The amount of time spent in NMFS-designated BIAs (Ferguson et al. 2015; Calambokidis et al. 2015) by tagged blue whales ranged from less than 1 up to 96 percent of their total tracking periods (Mate et al. 2017). The two most heavily used BIAs (of the six overlapping U.S. Navy training ranges), in terms of number of whales having locations there, were the Santa Barbara Channel and San Miguel BIA, and Point Conception/Arguello BIA (**Figures 36 and 37**). Blue whale locations occurred in the Santa Barbara Channel and San Miguel BIA and Point Conception/Arguello BIA during all 5 months in which blue whales were tracked (July through November 2016) (**Figures 36 and 37**).

One blue whale had locations within the Tanner-Cortez Bank BIA and the track of another blue whale crossed this same area. Blue whale locations/tracks occurred in the Tanner-Cortez Bank BIA in August, September, and October.

One blue whale occurred in the Santa Monica Bay to Long Beach BIA. One other blue whale had a small number of locations within the San Nicolas Island BIA. Blue whale locations occurred in the Santa Monica to Long Beach BIA and the San Nicolas Island BIA in July. None of the blue whales tagged in 2016 were tracked within the San Diego BIA.

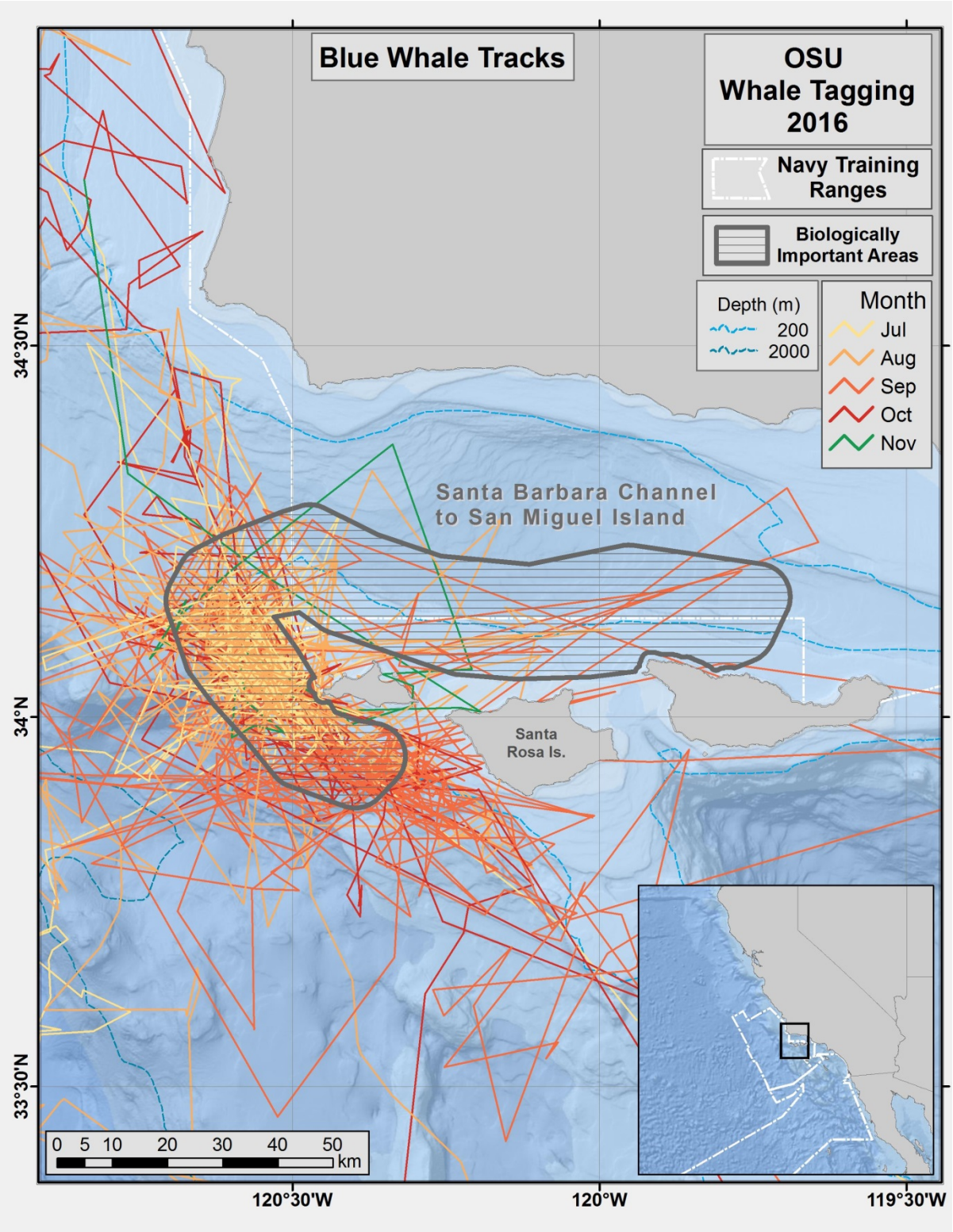

Figure 36. Satellite-monitored radio tracks in the Santa Barbara Channel and San Miguel BIA for blue whales tagged off southern and central California in July and August 2016 (5 location-only tags, 5 DM tags). From: Mate et al. 2017 [Project S4]

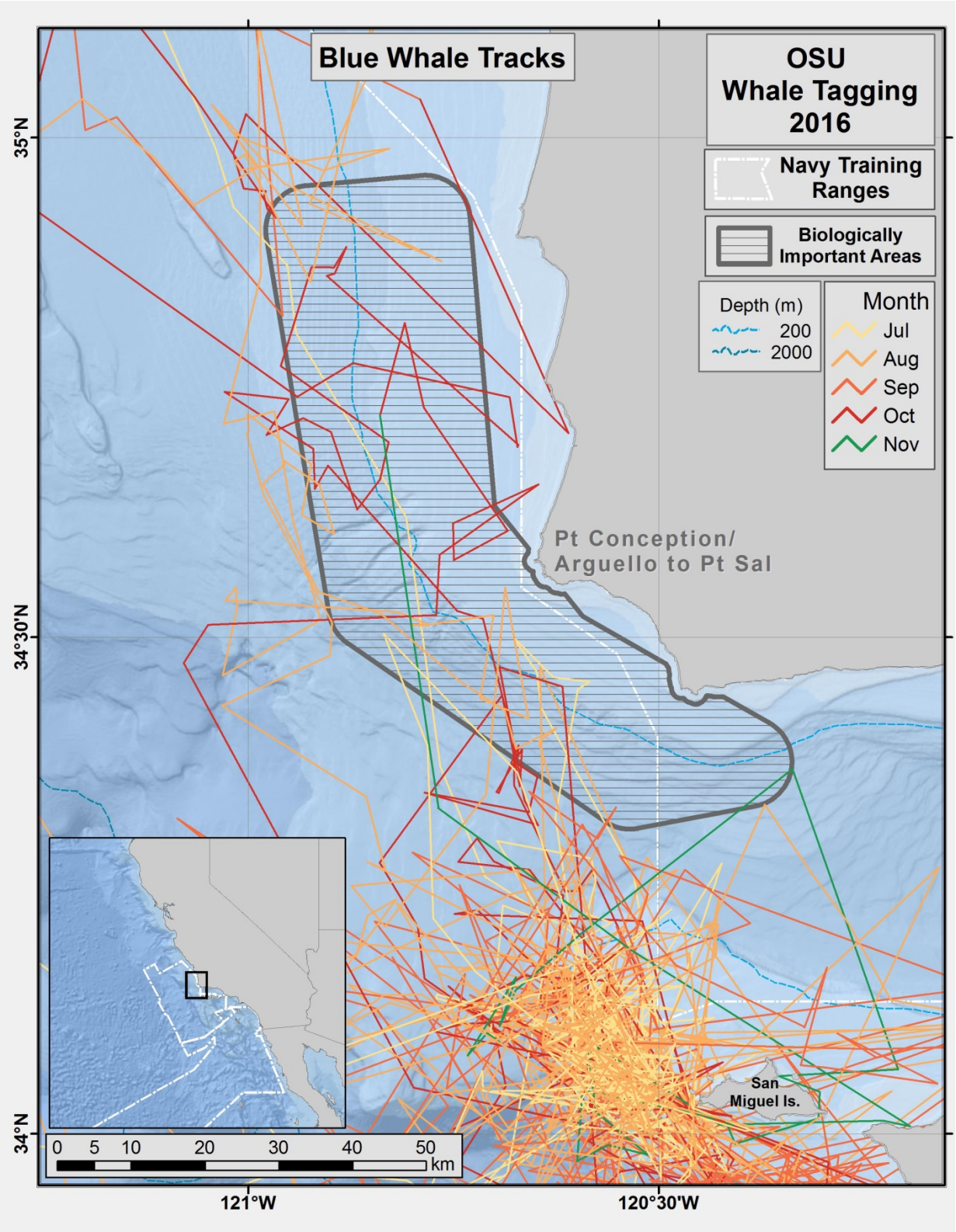

Figure 37. Satellite-monitored radio tracks in the Point Conception/Arguello BIA for blue whales tagged off southern and central California in July and August 2016 (3 location-only tags, 4 DM tags). From: Mate et al. 2017 [Project S4]

2.2.1.9 MONITORING QUESTION: WHAT ARE THE HABITAT-USE PATTERNS OF ODONTOCETES IN THE AREA OF THE PUULOA UNDET RANGE? [PROJECT H1]

Passive EARs were deployed in waters adjacent to the Puuloa UNDET range off the coast of Oahu from 2010 to 2013 (Shannon et al. 2016). The instrument deployed to the west of the UNDET range recorded three times as many odontocete detections (possibly spinner dolphins) as the EAR in the eastern location, possibly due to differences in substrate composition (western EAR: sandy bottom, eastern EAR: hard substrate with individual corals) and/or the behavior of the animals. A whistle detection rate of only 0.6 percent of files indicates this area is not likely commonly frequented by odontocetes. Additionally, the coastal shelf bathymetry on this particular section of coastline on Oahu is not consistent in general with preferential foraging grounds for odontocetes. This may be due to the comparatively long horizontal transit time from the potential shallow-water resting area at the Puuloa UNDET range out to sea to the shelf where nightly feeding by Hawaiian spinner dolphins begins (Benoit-Bird and Au 2003).

A weak seasonal pattern was found, with more detections recorded in late summer/early fall. There was no relationship between the hour of day and presence of whistles. The authors note that UNDET training in this area has a low chance of detrimental effects to transiting odontocetes, and that visual detections of spinner dolphins at Puuloa have observed transiting behavior rather than resting.

2.2.1.10 MONITORING QUESTION: WHAT IS THE AMBIENT AND ANTHROPOGENIC SOUNDSCAPE IN NWTT AND GOA TMAA? [PROJECT N1/G1]

Underwater ambient sounds (including marine mammal vocalizations) and anthropogenic sounds were recorded using HARPs over multiple years in two U.S. Navy training areas, NWTT and GOA TMAA (Wiggins et al. 2017) (**Figures 21** and **26**). In 2016, the ambient soundscape SPLs in both areas were re-processed using new and improved techniques, including calculating long (multi-year) spectrograms, sound pressure spectrum level percentiles, and average sound pressure spectrum levels over the recording periods.

The ambient soundscape was similar in both areas, with GOA TMAA showing higher levels from blue and fin whales at low frequencies (<30 Hz) and NWTT showing higher levels from ship propulsion (approximately 30–100 Hz), confirmed with higher number of detections of broadband ship sounds. MFAS was detected in GOA TMAA only during one period of 10 consecutive days in June 2016 during a known U.S. Navy exercise, and was detected in NWTRC at relatively low numbers on several occasions. LFAS (approximately 200 Hz) was detected at GOA TMAA at one site, but only a few times at low levels. LFAS was also detected at NWTRC at low levels and low numbers, and at frequencies of 900 to 1,000 Hz. Explosions were detected at both areas, although infrequently.

2.2.1.11 WHAT ARE THE SEASONAL AND ANNUAL OCCURRENCE PATTERNS OF SOUTHERN RESIDENT KILLER WHALES RELATIVE TO OFFSHORE NAVY TRAINING RANGES? [PROJECT N2]

Researchers at NMFS/NWFSC used animal telemetry, PAM, and computational modeling to investigate the spatial distribution of SRKW in the Pacific Northwest, and specifically in relation to the NWTRC (**Figure 8**) (Hanson et al. 2017). Between 9 November 2015 and 23 February

2016, two satellite-linked tags were deployed on SRKW, one on a K pod individual and one on an L pod individual. From 2012 through 2016, a total of eight satellite-linked tags were deployed on SRKW belonging to J, K and L pods (Hanson et al. 2017). The seasonal duration of satellite tag data spanned from late-December to mid-May. Nearly all locations occurred on the continental shelf, and the majority of these were in water depths between 20m to 100m. Winter locations of tagged whales included both inland and coastal waters and varied by pod. The majority of J pod locations occurred in inland waters, whereas K and L pod members had a primarily coastal distribution and occurred almost exclusively on the continental shelf. K and L pod showed a high use area between Grays Harbor and the Columbia River, outside of the Olympic Coast National Marine Sanctuary. J pod's primary high use areas were inland waters (Strait of Georgia) and the western entrance to the Strait of Juan de Fuca. Tagged SRKWs occurred periodically in the waters encompassed by the NWTRC areas W237A, W237B, or W237E. Specifically, K and L pods occurred in W237A, B, and E (mostly W237A), whereas J pod only occurred in the shoreward section of W237E. Very little overlap of J and K/L pod ranges occurred during the winter.

PAM data was collected from 2006 through 2015 using EARs (**Figure 22**). The acoustic recorder data documented the use of areas by SRKW in seasons outside of tag deployments, which were primarily limited to winter months. These detections included areas both inside and outside the NWTRC, but all recorders were on the outer coast. SRKW detections in, or south of, the range complex occurred in all months of the year. Therefore, acoustic data indicate that the NWTRC is periodically occupied by SRKW throughout the year.

2.2.1.12 MONITORING QUESTION: WHAT IS THE ABUNDANCE, DISTRIBUTION, AND DENSITY OF MARINE MAMMALS IN THE INLAND WATERS OF PUGET SOUND? [PROJECT N3]

From 2013 to 2016, researchers conducted systematic line-transect aerial surveys for marine mammals in eight sub-regions of Puget Sound encompassing inland waters of Washington State (Smultea et al. 2017) (**Figure 23**). The final survey mobilization, a winter effort, was completed in January 2016. Surveys focused on estimating seasonal in-water density and abundance of cetaceans, particularly harbor porpoise and harbor seals. A total of 20,554 km of observation effort was conducted during 61 flights on 35 days across four seasons (winter, spring, summer, and fall) during six separate survey periods. Observers recorded 11 marine mammal species including harbor seal, harbor porpoise, California sea lion, Steller sea lion, humpback whale, gray whale (*Eschrichtius robustus*), minke whale (minke whale only sighted in Strait of Juan de Fuca, not in Puget Sound), Risso's dolphin, Dall's porpoise (*Phocoenoides dalli*), killer whale, and otter (river otter [*Lontra Canadensis*] or sea otter [*Enhydra lutris*]).

Density and abundance analyses were limited to in-water sightings of 386 harbor porpoise, 2,170 harbor seal, and 66 sea lion (California and Steller) groups made during 7,649 km of observation effort considered suitable for distance-sampling analysis (systematic, Beaufort sea state 0–2, with cloud cover used as a filtering factor only for harbor porpoise). Harbor porpoise density and abundance estimates were corrected for missed trackline animals using $g(0)$ (trackline detection probability) from previous studies of harbor porpoise in Puget Sound.

Overall, estimated pooled harbor porpoise density was 0.86 individuals/km^2, with an abundance of 2,269 (95 percent confidence interval [CI95]=1,187–2,729, coefficient of variation [CV]=37.8%). Highest seasonal densities occurred in summer (1.05 individuals/km^2) and lowest occurred in winter (0.42 individuals/km^2). Geographically, highest overall densities occurred in the South Whidbey (2.03 individuals/km^2), Admiralty Inlet (1.72 individuals/km^2), and Southern Puget Sound (0.86 individuals/km^2) sub-regions, with notably fewer animals in the Bainbridge (0.53 individuals/km^2) and Vashon Island (0.25 individuals/km^2) sub-regions. Harbor porpoise were also observed in Hood Canal, including shallow tidal areas where they had been absent for decades.

For harbor seals seen in-water, overall estimated pooled density was 3.57 individuals/km^2, with an abundance of 9,404 (CI95=1,453–60,860, CV=118.6%). Because haul-out areas were avoided during surveys, density estimates represent in-water densities outside of haul-out areas, and abundance does not represent the total abundance in Puget Sound. Additional study by the Washington Department of Fish and Wildlife (e.g., Jeffries et al. 2014) will consider counts at haul-outs and during times of year and day when most harbor seals would be expected to be visible and counted. Highest seasonal densities of harbor seals occurred in spring and summer (4.73 individuals/km^2 and 4.70 individuals/km^2, respectively) and lowest in winter (2.2 individuals/km^2). Geographically, highest densities occurred in the Southern Puget Sound (6.37 individuals/km^2) and Hood Canal sub-regions (5.74 individuals/km2), with notably fewer animals in the Seattle (1.17 individuals/km^2) sub-region.

For sea lions seen in-water, overall estimated pooled density was 0.02 individuals/km^2 with an abundance of 53 (CI95=38–74, CV=16.8%). The sub-region with the highest estimated abundance and density of sea lions was Admiralty Inlet, with an estimated 15 sea lions (density=0.06 sea lions/km^2). Seasonal fluctuations were apparent, with highest estimated abundances in spring (66) and lowest in winter (20).

Collectively, the aerial survey data indicate that the harbor seal continues to be the most common marine mammal species in Puget Sound year-round. In contrast, Steller sea lions and California sea lions inhabit the region primarily during fall, when they occur throughout much of Puget Sound. The highest densities of harbor seals occurred in Southern Puget Sound.

2.2.1.13 MONITORING QUESTION: WHAT IS THE ABUNDANCE AND HABITAT USE OF CALIFORNIA SEA LIONS THAT HAUL OUT AT NAVY FACILITIES? [PROJECT N5]

Between 2014 and 2016, researchers at AFSC/NMML tagged a total of 30 adult male California sea lions in Puget Sound, WA (**Figure 38**). Animals were tagged using floating traps near the Bremerton and Manchester Naval installations. Sixteen animals were tagged in 2014-2015, and 14 animals were tagged in 2016. All 30 animals were instrumented with satellite-tracked tags, which relayed at-sea locations, haul-out locations, and dive data from December through August. Animal locations were estimated from satellite locations using a correlated random walk model (CRAWL) based on the quality of the satellite locations.

Analyses were conducted in 2016 and include daily locations estimated for all 30 sea lions. Although no abundance estimates were derived as part of this work, animal movements were analyzed in relation to the Olympic Coast National Marine Sanctuary (OCNMS). Four of the tags

were discovered to have errors in programming so did not collect dive data. Ten out of 26 correctly-instrumented animals hauled out in the OCNMS (*n*=702 occurrences). Twelve of these 26 animals had locations (hauled out and/or at-sea) within the OCNMS (*n*=2,111 occurrences). Locations of activity in the OCNMS represented 5.4 percent of all locations (*n*=39,050).

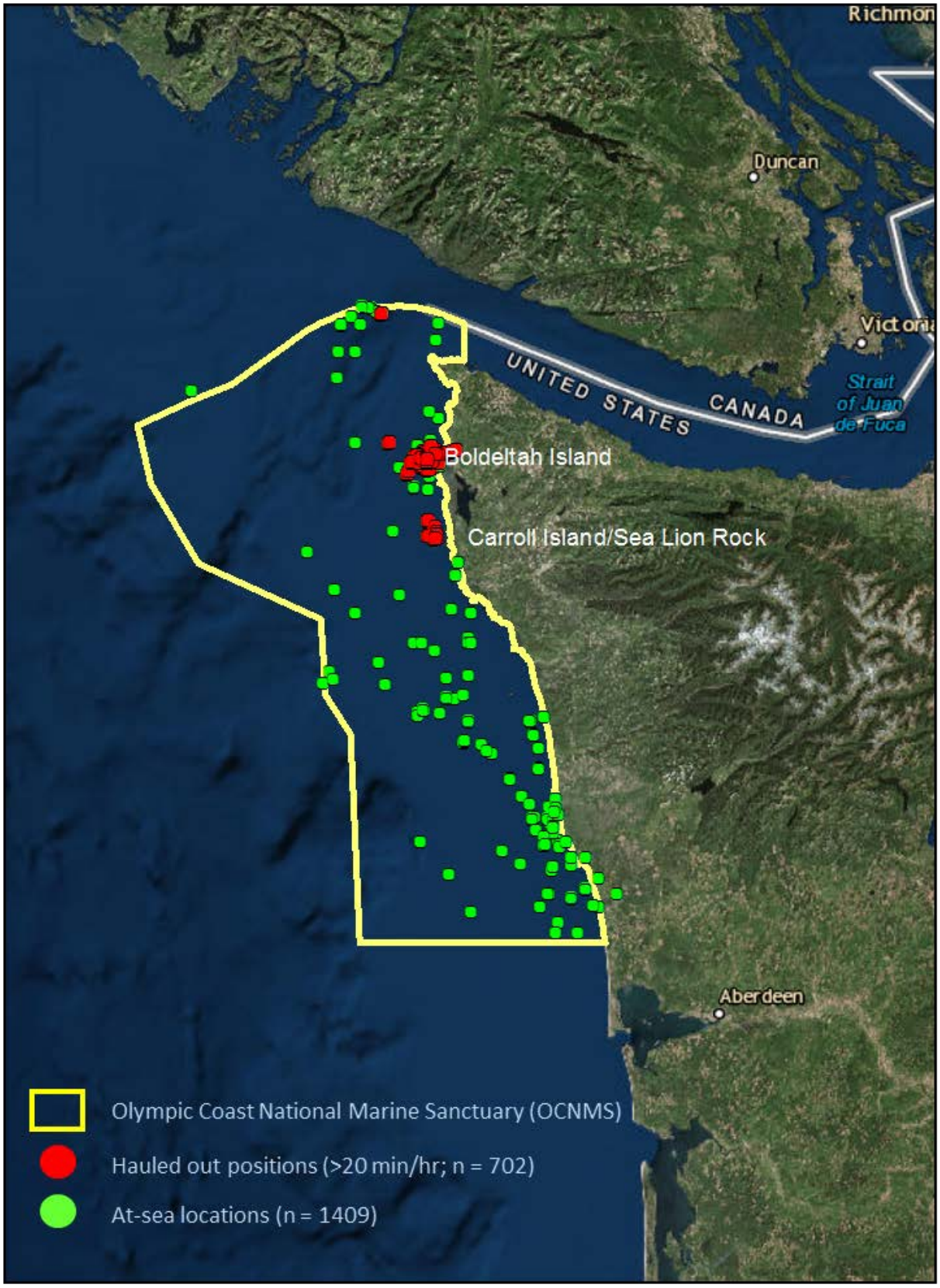

Figure 38. Adult male California sea lion use of the Olympic Coast National Marine Sanctuary (OCNMS). (R. DeLong, NMFS, pers. comm.) [Project N5]

2.2.1.14 MONITORING QUESTION: WHAT IS THE DENSITY OF HARBOR SEALS IN HOOD CANAL, WASHINGTON? [PROJECT N6]

The goal of this project is to develop estimates of in-water density and abundance of harbor seals in various regions of Hood Canal, Washington, in order to evaluate impacts and estimate exposures to U.S. Navy activities that may cause acoustic disturbance. To determine the best approach for estimating in-water density and abundance of harbor seals in Hood Canal using existing data, a workshop was held in October 2015 in Seattle, Washington, and was attended by several experts and scientists with experience in the region. The resulting decision was to use line-transect aerial survey data (collected from 2013 to 2016, see **Project [N3]**) from Hood Canal to directly estimate harbor seal density and abundance in the water. Analysis and reporting are in progress.

2.2.2 Conceptual Framework Category 2. Exposure

The following sections summarize progress made this monitoring year on addressing the issue of *exposure* of protected marine species to anthropogenic noise generated by U.S. Navy training activities. Only projects conducted in MITT and HSTT address this topic.

A number of monitoring projects in 2016 addressed questions of marine mammal *exposure* to sound—specifically species that may be exposed to U.S. Navy sonar and UNDETs. This work included examining RLs, movements, and habitat-use patterns in the vicinity of training and testing ranges. Projects in several study areas addressed the spatial and temporal overlap of animal distribution with training and testing activities. Progress has also been made in developing and refining PAM tools to analyze marine species exposure to MFAS.

2.2.2.1 MONITORING QUESTION: WHAT IS THE BASELINE ABUNDANCE AND POPULATION STRUCTURE OF ODONTOCETES THAT MAY BE EXPOSED TO SONAR AND/OR EXPLOSIVES IN THE MITT STUDY AREA? [PROJECT M1]

Although the PIFSC CRP is building photo-ID catalogs for spinner dolphins, bottlenose dolphins, short-finned pilot whales, pygmy killer whales, false killer whales, rough-toothed dolphins, and humpback whales, the encounter rates and numbers of distinctive individuals within each catalog are still too small to conduct robust abundance analyses (Hill et al. 2017). Existing photo-ID data are currently being evaluated to determine if such analyses are feasible for any of the cataloged species.

2.2.2.2 MONITORING QUESTION: WHAT IS THE EXPOSURE OF CETACEANS AND SEA TURTLES TO EXPLOSIVES AND/OR SONAR IN THE MITT STUDY AREA? [PROJECTS M1, M2]

Between 2013 and 2016 for Project [M2], 15 turtles were outfitted with satellite tags inside and near Apra Harbor, and 13 of these tags have completed their data transmission periods (Martin and Jones 2016). From the spatial analysis of the GPS locations and movements from these satellite tags, there has been no direct overlap of the turtles with the Agat Bay Mine Neutralization Site, Piti Point Mine Neutralization Site, and Outer Apra Harbor Underwater Detonation Site; however, turtles are spending significant amounts of time in and moving

through areas within 1–2 km of these sites. The lack of direct overlap between these sites and turtle locations could be due to the relatively low frequency of GPS locations obtained from these tags (often a maximum of one per day). Analysis and filtering of Argos location classes may provide data with higher spatial and temporal resolution.

For Project [M1], satellite-tag telemetry data from cetaceans tagged during visual survey efforts are continuing to be incorporated into a habitat analysis using kernel density estimates. For species for which sufficient data are available, these habitat-use results will be compared with locations of the three underwater detonation ranges off Guam, with results and reporting expected in 2017–2018.

2.2.2.3 MONITORING QUESTION: WHAT ARE THE OCCURRENCE OF AND ESTIMATED RECEIVED LEVELS OF MFAS ON 'BLACKFISH' AND HUMPBACK, MINKE, SPERM, AND BLAINVILLE'S BEAKED WHALES WITHIN THE PMRF INSTRUMENTED RANGE? [PROJECT H2]

Acoustic data were collected on bottom-mounted hydrophones from 28 August 2015 to 7 September 2016 at PMRF. These data were analyzed using automated detection algorithms to identify and localize several species of marine mammals, and estimate several animals' RLs from MFAS transmissions (Martin et al. 2017). In addition, data collected from 2007 through 2010 were analyzed for the occurrence of beaked whales, humpback whales, and sperm whales. While manual processes are currently required to validate the species detections and localizations, the automated quick-look data are useful tools that help pinpoint data collections for further investigation (such as Bryde's whale calls that occur in summer months).

Automated DCLTDE algorithms have been developed for fin, sei, Bryde's, minke, and sperm whales, Blainville's beaked whales, and other beaked whales with FM echolocation clicks (e.g. Cuvier's beaked whale foraging clicks and Cross Seamount-type clicks). A high-FM vocalization detector has also been developed recently for killer whales. In addition, automated MFAS detectors have been developed for marine species exposure analysis.

Researchers performed a "test case" analysis of three minke whales that were localized and tracked during the onset of surface ship MFAS during a training event in February 2016 (**Figure 39**). One of the minke whales (whale C in **Figure 39**) was located off the range in the southern area where localization accuracy is degraded. Whale A traversed the range headed northwest while whale B was traveling southeast from the northeast portion of the range. Gaps are evident in the whale tracks over several MFAS periods. The whale closest to MFAS source (whale C) is depicted separately in a timeline (**Figure 40**). The CSEL (red lines, **Figure 40**) begins at the same level as the sound exposure level (SEL, black lines) of 137.3 decibels re 1 microPascal-squared-second (dB re μPa^2s) at the onset of sonar activity, which lasted for approximately 12 min. Even though the ship was at a distance of more than 20 km from the whale, the CSEL increased to 146.7 dB re μPa^2s during that time. The second sonar activity occurred at distances of 22 to 54 km from whale A, with the CSEL increasing to 148.7 dB re μPa^2s.

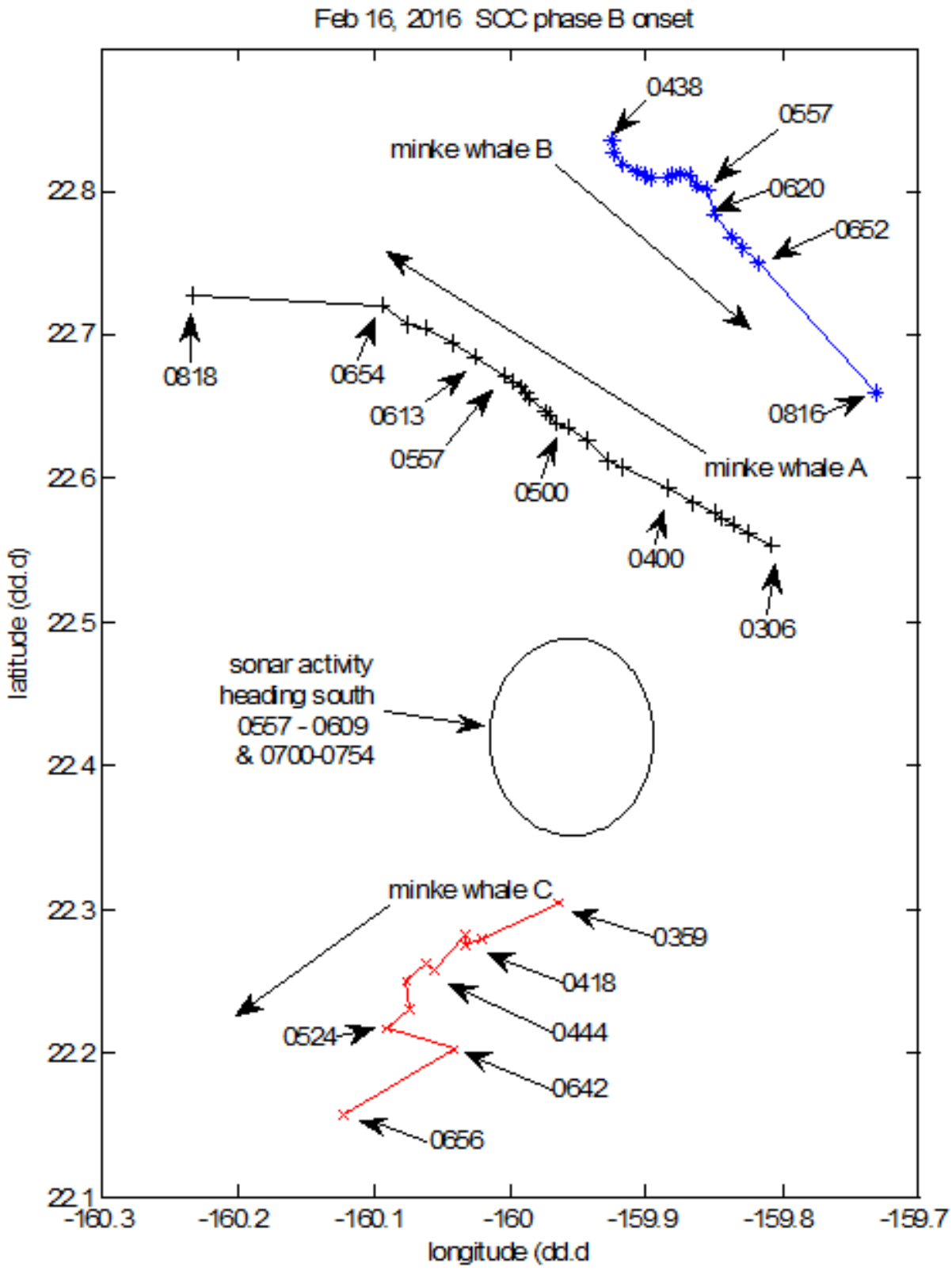

Figure 39. February 2016 onset of surface ship MFAS training. Three minke whales localized and tracked between 0359 and 0818 GMT shown with some call times identified. The ellipse in the center is the approximate area of the MFAS activity between 0557 and 0754 GMT. From: Martin et al. 2017 [Project H2]

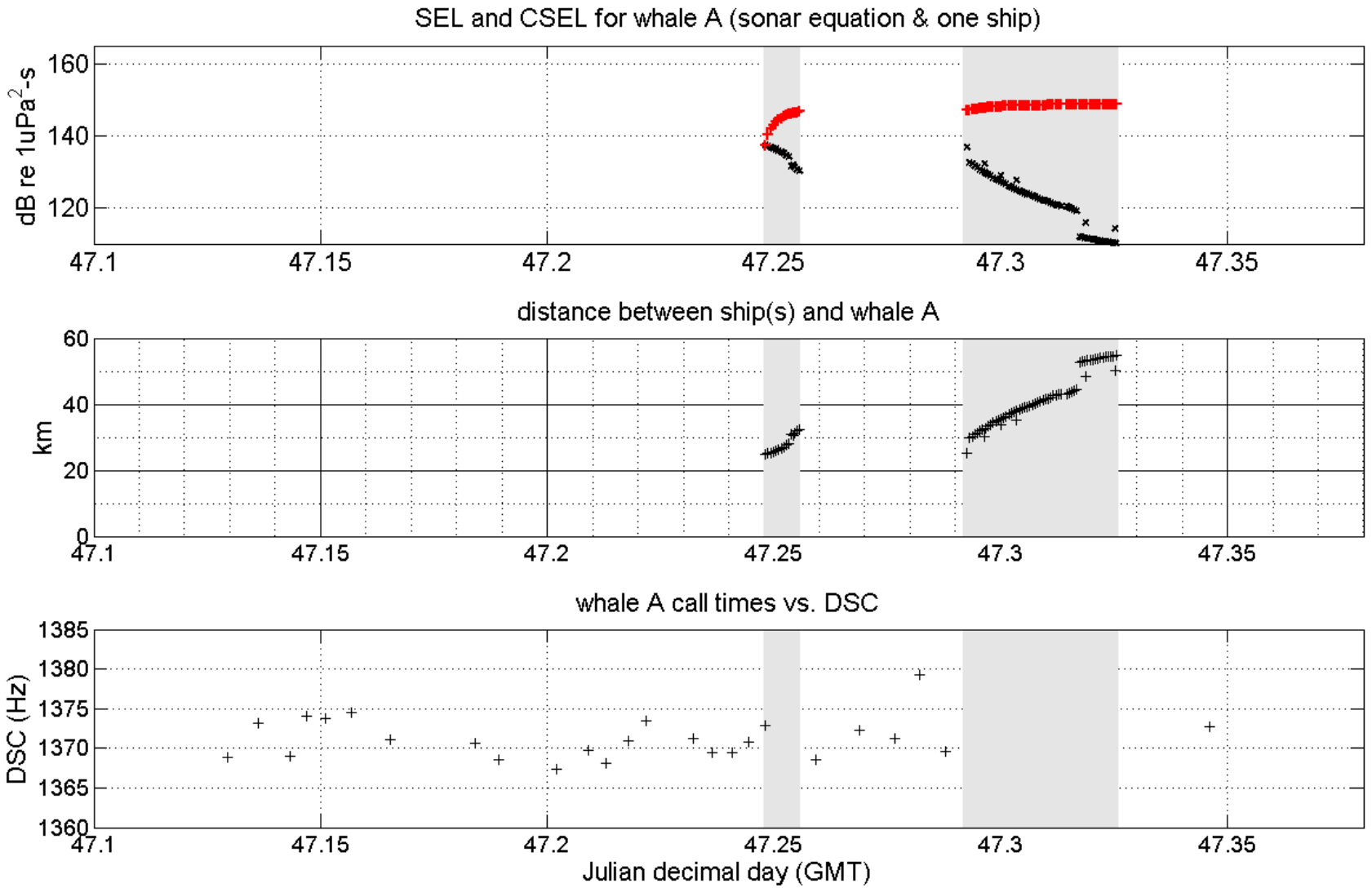

Figure 40. Estimated CSEL on whale A for the closest MFAS ship. All panels are scaled for the same time period (16 February 2016 between 0224 and 0900 GMT) with vertical gray shaded areas indicating times that MFAS occurred. The upper panel shows the estimated CSEL (red lines) and SEL (black lines). The middle panel shows the distance between the closest ship and whale A while the bottom panel shows whale A's dominant signal component (DSC) (Martin et al. 2015) frequency with the plus symbols indicating times of calls. From: Martin et al. 2017 [Project H2]

2.2.2.4 MONITORING QUESTION: ARE MARINE MAMMALS (AND SEA TURTLES) EXPOSED TO MFAS, ESPECIALLY AT LEVELS ASSOCIATED WITH ADVERSE EFFECTS? IF SO, AT WHAT LEVELS ARE THEY EXPOSED? [PROJECT H4]

Over 17–18 February in both 2015 and 2016, two days of aerial surveys (for a total of four days) were conducted on and around PMRF in order to detect and observe mammals and sea turtles that may be exposed to MFAS during the SCC training event (Mobley et al. 2017). Sighting locations that occurred within 1 hour (hr) of MFAS transmissions were compared with ship locations at the time of transmission in order to estimate potential RLs from MFAS exposure. A total of 49 sightings met this criterion, of which 33 also met higher confidence standards for the RL estimates. The mean RLs for these 33 sightings ranged from 136.7 to 170.8 decibels referenced to 1 microPascal (dB re: 1µPa) root mean square (RMS). In the 2015–2016 reporting period, aerial survey observers recorded three marine mammal species in association with SCC events. These species included humpback whale, Hawaiian monk seal (*Neomonachus schauinslandi*), and spinner dolphin. Estimated RLs for humpback whales sighted in 2016 averaged 138 dB re: 1µP.

Aerial surveys were also performed in association with SCC training events in 2015 and 2016, during which a total of six species were identified, including the bottlenose dolphin, humpback whale, Hawaiian monk seal, short-finned pilot whale, and spinner dolphin (**Figures 41 and 42**).

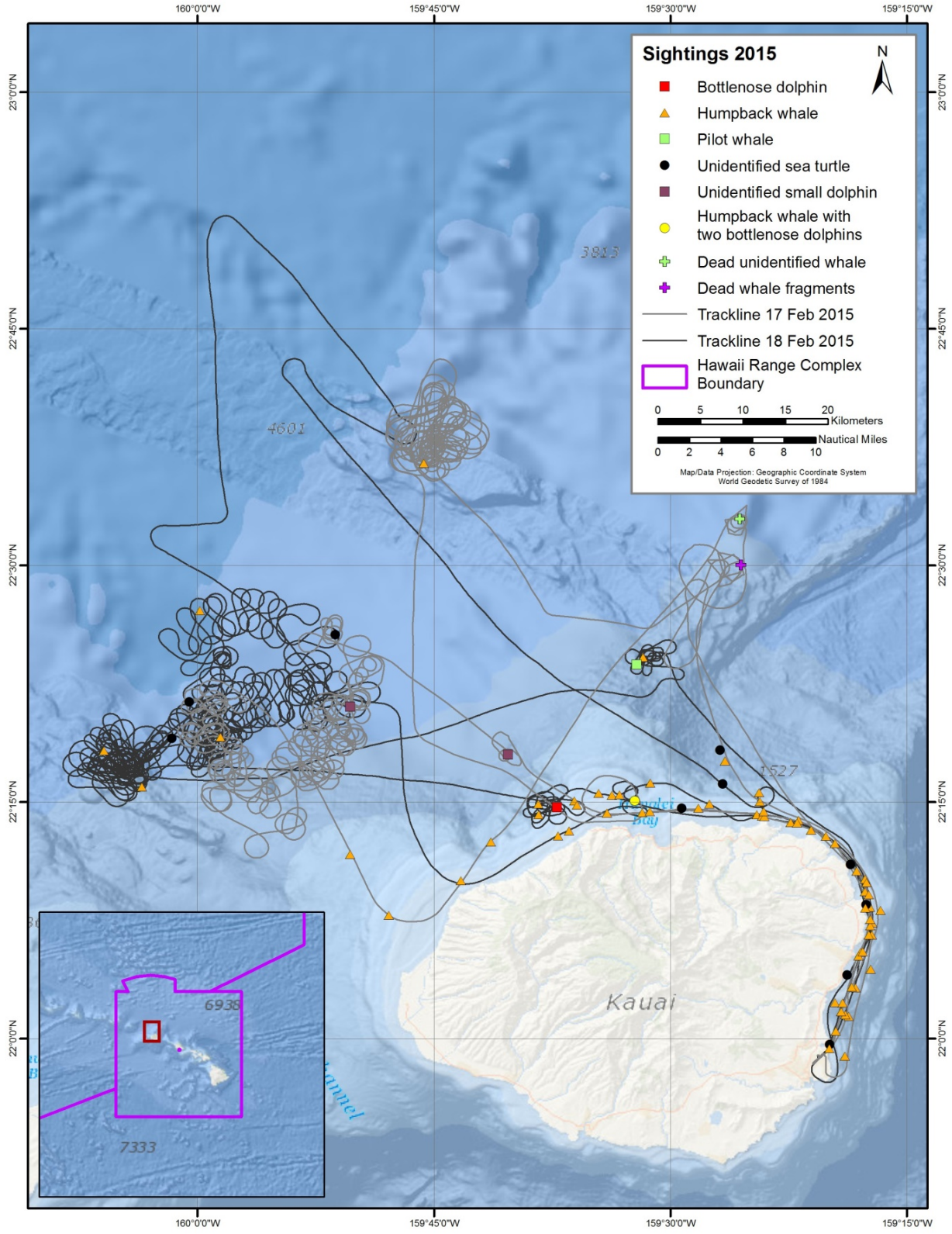

Figure 41. Effort and sighting locations off Kauai during SCC ship follows (17–18 February 2015). [Project H4]

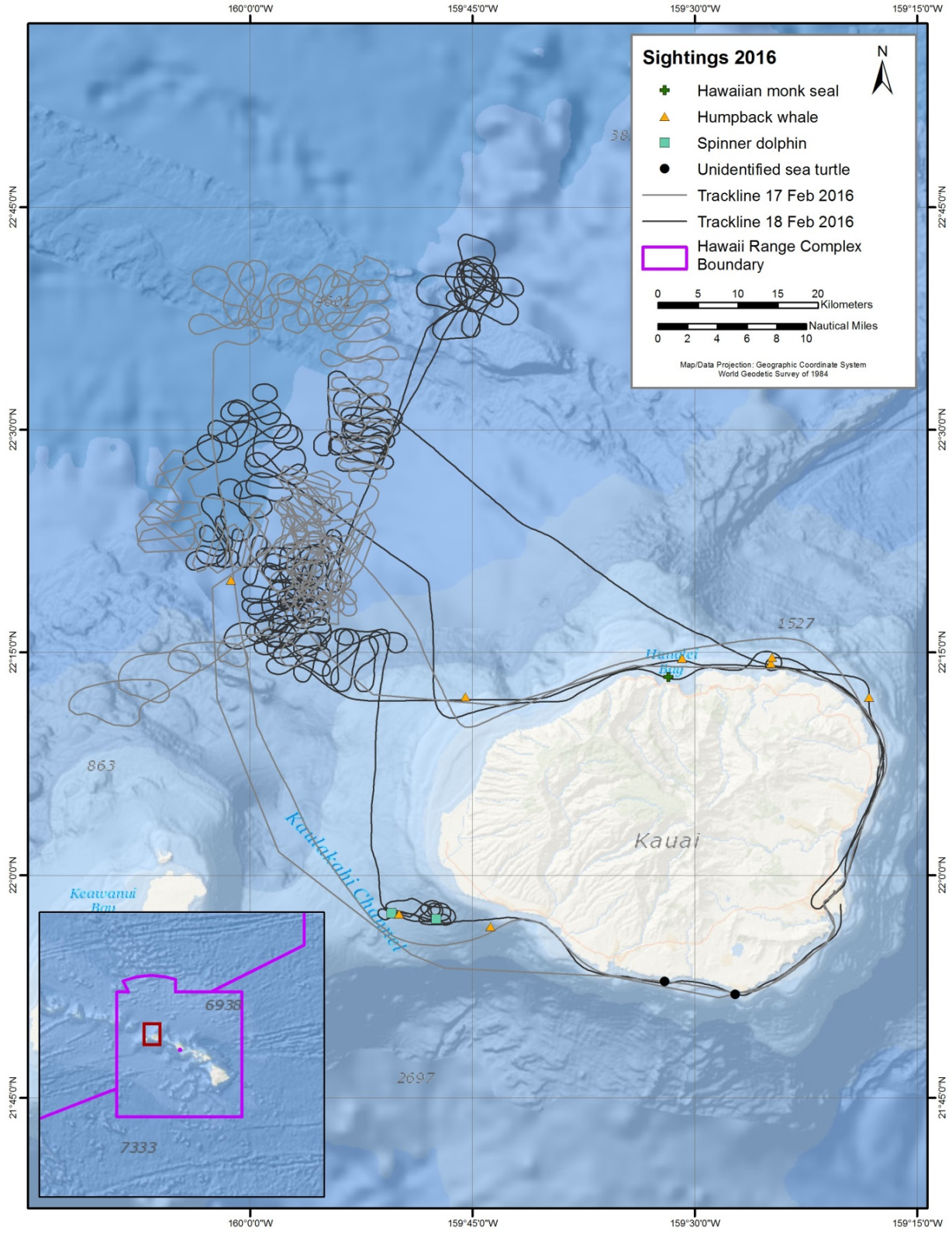

Figure 42. Effort and sighting locations off Kauai during SCC ship follows (17–18 February 2016). [Project H4]

2.2.2.5 MONITORING QUESTION: WHAT IS THE EFFECTIVENESS OF NAVY LOOKOUTS ON NAVY SURFACE SHIPS AND WHAT SPECIES ARE SIGHTED DURING SONAR TRAINING EVENTS? [PROJECT H5]

In February 2016, a Lookout Effectiveness (LOE) Study was conducted during an SCC training event, the fourteenth such study performed aboard a U.S. Navy destroyer (Vars et al. 2016). Data were obtained to characterize the possible exposure of marine species to MFAS. Sighting information included the bearing and distance of the animal(s) from the ship. This information can be used to determine the level of exposure a marine mammal may experience during an MFAS event; however, no active sonar was used as part of this particular SCC event.

The MMO team spent approximately 36 hr over 6 days searching for marine species during the training event. The highest rate of sightings occurred in the channel between Kauai and Niihau. In total, 13 unique sightings, comprising at least 20 individual marine mammals, were recorded during the 6 days of observation. Of the 13 sightings, humpback whale (*n*=3) and rough-toothed dolphin (*n*=1) were the only species positively identified, accounting for 50 percent of individuals sighted. Unidentified large whales (*n*=9) (which were also most likely humpback whales) accounted for the remaining 50 percent of individuals sighted. None of the 13 sightings occurred when sonar was active.

MMOs made 12 sightings independent of the ship's lookout (LO) team. There were four sightings made concurrently by both the MMO and LO team. There was one sighting by the LO team independent of the MMOs.

Since 2014, MMOs have embarked on U.S. Navy warships during a total of four training events in HRC: three SCC events (in February 2014, 2015, and 2016) and one Koa Kai event (January 2014) (Dickenson et al. 2014; Shoemaker et al. 2014; Vars et al. 2016; Watwood et al. 2016). The February 2016 embark was marked by fewer sightings than the previous years (with the exception of the January 2014 Koa Kai event). The humpback whale continued to dominate sightings of identified cetaceans, which is expected based on the location of the training events and their timing, which coincides with the presence of humpback whales on their breeding grounds during the winter in Hawaiian waters. LOE studies since 2014, all in Hawaii for the Pacific ranges, have identified rough-toothed dolphins (2016), short-finned pilot whales (January 2014), and bottlenose dolphins (January 2014). Sea turtles were not seen during the 2016 LOE study; January 2014 was the last LOE study that had sea turtle sightings.

2.2.2.6 MONITORING QUESTION: WHAT ARE THE SPATIAL-MOVEMENT AND HABITAT-USE PATTERNS (E.G., ISLAND-ASSOCIATED OR OPEN-OCEAN, RESTRICTED RANGES VS. LARGE RANGES) OF SPECIES THAT ARE EXPOSED TO MFAS, AND HOW DO THESE PATTERNS INFLUENCE EXPOSURE AND POTENTIAL RESPONSES? [PROJECT H7]

Over the course of 7 days in February 2016, small-vessel surveys were performed on and around PMRF in order to provide visual species identifications, deploy satellite tags, and take individually-identifying photos of marine mammals that may be exposed to MFAS (Baird et al. 2016). In addition, information from tag deployments on two short-finned pilot whales, one rough-toothed dolphin, and one bottlenose dolphin, tagged in September 2015, were included in the analyses.

Data revealed strong associations by the rough-toothed and bottlenose dolphins to the islands of Kauai and Niihau. Based on photo-ID, all were part of groups known to be resident to the islands. Probability-density analyses of all tag-location data obtained for bottlenose dolphins and rough-toothed dolphins tagged off Kauai since 2011 indicate that core ranges (i.e., the 50 percent kernel density polygons) are relatively small (1,173 and 1,535 km^2, respectively) (**Figures 43 and 44**). Data from tagged resident short-finned pilot whales collected off Kauai and from tagged short-finned pilot whales collected off Kauai and Oahu had much larger core ranges for resident populations versus pelagic populations. Tag data were available from five different social groups of short-finned pilot whales, one presumed to be from the pelagic population and four from the insular population. Probability-density analyses were undertaken separately for 17 resident short-finned pilot whales tagged off Kauai since 2008, and for six short-finned pilot whales tagged off Kauai and Oahu thought to be from the pelagic population. Core range for the pelagic population was more than 10 times larger (111,135 km^2) than for the resident population (9,062 km^2), and the overall range was almost an order of magnitude larger for the pelagic population (695,419 km^2) (**Figure 45**). These data suggest that the likelihood of exposure to MFAS on PMRF varies substantially with species, and between insular and pelagic populations. In all three species (short-finned pilot whales, rough-toothed dolphins, and bottlenose dolphins), core areas overlap with PMRF to varying degrees. This trend means that resident animals are likely to be exposed regularly to MFAS, since the channel between Kauai and Niihau is important to these species.

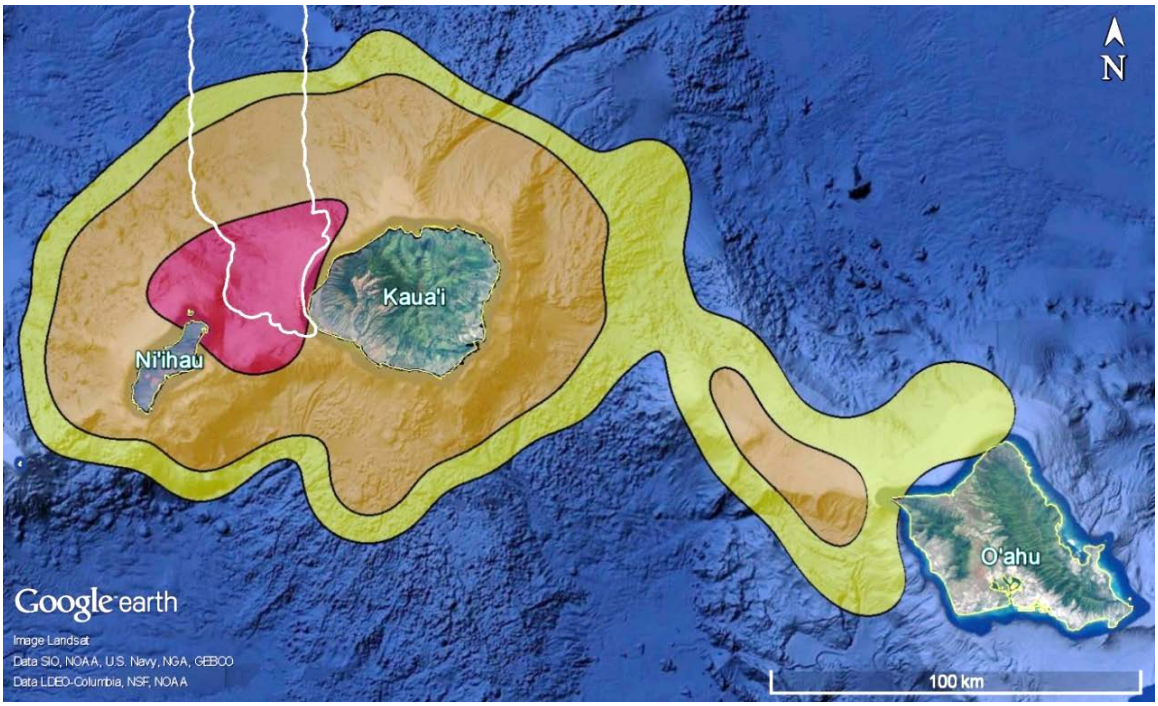

Figure 43. A probability-density representation of rough-toothed dolphin location data for all individuals tagged off Kauai (*n*=17). From: Baird et al. 2016 [Project H7]. The red area indicates the 50 percent density polygon (the "core range"), the tan represents the 95 percent polygon, and the yellow represents the 99 percent polygon.

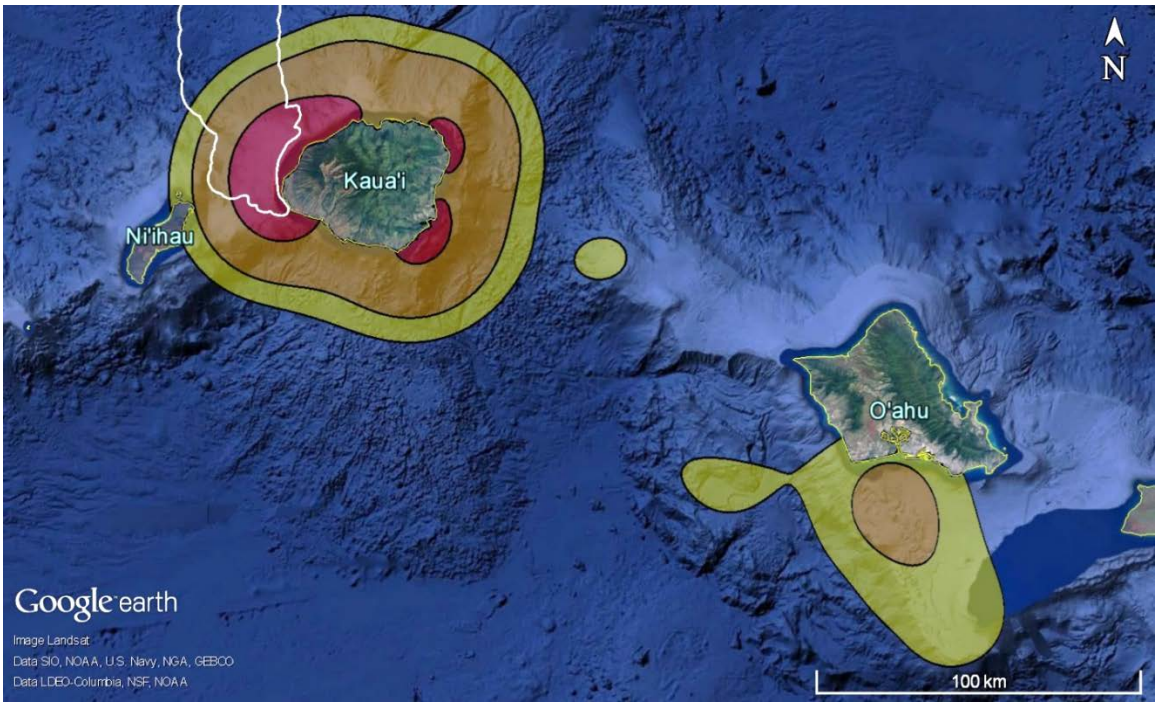

Figure 44. A probability-density representation of bottlenose dolphin location data from all individuals tagged off Kauai (*n*=13). From: Baird et al. 2016 [Project H7]. The red area indicates the 50 percent density polygon (the "core range"), the tan represents the 95 percent polygon, and the yellow represents the 99 percent polygon.

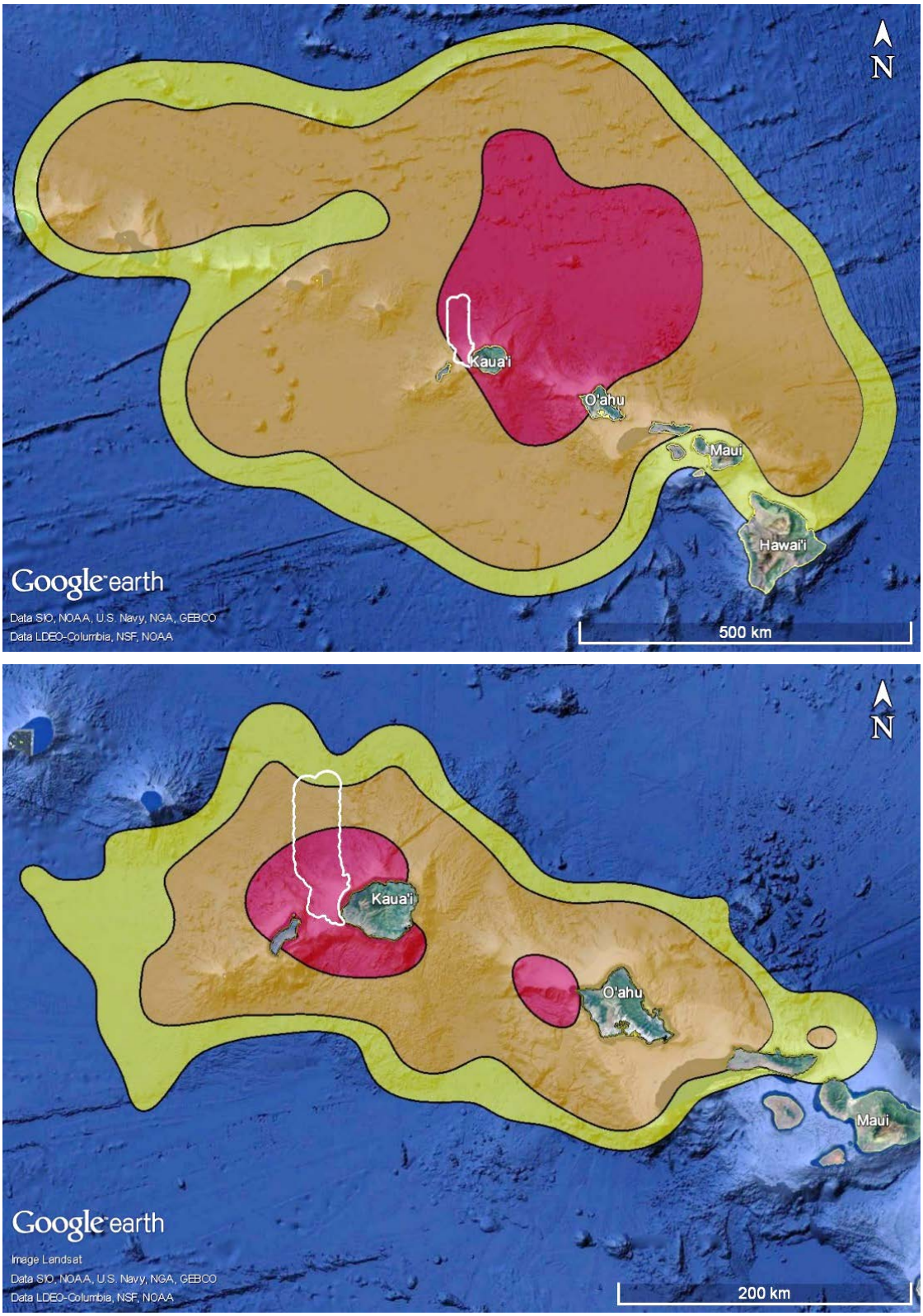

Figure 45. Probability density representation of short-finned pilot whales belonging to the open-ocean population (*n*=6, top) vs. the island-associated population (*n*=17, bottom). From: Baird et al. 2017 [Project H8]. The red area indicates the 50 percent density polygon (the "core range"), the tan represents the 95 percent polygon, and the yellow represents the 99 percent polygon.

2.2.2.7 MONITORING QUESTION: WHAT ARE THE OCCURRENCE OF AND ESTIMATED RECEIVED LEVELS OF MFAS ON 'BLACKFISH' AND ROUGH-TOOTHED DOLPHINS WITHIN THE PMRF INSTRUMENTED RANGE? [PROJECT H8]

In an effort to assess the exposure levels of marine mammals to MFAS, data were analyzed from 20 satellite tags deployed on odontocetes prior to three SCC events held on PMRF between August 2013 and February 2015 (Baird et al. 2017). Eleven of the 20 tags had either stopped transmitting prior to the start of the SCC, or the tagged individuals were too far away from the MFAS source for exposure levels to be estimated. For the other nine individuals (one false killer whale, three rough-toothed dolphins, and five short-finned pilot whales), locations obtained from satellite tags were combined with information on MFAS use and ship tracks from PMRF to assess exposure to MFAS.

The false killer whale (**Figure 46**) was estimated to be exposed to MFAS at distances ranging from 6.5 to 75.4 km over a 1.6-day span. Maximum RLs at 10 m depth were: mean (standard deviation [SD]) = 160.2 (9.55); median = 156.6 dB re: 1 µPa RMS. During the period of MFAS exposure the false killer whale transited in a direction that took it from an area of relatively low exposure (starting at an estimated RL of mean = 90.9 (7.68); median = 89.4 dB re: 1 µPa RMS) to the area of highest RL, moved away from the exposure for several hours, then moved back through the area of exposure (to an estimated maximum mean RL = 150.8 (7.05); median = 157.6 dB re: 1 µPa RMS), then to an area of lower RLs.

The three rough-toothed dolphins were exposed to MFAS at ranges of 19.5 to 94.4 km, with maximum modeled mean (SD) RLs at 10 m of 150.6 (0.96), 155.3 (3.5), and 157.1 (1.5) dB re: 1 µPa RMS. The individual with highest estimated RLs (SbTag014) moved from an area farther from the MFAS source into an area with the maximum estimated RL before moving into an area with lower RLs (<140 dB re: 1 µPa RMS).

The five short-finned pilot whales represented four different groups. Two of the four groups were exposed to MFAS at ranges of 2.3–36.7 and 3.2–48.1 km, while the others were exposed at distances of 14.9–39.5 km and 48.0–57.3 km. Two individuals (GmTag081, GmTag083) exposed at relatively short distances had high maximum modeled RLs at 10 m (GmTag081 mean = 169 (1.41), median = 168.9 dB re: 1 µPa RMS; GmTag083 mean = 168.3 (1.50), median = 167.9 dB re: 1 µPa RMS).

These case studies indicated relatively high exposure levels (>150 dB re: 1 µPa RMS) for all nine individuals studied, all of whom were from populations that are generally resident to the area. Given that MFAS has been used in Hawaii for many years, these individuals have likely been exposed to MFAS on multiple previous occasions.

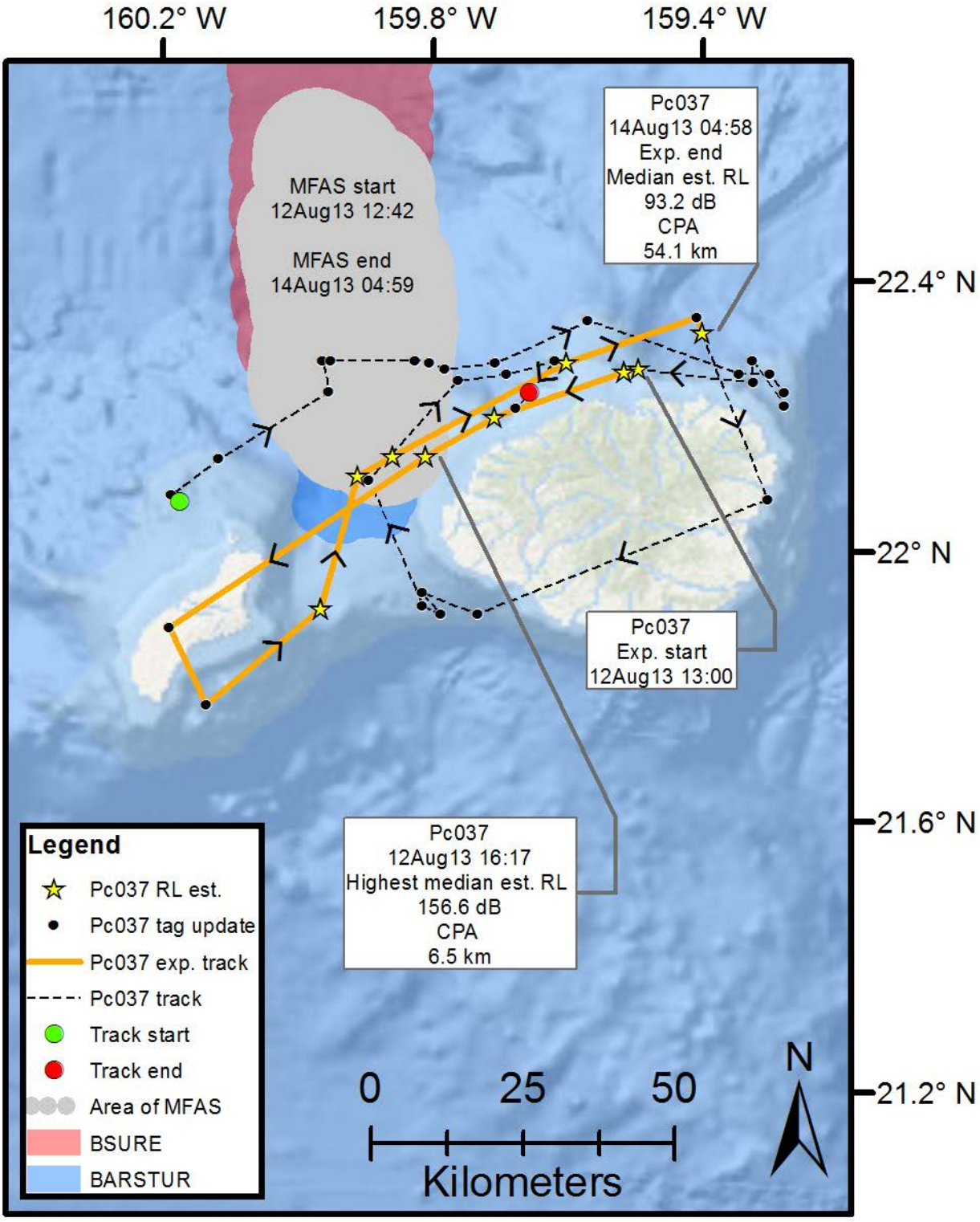

Figure 46. Filtered locations of false killer whale PcTag037 from 11 August to 15 August 2013 prior to, during, and shortly after the end of a SCC. The general area of MFAS use is shown in gray shading, while the interpolated track during MFAS exposure is shown in orange. From: Baird et al. 2017 [Project H8]

2.2.2.8 MONITORING QUESTION: DOES EXPOSURE TO SONAR OR EXPLOSIVES IMPACT THE LONG-TERM FITNESS AND SURVIVAL OF INDIVIDUALS OR THE POPULATION, SPECIES, OR STOCK (WITH FOCUS ON BLUE WHALE, FIN WHALE, HUMPBACK WHALE, CUVIER'S BEAKED WHALE, AND OTHER REGIONAL BEAKED WHALE SPECIES)? [PROJECT S1]

Passive acoustic monitoring was conducted in the U.S. Navy's SOCAL Range Complex from June 2015 to April 2016 to detect marine mammal and anthropogenic sounds (Rice et al. 2017). HARPs recorded sounds between 10 Hz and 100 kHz at three locations: west of San Clemente Island (1,000 m depth, site H), southwest of San Clemente Island (1,200 m depth, site N), and west of La Jolla, California (500 m depth, site P) (**Figure 18**). The goal of this effort was to characterize the vocalizations of marine mammal species present in the area, to determine their seasonal presence patterns, and to evaluate the potential for impact from naval training.

Calls of two baleen whale species were detected: blue whale B calls and fin whale 20-Hz calls. In general, fewer baleen whale (i.e., blue and fin whale) vocalizations were detected at site P, with the highest level of detections at site H. Blue whale calls were detected at all sites and were most prevalent during the summer and fall. Northeast Pacific blue whale B calls were detected from June 2015 through January 2016 with a peak in September 2015. The fall peak in Northeast Pacific B calls is consistent with earlier recordings at these sites (2012: Kerosky et al. 2013a; 2012–2014: Debich et al. 2015a; January–July 2014: Debich et al. 2015b). There was no discernible diel pattern for the Northeast Pacific B calls.

Fin whales were detected throughout the recordings at all sites. The highest values of the fin whale acoustic index (representative of 20-Hz calls) were measured at site H. A peak in the fin whale acoustic index occurred from November 2015 to January 2016. While the peak in the fin whale acoustic index is consistent with earlier recordings, index levels are overall lower than reported for previous monitoring periods (July 2014–May 2015; Širović et al. 2016) but the results are consistent with other reports (2012: Kerosky et al. 2013; 2012–2014: Debich et al. 2015a; January–July 2014: Debich et al. 2015b).

Cuvier's beaked whales were detected throughout the deployment period. FM echolocation pulses from Cuvier's beaked whales were regularly detected at sites H and N but were more common at site H. There were no detections at site P. Detections were highest from November 2015 to April 2016 at site H. There were more Cuvier's beaked whale detections at site H than reported in previous years, but the results at site N were similar to those in previous monitoring periods (July 2014–May 2015; Širović et al. 2016). There was no discernible diel pattern for Cuvier's beaked whale detections. The FM pulse type, BW43, possibly produced by Perrin's beaked whales (Baumann-Pickering et al., 2014) was detected sporadically. Detections were infrequently made at sites H and N, but were more prevalent at site N. BW43 pulses were only detected once in June 2015 at site H, but occurred intermittently at site N between September 2015 and April 2016. There were no detections at site P. There were slightly fewer BW43 detections during June 2015–April 2016 than in the previous monitoring period (July 2014–May 2015; Širović et al. 2016) but the results are consistent with other reports (2012: Kerosky et al. 2013a; 2012–2014: Debich et al. 2015a; January–July 2014: Debich et al. 2015b).There was no discernible diel pattern for BW43 detections.

MFAS was detected at all sites with a peak in August 2015. Site N had the most MFAS packet detections normalized per year and highest CSELs, including events concurrent with a major naval exercise during late August. Site H had fewer detections than site N as well as lower RLs and SELs. Site P had the highest maximum RLs, though the fewest MFAS packet detections.

2.2.3 Conceptual Framework Category 3. Response

The following sections summarize progress made this monitoring year on addressing the issue of *response* of protected marine species to anthropogenic noise generated by U.S .Navy training activities. Only projects conducted in HSTT address this topic.

Monitoring projects conducted in HRC and SOCAL addressed potential *responses* of protected marine species to anthropogenic sound, including call cessation, changes in dive behavior, and stranding likelihood. For example, researchers have analyzed behavioral responses based on data collected before, during, and after a training event and have found differences in: 1) acoustic activity such as calling, 2) foraging activity with changes in RLs, and 3) movement such as relocation to areas outside of where MFAS was used. An analysis of five years of stranding data in the Main Hawaiian Islands (MHI) found no significant difference between the number of strandings occurring before vs. after training events using MFAS, and agreement between the baseline rate of strandings reported by the general public and that recorded during aerial monitoring surveys.

2.2.3.1 MONITORING QUESTION: WHAT, IF ANY, ARE THE SHORT-TERM BEHAVIORAL RESPONSES OF 'BLACKFISH' AND HUMPBACK, MINKE, SPERM, AND BLAINVILLE'S BEAKED WHALES WHEN EXPOSED TO MFAS/EXPLOSIONS AT DIFFERENT LEVELS/CONDITIONS AT PMRF? [PROJECT H2]

Martin et al. (2017) performed estimation of marine mammal exposures to MFAS and possible subsequent behavioral reactions by analyzing data collected before, during, and after SCC training events held at PMRF. Behavior of Blainville's beaked whales and minke whales was analyzed in relation to Navy sonar use.

A semi-automated kinematic tracking and snapshot analysis was used to track 25 minke whales over 4.5 days at PMRF (**Figure 47**). Minke whales emitted more "boing" calls in the first day of data (prior to MFAS onset), with reduction during the periods of MFAS activity during training represented by the gray vertical sections. These data are similar to those previously reported for minke whales during three training events in February of 2011, 2012, and 2013 (Martin et al. 2015). In addition, calling whales in the same latitudinal area as the MFAS activities appeared to reduce calling, or move outside the area where MFAS used. Whales began calling soon after sonar stopped, suggesting some minke whales remain in the area after cessation of calling and resume calling rather than departing the area when sonar activity begins.

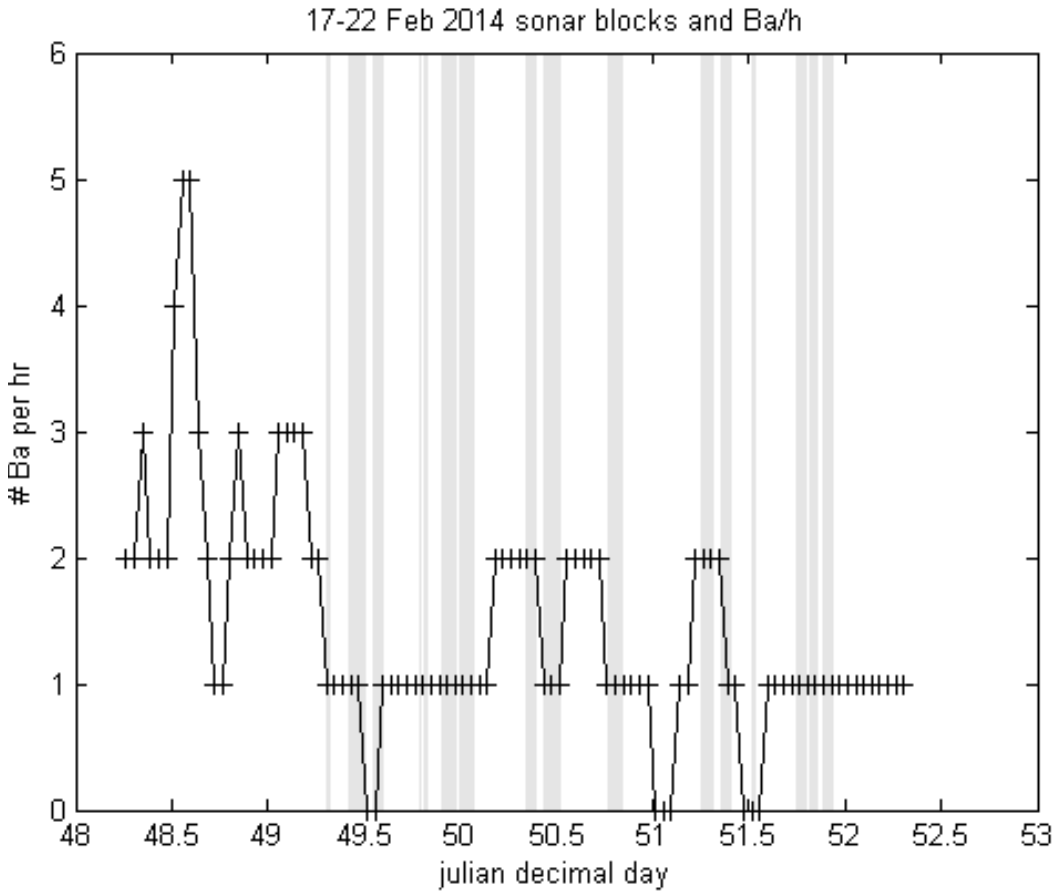

Figure 47. Snapshots per hour of individual minke whale counts over 98 hr of data. Time axis is in Julian decimal days for 17 to 21 February 2014. MFAS activity times are indicated by the gray vertical areas. The data include over a day prior and several hours after MFAS activity. [Project H2]

Martin et al. (2017) also analyzed individual beaked whale group dives that occurred before, during, or after periods of MFAS activity at PMRF. Data from six NTEs that occurred in 2011–2013 were examined to identify changes in foraging behavior by individual Blainville's beaked whale groups that were detected within 30 min of the onset or cessation of sonar. Of the 100 Blainville's beaked whale group vocal periods, or foraging dives, that occurred during MFAS activity or within 30 min of onset or cessation, 24 group dives occurred before sonar started. Of these, 16 dives ended within 5 min of sonar starting (either before or after the onset, considered a response), four dives ended earlier than within 5 min of onset (before sonar started, so no response) and four dives continued after sonar began (no response). Thirty-five group dives began after sonar ended; of these, 23 dives occurred within 15 min of sonar ended (considered a response by groups that were already diving but not actively foraging) while 12 dives occurred within 15 to 30 min of sonar ending (this is considered a response by groups that did not begin diving until the sonar ended). Finally, 37 group dives occurred during periods of sonar; seven of these groups may have responded by starting or ending their foraging dives when the source vessel changed their orientation or proximity to the group, while 30 groups did not appear to respond.

In general, groups presumed to be foraging prior to the onset of sonar—but that ceased foraging when sonar began—experienced higher RLs than those that did not cease foraging when sonar began. The vessel emitting MFAS was generally farther away from groups that did not respond compared to groups that responded. Also, the vessel was approaching the groups that responded more frequently than in groups that did not respond.

2.2.3.2 MONITORING QUESTION: DO MARINE MAMMALS STRAND ALONG SHORELINES OF THE MAIN HAWAIIAN ISLANDS WITHIN ONE WEEK FOLLOWING NAVY TRAINING EVENTS? [PROJECT H6]

From 2010 through 2014, aerial shoreline surveys were performed immediately following NTEs that involved MFAS (Deakos et al. 2017). Although no marine mammal strandings were recorded during any of these aerial surveys (approximately 68 hr of survey effort over 16 days across 2010–2014), strandings reported by the public during this time period throughout the MHI were also analyzed in the context of NTEs involving MFAS. A total of 88 publicly reported strandings over the 5-year period was examined. Sixteen cetacean species were reported as stranded, with spinner dolphins and humpback whales being the most common, representing over 30 percent of all strandings. The absence of observed strandings from the aerial surveys did not significantly depart from the baseline rate of reported strandings for the MHI during the same period. This indicates that the aerial reporting of zero strandings across 16 survey days is consistent with the overall baseline rate. For publicly reported strandings (n=7) that coincided with NTEs that involved aerial monitoring, the probability of strandings occurring before a training event vs. “during and after” (i.e., within 7 days) was not significantly different.

2.2.3.3 MONITORING QUESTION: WHAT, IF ANY, ARE THE SHORT-TERM BEHAVIORAL AND/OR VOCAL RESPONSES WHEN EXPOSED TO SONAR OR EXPLOSIONS AT DIFFERENT LEVELS OR CONDITIONS? [PROJECT S1]

In 2016, work continued on a study of the behavioral impacts of sonar on marine mammals using PAM data collected in SOCAL (Širović et al. 2017). The goal of this study is to examine existing PAM data for acoustic behavioral response of blue whales and Cuvier’s beaked whales to sonar in an area of frequent naval activity. Acoustic data were collected from 2006 to 2015 by HARPs located at four strategic sites (**Figure 18**) where there are long-term recordings and different historic levels of MFAS detections. The recording effort at sites E, H, M, and N from 2006 to 2015 varied between 674 and 2,284 days per site, cumulatively resulting in 19 years of recordings and 227 terabytes (TB) of acoustic data over 79 instrument deployments (**Figure 48**). Although no behavioral response analyses have yet been conducted, researchers are currently engaged in data preparation, definition of signal parameters to be used in analysis, and identification of likely statistical approaches. Models are also being developed to investigate the interplay between acoustic behavior and sonar parameters, such as duration of sonar events, SEL, and maximum received sonar SPLs. Automated routines have been established and/or modified to detect and classify acoustic signals of blue whales and Cuvier’s beaked whales, as well as anthropogenic sounds (e.g., MFAS pings, explosions).

Figure 48. Status of analyses for MFAS, UNDETs, blue whale B and D calls, and Cuvier's beaked whales over 19 years of acoustic recordings, comprising 227 TB of data in 79 deployments at four sites. Colors denote current state of the analysis, as defined in the legend. [Project S1]

2.2.3.4 MONITORING QUESTION: WHAT, IF ANY, ARE THE SHORT-TERM BEHAVIORAL AND/OR VOCAL RESPONSES WHEN EXPOSED TO SONAR OR EXPLOSIONS AT DIFFERENT LEVELS OR CONDITIONS? [PROJECT S2]

An initial risk function was completed for Cuvier's beaked whales (Moretti 2017).This proof-of-concept study was the first application of passive acoustic methods to the derivation of a Cuvier's beaked whale risk function. Sonar pings detected in M3R data archives recorded on SCORE were analyzed in relation to beaked whale vocalizations in order to derive the risk function, which estimates the probability of foraging dive disturbance as a function of sonar RL_{rms}. Overall, the probability of disturbance (measured by group vocalization periods) was predicted to be lowest at moderate sonar intensity and highest at high sonar intensity. The results provide preliminary evidence that sonar detection reports can be used to approximate the impact of MFAS on beaked whale behavior. Researchers also investigated an alternate methodology for determining RL_{rms} by using the voltage level at each hydrophone (which is automatically recorded) as a proxy for RL at the animal as opposed to estimating the RL_{rms} based on a propagation model (Moretti 2017). This method is faster and does not require precise ship tracks. It is presently being validated with data from a calibrated source, which was deployed from the R/V *Sally Ride* in January 2017 at SCORE.

2.2.4 Conceptual Framework Category 4. Consequences

The following section summarizes progress made this monitoring year on addressing potential marine species population *consequences* caused by anthropogenic noise generated by U.S. Navy training activities. Only two projects addressed this topic, and both were conducted in HSTT. As part of these projects, the abundance and density of two beaked whale species were estimated over a 5-year period, and no population-level changes were detected for the time period studied.

2.2.4.1 MONITORING QUESTIONS: WHAT ARE THE LONG-TERM TRENDS IN OCCURRENCE OF MARINE MAMMALS (E.G., MINKE, HUMPBACK, FIN, BRYDE'S, BLAINVILLE'S) ON THE PMRF RANGE? [PROJECT H3]; AND,

DOES EXPOSURE TO SONAR OR EXPLORIVES IMPACT THE LONG-TERM FITNESS AND SURVIVAL OF INDIVIDUALS OR THE POPULATION, SPECIES, OR STOCK (WITH INITIAL FOCUS ON CUVIER'S BEAKED WHALES)? [PROJECT S2]

Beaked whale abundance and density at SCORE and PMRF were estimated using a dive-counting passive acoustic method (Moretti 2017). This approach incorporates echolocation clicks recorded by M3R, mean group size recorded by expert observers, and foraging dive rates measured via depth-recording satellite tags. This method was applied to SCORE detection archives from 2010 to 2014. Annual abundance estimates of beaked whales at SCORE showed no decline in the Cuvier's beaked whale population over the 5-year period from 2010 through 2014 (**Figure 49**). Likewise, initial abundance values for Blainville's beaked whales were derived for PMRF, using M3R data archives from 2010 to 2014. There was no indication of a change in the population trend line for beaked whales over the 5-year project period (**Figure 50**).

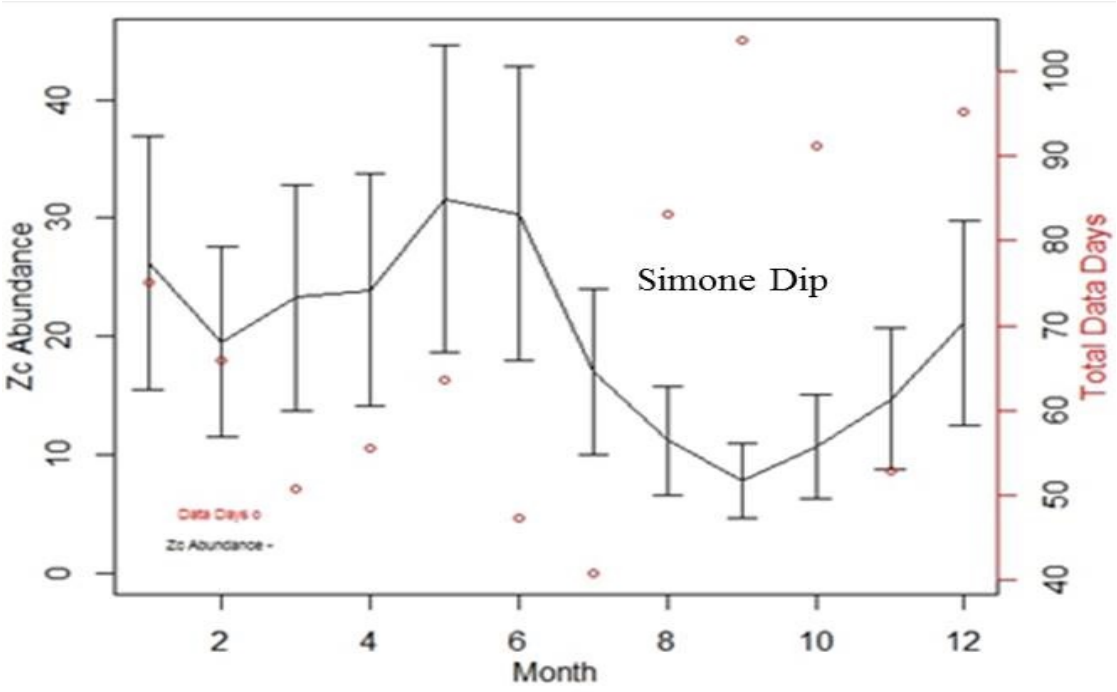

Figure 49. Corrected composite estimate of monthly abundance of Cuvier's beaked whales at SCORE with 2010–2014 data. From: Moretti 2017 [Project H3]

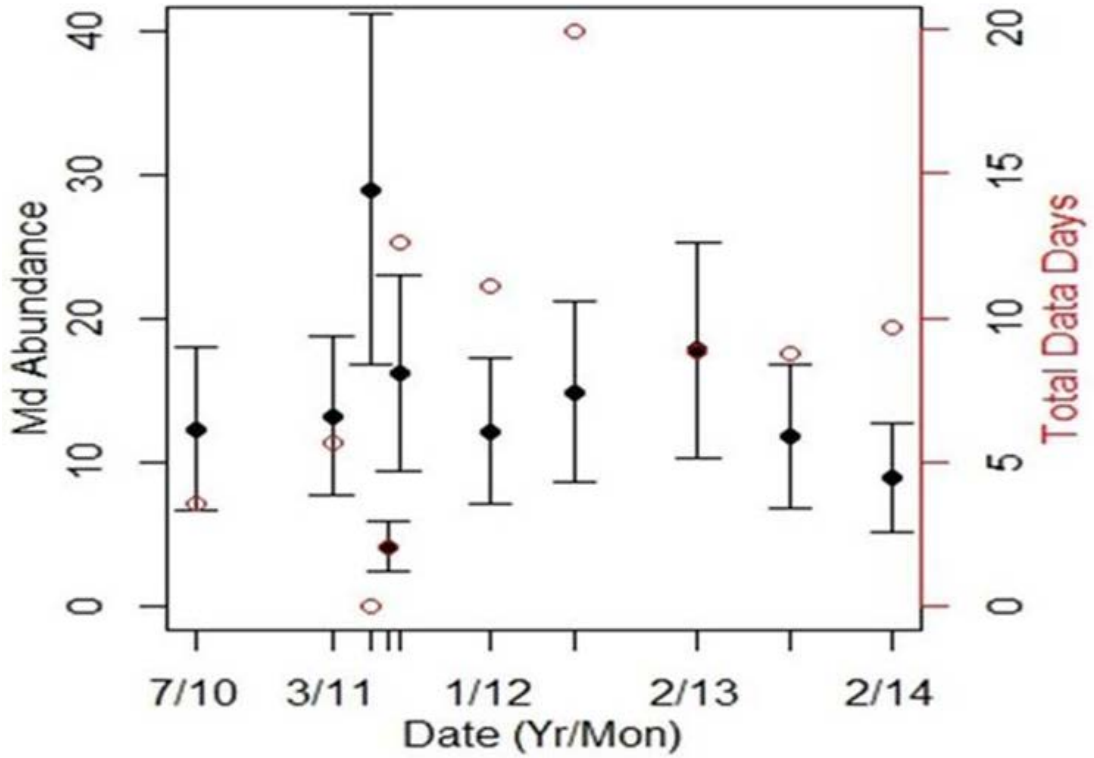

Figure 50. Abundance estimates for 2010–2014 for Blainville's beaked whales at PMRF. From: Moretti 2017 [Project H3]

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3. Adaptive Management and Yearly Monitoring Goals

The Strategic Planning process is used to set intermediate scientific objectives, identify potential species of interest at a regional scale, and evaluate and select specific monitoring projects to fund or continue supporting for a given FY. Continuing or new monitoring projects for calendar year 2017 are listed below in **Table 4** and are also listed on the U.S. Navy's Marine Species Monitoring web site:

http://www.navymarinespeciesmonitoring.us/regions/pacific/current-projects/

Table 4. 2017 Monitoring projects for Pacific Navy Ranges: HSTT (HRC and SOCAL), MITT, NWTT, GOA TMAA

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 11)	Continuing or Proposed New Start
Location: Hawaii Range Complex (HSTT)			
Title: Long-term Trends in Abundance of Marine Mammals at PMRF **Methods:** Analysis of archived PMRF hydrophone recordings **Performer:** Naval Undersea Warfare Center Newport	• What are the long term trends in occurrence of marine mammals (e.g., minke, humpback, fin, Bryde's, Blainville's beaked whales) on the PMRF range?	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes and testing ranges #8: Application of passive acoustic tools and techniques for detecting, classifying, and tracking marine mammals #9: Application of analytic methods to evaluate exposure and/or behavioral response of marine mammals to Navy training and testing activities #12: Evaluate trends in distribution and abundance for populations of protected species that are regularly exposed to sonar and underwater explosives #13: Assess existing data sets which could be utilized to address the current objectives	Continuing from FY15
Title: Estimation of Received Levels of MFAS on Marine Mammals at PMRF **Methods:** PAM, tagging (GPS LIMPET tags if available), photo-ID, biopsy, visual survey. **Performer:** SSC Pacific; and Cascadia Research Collective	• What is the occurrence and estimated received levels of MFAS on 'blackfish,' humpback, minke, sperm and Blainville's beaked whales within the PMRF instrumented range?	#3: Determine what species and populations of marine mammals and ESA-listed species are exposed to Navy training and testing activities #6: Establish the regional baseline vocalization behavior, including seasonality and acoustic characteristics) of marine mammals where Navy training and testing activities occur #7: Determine what behaviors can most effectively be assessed for potential response to Navy training and testing activities. #8: Application of passive acoustic tools and techniques for detecting, classifying, and tracking marine mammals #9: Application of analytic methods to evaluate exposure and/or behavioral response of marine mammals to Navy training and testing activities #10: Evaluate acoustic exposure levels associated with behavioral responses of marine mammals to support development and refinement of acoustic risk functions. #12: Evaluate trends in distribution and abundance for populations of protected species that are regularly exposed to sonar and underwater explosives #13: Assess existing data sets which could be utilized to address the current objectives	Continuing from FY15

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 11)	Continuing or Proposed New Start
Location: Hawaii Range Complex (HSTT) (continued)			
Title: Cetacean studies on PMRF **Methods:** Tagging, photo-ID, biopsy, visual survey **Performer:** Cascadia Research Collective	• What are the spatial-movement and habitat-use patterns (e.g., island-associated or open-ocean, restricted ranges vs. large ranges) of species that are exposed to MFAS, and how do these patterns influence exposure and potential responses?	#4: Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur. #12: Evaluate trends in distribution and abundance for populations of marine mammals and ESA-listed species that are regularly exposed to sonar and underwater explosives.	Continuing from FY15
Title: Behavioral Response of Marine Mammals to Navy Training and Testing at PMRF **Methods:** PAM, tagging, photo-ID, biopsy, visual survey **Performer:** Space and Naval Warfare Systems Center Pacific; Naval Undersea Warfare Center Newport; and Cascadia Research Collective	• What are the occurrence of and estimated received levels of MFAS on 'blackfish' and humpback, minke, sperm, and Blainville's beaked whales within the PMRF instrumented range? • What, if any, are the short-term behavioral responses of 'blackfish' and humpback, minke, sperm, and Blainville's beaked whales when exposed to MFAS/explosions at different levels/conditions at PMRF?	#4: Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur #6: Establish the regional baseline vocalization behavior, including seasonality and acoustic characteristics of marine mammals where Navy training and testing activities occur. #7: Determine what behaviors can most effectively be assessed for potential response to Navy training and testing activities #8: Application of passive acoustic tools and techniques for detecting, classifying, and tracking marine mammals #9: Application of analytic methods to evaluate exposure and/or behavioral response of marine mammals to Navy training and testing activities #10: Evaluate acoustic exposure levels associated with behavioral responses of marine mammals to support development and refinement of acoustic risk functions #11: Evaluate behavioral responses of marine mammals exposed to Navy training and testing activities to support PCoD development and application #12: Evaluate trends in distibution and abundance for populations of marine mammals and ESA-listed species that are regularly exposed to sonar and underwater explosives. #13: Assess existing data sets which could be utilized to address the current objectives	Continuing from FY15
Title: Navy Civilian Marine Mammal Observers on DDGs **Methods:** Visual survey embarked on DDG during training exercise **Performer:** U.S. Navy and HDR, Inc.	• What is the effectiveness of Navy lookouts on Navy surface ships for mitigation and what species are sighted during sonar training events? (This project spans all Navy at-sea ranges.)	#3: Determine what species and populations of marine mammals and ESA-listed species are exposed to Navy training and testing activities. #4: Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur. #11: Evaluate behavioral responses of marine mammals exposed to Navy training and testing activities to support PCoD development and application	Continuing from FY10

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 11)	Continuing or Proposed New Start
Location: Hawaii Range Complex (HSTT) (continued)			
Title: Humpback Whale Tagging Pilot Project **Methods:** (pinger/satellite tagging/PAM) **Performer:** Space and Naval Warfare Systems Center Pacific	• What is the density of humpback whales on and off the instrumented range at PMRF? • What are the movement patterns, habitat use, and behavior of humpback whales (nearshore and offshore) of different age-sex classes on and off the instrumented range at PMRF?	#2: Estimate the distribution, abundance, and density of marine mammals and sea turtles in Navy range complexes, testing ranges, and in specific training and testing areas #4: Establish the baseline habitat-use and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur.	New start FY17. Focus on collecting cue/call rates for PAM-based density estimation, and demonstrating utility of pinger tags for localizing non-vocalizing individuals on the instrumented range.
Location: Southern California Range Complex (HSTT)			
Title: Blue and Fin Whale Satellite Tagging and Genetics **Methods:** Satellite tagging, photo-ID, biopsy, visual survey **Performer:** Oregon State University	• What are the movement patterns, occurrence, and residence times of blue and fin whales within Navy training and testing areas along the U.S. West Coast as compared to other areas visited by tagged whales outside of Navy training and testing areas? • What are the residency time/occupancy patterns of blue whales within NMFS-designated Biologically Important Areas (BIAs) for this species along the U.S. West Coast?	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas #3: Determine what species and populations of marine mammals and ESA-listed species are exposed to Navy training and testing activities. #4: Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur #5: Establish the baseline behavioral patterns(foraging, diving, etc.) of marine mammals where Navy training and testing activities occur.	Continuing from 2014. Final field effort summer 2017. Final analysis and reporting in 2018.
Title: Marine Mammal Sightings During CalCOFI Cruises **Methods:** Visual and passive acoustic surveys during quarterly CalCOFI cruises **Performer:** Scripps Institution of Oceanography, University of California San Diego	• What is the seasonal occurrence and density of cetaceans within the Navy's Southern California Range Complex?	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas #4: Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur	Continuing from 2004 with planned participation through 2018.

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 11)	Continuing or Proposed New Start
Location: Southern California Range Complex (HSTT) (continued)			
Title: Cuvier's Beaked Whale Impact Assessment at the Southern California Offshore Antisubmarine Warfare Range (SOAR) **Methods:** PAM, satellite tagging, Photo-ID, visual survey **Performer:** Naval Undersea Warfare Center Newport	• What are the baseline population demographics, vital rates, and movement patterns for a designated key species in the SOCAL range complex? • What, if any, are the short-term behavioral and/or vocal responses when exposed to sonar or explosions at different levels or conditions? • Does exposure to sonar or explosives impact the long-term fitness and survival of individuals or the population, species or stock? (with initial focus on Cuvier's beaked whales)	#2: Estimate the distribution, abundance, and density of marine mammals and sea turtles in Navy range complexes, testing ranges, and in specific training and testing areas. #4: Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur #6: Establish the regional baseline vocalization behavior, including seasonality and acoustic characteristics) of marine mammals where Navy training and testing activities occur #7: Determine what behaviors can most effectively be assessed for potential response to Navy training and testing activities #8: Application of passive acoustic tools and techniques for detecting, classifying, and tracking marine mammals #9: Application of analytic methods to evaluate exposure and/or behavioral response of marine mammals to Navy training and testing activities #11: Evaluate behavioral responses of marine mammals exposed to Navy training and testing activities to support PCoD development and application #12: Evaluate trends in distribution and abundance for populations of marine mammals and ESA-listed species that are regularly exposed to sonar and underwater explosives. #13: Assess existing data sets which could be utilized to address the current objectives	Continuing from 2016
Title: Navy Civilian Marine Mammal Observers On DDGs **Methods:** Visual survey embarked on DDG during training exercise **Performer:** U.S. Navy and HDR, Inc.	• What is the effectiveness of Navy lookouts on Navy surface ships for mitigation and what species are sighted during sonar training events? (This project spans all Navy at-sea ranges.)	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas #11: Evaluate behavioral responses of marine mammals exposed to Navy training and testing activities to support PCoD development and application	Continuing from FY10.

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 11)	Continuing or Proposed New Start
Location: Southern California Range Complex (HSTT) (continued)			
Title: Cuvier's Beaked Whale, Blue Whale, and Fin Whale Impact Assessments at Non-Instrumented Range Locations in the SOCAL Range Complex **Methods:** PAM **Performer:** Scripps Institution of Oceanography, University of California San Diego	• What, if any, are the short-term behavioral and/or vocal responses when exposed to sonar or explosions at different levels or conditions? • Does exposure to sonar or explosives impact the long-term fitness and survival of individuals or the population, species, or stock? (with focus on blue whale, fin whale, humpback whale, Cuvier's beaked whale, and other regional beaked whale species)	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas #4: Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur #6: Establish the regional baseline vocalization behavior, including seasonality and acoustic characteristics) of marine mammals where Navy training and testing activities occur #7: Determine what behaviors can most effectively be assessed for potential response to Navy training and testing activities #8: Application of passive acoustic tools and techniques for detecting, classifying, and tracking marine mammals #9: Application of analytic methods to evaluate exposure and/or behavioral response of marine mammals to Navy training and testing activities #10: Evaluate acoustic exposure levels associated with behavioral responses of marine mammals to support development and refinement of acoustic risk functions #11: Evaluate behavioral responses by marine mammals exposed to Navy training and testing activities to support PCoD development and application. #13: Assess existing data sets which could be utilized to address the current objectives	Continuing from 2015
Location: Mariana Islands Training and Testing			
Title: Small-vessel Visual Surveys **Methods:** Visual surveys (nearshore small vessel winter and summer season), photo-identification (develop catalogs for multiple cetacean species), biopsy and genetic analysis, satellite tagging, opportunistic acoustic recording during sightings **Performer:** National Marine Fisheries Service Pacific Islands Fisheries Science Center Cetacean Research Program	• What species of beaked whales and other odontocetes occur in the MITT study area? • Are there locations of greater relative cetacean abundance in the MITT study area? • What is the baseline abundance and population structure of cetaceans that may be exposed to sonar and/or explosives in the MITT study area? • What is the seasonal occurrence and movements of baleen whales in the MITT study area? • What is the exposure of cetaceans and sea turtles to explosives and/or sonar in the MITT study area?	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas #2: Estimate the distribution, abundance, and density of marine mammals and sea turtles in Navy range complexes, testing ranges, and in specific training and testing areas #3: Determine what species and populations of marine mammals and ESA-listed species are exposed to Navy training and testing activities #4: Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur #5: Establish the baseline behavioral patterns(foraging, diving, etc.) of marine mammals where Navy training and testing activities occur.	Continuing from FY10

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 11)	Continuing or Proposed New Start
Location: Mariana Islands Training and Testing (continued)			
Title: Acoustic Analysis of High-frequency Acoustic Recording Package Data **Methods:** Analysis of archived acoustic recordings made by moored high frequency passive acoustic monitoring devices **Performer:** National Marine Fisheries Service Pacific Islands Fisheries Science Center Cetacean Research Program	• What patterns of variability are present in the Blainville's beaked whale calls?	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas #3: Determine what species and populations of marine mammals and ESA-listed species are exposed to Navy training and testing activities #6: Establish the regional baseline vocalization behavior, including seasonality and acoustic characteristics) of marine mammals where Navy training and testing activities occur #8: Application of passive acoustic tools and techniques for detecting, classifying, and tracking marine mammals	Continuing from FY12
Title: Sea Turtle Tagging in the Mariana Islands Training and Testing Study Area **Methods:** Sea turtle satellite tagging, habitat use analysis of tag data **Performer:** National Marine Fisheries Service Pacific Islands Fisheries Science Center Marine Turtle Biology & Assessment Program	• What are the occurrence, habitat use, abundance, and population structure of sea turtles in the MITT study area? • What is the exposure of cetaceans and sea turtles to explosives and/or sonar in the MITT study area? • Are there locations of greater cetacean and/or sea turtle concentration in the MITT study area?	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas #2: Estimate the distribution, abundance, and density of marine mammals and sea turtles in Navy range complexes, testing ranges, and in specific training and testing areas #3: Determine what species and populations of marine mammals and ESA-listed species are exposed to Navy training and testing activities #4: Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur #12: Evaluate trends in distribution and abundance for populations of marine mammals and ESA-listed species that are regularly exposed to sonar and underwater explosives.	Continuing from FY14

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 11)	Continuing or Proposed New Start
Location: Northwest Training and Testing			
Title: Modeling the Offshore Distribution of Southern Resident Killer Whales and Chinook salmon in the Pacific Northwest **Methods:** Passive acoustic monitoring, model development, analyze multi-year archival data. **Performer**: National Marine Fisheries Service Northwest Fisheries Science Center, Cascadia Research Collective	• What are the seasonal and annual occurrence patterns of Southern Resident killer whales relative to offshore Navy training ranges? • What is the seasonal distribution and variability between runs (spring runs vs fall runs) of Chinook salmon stocks in coastal waters (Southeast Alaska to California)?	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas #2: Estimate the distribution, abundance, and density of marine mammals and sea turtles in Navy range complexes, testing ranges, and in specific training and testing areas #3: Determine what species and populations of marine mammals and ESA-listed species are exposed to Navy training and testing activities #4: Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur #6: Establish the regional baseline vocalization behavior, including seasonality and acoustic characteristics) of marine mammals where Navy training and testing activities occur	Continuing from 2014. Reporting expected 2017 for Chinook salmon component
Title: Humpback Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean **Methods:** Satellite tagging, photo ID, biopsy, visual survey **Performer**: Oregon State University	• What are the occurrence, movement patterns, and residency patterns of multiple humpback whale Distinct Population Segments within Navy Pacific Ocean at-sea ranges (SOCAL,HRC, NWTT, GOA)?	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas #3: Determine what species and populations of marine mammals and ESA-listed species are exposed to Navy training and testing activities #4: Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur	New start. Field work in 2017, analysis and reporting expected through 2018.
Location: Gulf of Alaska Temporary Maritime Activities Area			
Title: Passive Acoustic Monitoring of Marine Mammals in the Gulf of Alaska Temporary Maritime Activities Area using Bottom-Mounted Devices **Methods:** Passive acoustic monitoring **Performer:** Scripps Institution of Oceanography, University of California San Diego	• What is the temporal occurrence of baleen whales and beaked whales in the GOA TMAA?	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas #6: Establish the regional baseline vocalization behavior, including seasonality and acoustic characteristics) of marine mammals where Navy training and testing activities occur #8: Application of passive acoustic tools and techniques for detecting, classifying, and tracking marine mammals #11: Evaluate behavioral responses of marine mammals exposed to Navy training and testing activities to support PCoD development and application	Re-start in 2017 of similar effort July 2011–September 2015 that was associated with the first set of 5-year authorizations and environmental planning for GOA TMAA. Field work May-July 2017, with reporting expected in March 2018.

Concluding Projects

Several monitoring projects concluded their final year of effort in 2016, and will not continue in 2017:

- **Marine Mammal Density Surveys in the Pacific Northwest (Inland Puget Sound)**. This was the fourth and final year to estimate seasonal in-water density and abundance of marine mammals, particularly harbor porpoise and harbor seals. From 2013 to 2016, a series of systematic line-transect aerial surveys were conducted to cover Puget Sound and encompassing inland waters of Washington State. Effort spanned all four seasons. Data were sufficient to estimate in-water densities and abundances of harbor seals and harbor porpoise with good precision. Observations of harbor porpoise document a marked increase in the abundance and density of this species since the early 1990s. This is concurrent with a decline in Dall's porpoise sightings in Puget Sound, the reasons for which are unknown.
- **Tagging and Behavioral Monitoring of Sea Lions in the Pacific Northwest in Proximity to Navy Facilities.** 2016 represented the third and final year of sea lion tagging at naval facilities. Objectives of this research effort were to: determine the correction factor which would "correct" the in-water density estimates and to describe regional marine habitat usage by adult male California sea lions in the inland and offshore waters of the NWTT Study Area. Final reporting expected in 2017.
- **PAM for Marine Mammals in the NWTRC.** Deployment of offshore HARPs concluded with the last device removed in May 2015. Reporting included in this annual report represents a final analysis of NWTT passive acoustic data cumulatively collected from July 2004 through May 2014 (Wiggins et al. 2017)."
- **Aerial Survey Monitoring for Marine Mammals and Sea Turtles in the Hawaii Range Complex in Conjunction with a Navy Training Event: SCC.** Orbital aerial surveys following Navy ships conducting exercises have been performed in HRC since February 2009, with the first such ship-follow survey conducted over the same ship for the Lookout Effectiveness [H5] study in February 2010. The first combination of ship-follow aerial survey, Lookout Effectiveness, and acoustic recording by the instrumented range was in February 2011. This methodology was utilized with the goal of obtaining focal follows from animals in close proximity to an NTE to ascertain exposure and response. Due primarily to limitations of locally available aircraft and challenging sea states, obtaining a sufficient sample size of high-quality focal follow video for visual behavioral analysis has been less productive than initially hoped. Additionally, although not without its own limitations, the alternative approach of utilizing satellite tag telemetry in conjunction with acoustic analysis from the instrumented range [H7] for estimation of received level, and some types of behavioral response are currently prioritized over the aerial methodology.
- **Shoreline Survey and Stranding Summary.** Aerial surveys searching shorelines of the Hawaiian Islands for stranded marine mammals following Navy training events using MFAS were conducted in 2010–2014. Each of these individual aerial surveys resulted in separate technical reports. The report presented this year was a final summary of the

results of all of these surveys combined. The primary result is that no sightings of stranded animals were made across all these surveys. Additionally, local stranding network data were utilized to determine that the baseline rate of stranding detections was consistent with the result of no aerial detections, as well as to determine that these data could not detect any effect of increased stranding rates when comparing “before exercise” with “during and after exercise” periods associated with the same Navy training events that had been aerially surveyed. These results suggest that further investment in these surveys are not likely to be productive. Therefore with this final summary and analysis, the post-exercise aerial shoreline aerial survey project has been completed.

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