2017 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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List of Contributors (Main Document):
Kristen Ampela (HDR, Inc.), Cathy E. Bacon (HDR, Inc.), Andrea Balla-Holden (U.S. Pacific Fleet), Mark Deakos (HDR, Inc.), Dagmar Fertl (HDR, Inc.), Chip Johnson (U.S. Pacific Fleet), Julie A. Rivers (U.S. Pacific Fleet), Jessica Chen (Naval Facilities Engineering Command, Pacific), and Robert K. Uyeyama (Naval Facilities Engineering Command, Pacific).

List of Contributors (Technical Reports) (Alphabetized by organization):
Robin W. Baird, (Cascadia Research Collective); Thomas A. Jefferson (Clymene Enterprises); Kristen Ampela, Jessica Aschettino, and Mark H. Deakos (HDR, Inc.); Tara Leota (Kauai Sea Rider Adventures); Erin A. Falcone, Erin L. Keene, Brenda K. Rone, and Gregory S. Schorr (Marine Ecology and Telemetry Research); Gabriela C. Alongi, Cameron R. Martin, Stephen W. Martin, and Brian M. Matsuyama (National Marine Mammal Foundation); Nancy DiMarzio and David J. Moretti (Naval Undersea Warfare Center Division Newport); Robert L. DeLong, Patrick Gearin, Jeffrey D. Harris, Jeffrey L. Laake, Sharon R. Melin, and Anthony J. Orr (NOAA Fisheries-AFSC); Brian Burke, Candice K. Emmons, Blake E. Feist, M. Bradley Hanson, Marla M. Holt, Andrew O. Shelton, and Eric J. Ward (NOAA-NWFSC); Amanda L. Bradford, T. Todd Jones, Allan D. Ligon, Summer L. Martin, Erin M. Oleson, and Adam C. Ü (NOAA Fisheries-PIFSC); Marie C. Hill (NOAA Fisheries-PIFSC and Joint Institute for Marine and Atmospheric Research, Research Corporation of the University of Hawaii); William H. Satterthwaite (NOAA-SWFSC); C. Scott Baker, Tomas Follett, Craig Hayslip, Ladd M. Irvine, Barbara A. Lagerquist, Bruce R. Mate, Daniel M. Palacios, Debbie Steel, and Martha H. Winsor (Oregon State University); Marie A. Roch (San Diego State University); Simone Baumann-Pickering, Amanda J. Debich, John A. Hildebrand, Anna Meyer-Löbbecke, Macey Rafter, Ally C. Rice, Ana Širović, Bruce J. Thayre, Jennifer S. Trickey, Sean M. Wiggins, and Emily Wilson (Scripps Institution of Oceanography); Mari A. Smultea (Smultea Environmental Sciences); Leslie Bolick, Jessica Carilli, Tyler A. Helble, E. Elizabeth Henderson, Roanne A. Manzano-Roth, Donald E. Marx, Jr., and Stephen H. Smith (Space and Naval Warfare Systems Center Pacific); Ben Jones, Cornelia Oedekoven, and Len Thomas (University of St. Andrews); Steven Jeffries, Dyanna Lambourn, and Josh Oliver (Washington Department of Fish and Wildlife).

Photograph Credit:
Blainville's beaked whale (*Mesoplodon densirostris*) photographed off Kauai by Mark Deakos under NMFS Permit #14451.

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, 2016a). 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) including the Naval Sea Systems Command's Naval Undersea Warfare Center Keyport Range Complex (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 for HSTT (NMFS 2013a, 2014b), MITT (NMFS 2015a), NWTT (NMFS 2015e), and GOA TMAA (NMFS 2011a, b, 2017b); Letters of Authorization (LOA) under the MMPA to Commander, U.S. Pacific Fleet and Commander, Naval Sea Systems Command for HSTT (NMFS 2013b, c), MITT (NMFS 2015b, 2016a), NWTT (NMFS 2015f, g), and GOA TMAA (NMFS 2011c, 2013d, 2017a); and Biological Opinions (BOs) under the Endangered Species Act for HSTT (NMFS 2013f, 2014a, 2015d, 2015i), MITT (NMFS 2015c, 2017d), NWTT (NMFS 2015h), and the GOA TMAA (NMFS 2011d, 2013e, 2017c).

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 § 218.155(f) (GOA TMAA).

This monitoring report was prepared in accordance with the annual monitoring reporting requirements for 2017, as described in these regulations. It presents NMFS and the public with results and progress made during the period of 1 January 2017 to 31 December 2017. 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, NWTT, and GOA TMAA monitoring programs are currently within the second set of 5-year authorizations and environmental planning documentation 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.

These objectives are considered within the conceptual framework that was developed in consultation with the project's Scientific Advisory Group (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 about marine species and their interaction with U.S. Navy training and testing activities.

With regard to these conceptual framework categories, several projects in 2017, particularly in HRC and SOCAL, represented progress beyond conceptual category of *occurrence* that of 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 assessing any population *consequences* resulting from these activities by investigating population trends.

Highlights of current scientific progress over the course of this reporting period include the following:

- Conducted visual cetacean surveys, photo-identification (photo-ID), biopsy sampling, and satellite tagging offshore of Guam, Saipan, and Tinian (at-sea ranges in the MITT), to characterize species' presence in nearshore waters. Kernel density estimation to examine core areas of usage for cetaceans in the MITT is underway, as is data analyses of high-frequency acoustic recording packages deployed in the MITT.
- Conducted coral reef surveys at Farallon de Medinilla in the Mariana archipelago; observed species included the Endangered Species Act-listed corals *Acropora globiceps* (1 colony) and *Pavona diffluens* (3 colonies). Found no evidence of significant impacts to coral (e.g., breakage, craters) from Navy training activities.
- Conducted satellite tagging of sea turtles at Guam and Saipan.
- Monitored marine mammals at PMRF using the bottom-mounted hydrophone range, which included two naval training events involving MFAS. Highlights included:
    - Estimated cumulative sound exposure from MFAS for 31 minke whales (*Balaenoptera acutorostrata*) tracked before and during a February 2017 Naval training event.
    - Improved automated detectors for Blainville's beaked whale (*Mesoplodon densirostris*) clicks, to better distinguish these from Cuvier's beaked whale and Cross Seamount-type beaked whale clicks.
    - A dive-counting passive acoustic analysis revealed no evidence of a decline in beaked whale abundance at PMRF from 2010 to 2017.
- Conducted visual surveys of odontocetes (including photo-ID, biopsy sampling, and satellite tagging) prior to a naval training event to collect data to be used in conjunction with marine mammal passive acoustic monitoring on U.S. Navy ranges at Pacific Missile Range Facility (PMRF). Analysis and final reporting ongoing, though preliminary results were provided and highlights included:
    - The telemetry of tagged pantropical spotted dolphins (*Stenella attenuata*) supports the hypothesis that there is no island-associated population of this

species off Kauai and Niihau. Also, melon-headed whales (*Peponocephala electra*) were sighted (and tagged) on PMRF for the first time since 2008.

- Two melon-headed whales were seen associating with rough-toothed dolphins (*Steno bredanensis*) on two occasions. One individual appeared to be a hybrid between a melon-headed whale and a rough-toothed dolphin. A biopsy sample was taken. Genetic analyses are underway to confirm hybrid ancestry.

- Humpback whales satellite-tagged in offshore waters between Kauai and Niihau were tracked directly north across abyssal waters, as well as past Kaula and Middle Bank towards the northwestern Hawaiian islands.
- Used generalized estimating equations (GEEs) to investigate the impacts of sonar on blue whales (*Balaenoptera musculus*) and Cuvier's beaked whales (*Ziphius cavirostris*) in SOCAL from passive acoustic monitoring data.
- Analyzed passive acoustic monitoring data from high-frequency acoustic recording packages in SOCAL and GOA TMAA for fin whale (*Balaenoptera physalus*) presence and seasonal occurrence. For SOCAL, this included analyses to compare patterns in fin whale song occurrence across the Southern California Bight. For GOA TMAA, dive behavior and call types were analyzed for a pair of fin whales in the GOA.
- Deployed satellite tags on blue whales and fin whales to study movement patterns and habitat use along the west coast of North America, including with respect to Navy range complexes and designated Biologically Important Areas; analyzed genetic samples to determine sex of the individuals, to define haplotypes for stock analysis, and to confirm species identification. Other accomplishments included:
    - Documented travel of satellite-tagged baleen whales in SOCAL moving throughout the range and into the NWTT.
    - Deployed dive monitoring tags on baleen whales to record dive depths, duration and body orientation/acceleration that reveal behavioral states such as foraging and traveling.
- Deployed satellite tags on humpback whales (*Megaptera novaeangliae*) to study habitat use (including with respect to designated Biologically Important Areas) by Distinct Population Segment (DPS), as determined by mitochondrial haplotype sequencing and nuclear microsatellite loci.
    - Located humpback whales tagged off Washington/Oregon in an area that encompassed northern California to Vancouver Island. Humpback whales tagged and biopsied off California ranged from Santa Barbara Channel (southern California) to the central Oregon coast.
    - One humpback whale has successful tag transmission of sufficient duration to track progress heading south to Bandaras Bay off Puerto Vallarta Mexico (160 days through Feb 2018). PhotoID from local researchers in Mexico confirm the

same whale and document social interactions with other humpback whales at this location.

- Monitored marine mammals at the Southern California Offshore Anti-Submarine Range (SOAR), including vessel-based surveys collecting satellite tagging, biopsy sampling, and analyzed photo-ID data for Cuvier's beaked whales and fin whales at SOAR. Highlights included:
    - Developed Cuvier's beaked whale calving and weaning rate data for Population Consequences of Disturbance models on Southern California Antisubmarine Warfare Range, using sightings of known reproductive Cuvier's beaked whale females with and without calves over time
    - Incorporated an automated sonar detector performing on streaming data into the Marine Mammal Monitoring on U.S. Navy Ranges software at SOAR.
    - A dive-counting passive acoustic analysis revealed no evidence of a decline in beaked whale abundance at SOAR from 2010 to 2017.
- Conducted near-shore and off-shore large vessel marine mammal survey concurrent with quarterly California Cooperative Oceanic Fisheries Investigations cruises in Southern California.
- Assessed the seasonal occurrence of endangered Southern Resident killer whales (*Orcinus orca*) relative to naval training ranges using satellite tag data, compiling visual and acoustic detections, and conducting spatial modeling.
- Estimated seasonal in-water density and abundance of harbor seals (*Phoca vitulina*) for six sub-regions in Puget Sound, Washington.
- Performed a kernel density analysis for California sea lions (*Zalophus californianus*) using four U.S. Navy facilities in Puget Sound, to describe how adult male sea lions use the area for foraging.
- Constructed the first coastwide state-space model for fall-run Chinook salmon (*Oncorhynchus tshawytscha*) using data from coded wire tags to estimate seasonal ocean distribution along the west coast of North America.
- Continued transition of the Marine Mammal Monitoring on U.S. Navy Ranges (M3R) project from the U.S. Navy's Living Marine Resources (LMR) applied research program to U.S. Pacific Fleet compliance monitoring. LMR and Pacific Fleet continue to fund separate but related and coordinated projects on SOAR.

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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
BREVE	Behavioral Response Evaluations Employing
BW	beaked whale
CA	core area(s)
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CARB	Compact Acoustic Recording Buoy
CFC	Conceptual Framework Category
CFR	Code of Federal Regulations
CNMI	Commonwealth of the Northern Mariana Islands
CRC	Cascadia Research Collective
CRP	Cetacean Research Program
CSEL	cumulative sound exposure level
d	day(s)
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
DDG	guided missile destroyer
DEMVAL	Demonstration-Validation
DM	dive monitoring
DoN	Department of Navy
DUR	dive duration monitoring
DPS	Distinct Population Segment
DSC	dominant signal component
EA	Environmental Assessment
EAR	Ecological Acoustic Recorder
EIS	Environmental Impact Statement
ESA	Endangered Species Act
EEZ	Exclusive Economic Zone
FDM	Farallon de Medinilla
FM	frequency-modulated
FY	fiscal year
GEE	generalized estimating equation
GOA	Gulf of Alaska
GPS	Global Positioning System
GVP	group vocal period(s)
HARP	high-frequency acoustic recording package
hr	hour(s)
HR	home range(s)
HRC	Hawaii Range Complex
HSTT	Hawaii-Southern California Training and Testing
Hz	Hertz
ICMP	Integrated Comprehensive Monitoring Program
IPI	interpulse intervals
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	location-only
LOA	Letters of Authorization
LOE	lookout effectiveness
m	meter(s)
M3R	Marine Mammal Monitoring on U.S. 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
NMFS	National Marine Fisheries Service
NTE	Navy Training Event
NUWC	Naval Undersea Warfare Center
NWFSC	Northwest Fisheries Science 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
OSI	Oceanwide Science Institute
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
PT MUGU	Point Mugu Sea Range
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 Command Course
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 Pacific	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
W237	Warning Area 237

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 (GOA) Navy Training Activities (DoN 2011a, 2016a). 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) including Naval Sea Systems Command's Naval Undersea Warfare Center (NUWC) Keyport Range Complex (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 for HSTT (NMFS 2013a, 2014b), MITT (NMFS 2015a), NWTT (NMFS 2015e), and GOA TMAA (NMFS 2011a, b, 2017b); Letters of Authorization (LOA) under the MMPA to Commander, U.S. Pacific Fleet and Commander, Naval Sea Systems Command for HSTT (NMFS 2013b, c), MITT (NMFS 2015b, 2016a), NWTT (NMFS 2015f, g), and GOA TMAA (NMFS 2011c, 2013d, 2017a); and Biological Opinions (BOs) under the Endangered Species Act (ESA) for HSTT (NMFS 2013f, 2014a, 2015d, 2015i), MITT (NMFS 2015c, 2017d), NWTT (NMFS 2015h), and GOA TMAA (NMFS 2011d, 2013e, 2017c).

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 § 218.155(f) (GOA TMAA).

This monitoring report was prepared in accordance with the annual monitoring reporting requirements for 2017, as described in these regulations. The authorizations for GOA TMAA were valid beginning 26 April 2017, with ongoing analysis and reporting efforts for collecting monitoring data in the study area from the previous authorizations.

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 documentation 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 (ISOs).

Furthermore, the regulations cited above associated with the authorizations for HSTT, MITT, NWTT, and GOA TMAA (i.e., § 218.75(e), § 218.95(e), § 218.145(f), and § 218.155(f), respectively) have in common an option for satisfying the monitoring report requirement with a multi-range-complex report:

> *"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."*

Therefore, monitoring results from all Pacific U.S. Navy ranges, (i.e., HSTT, MITT, NWTT, and GOA TMAA), are treated in this report in an integrated fashion in order to allow comparison across ranges and a cumulative view of progress made on monitoring goals across ranges. This report is the third such "multi-range"-complex annual monitoring report (see DoN 2016a, 2017).

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/). Projects are discussed annually with NMFS at an Adaptive Management Meeting and reprioritized as needed. This report contains a review of progress made on these projects in the 2017 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 HSTT Study Area includes two existing U.S. Navy range complexes: HRC (**Figure 2**) and SOCAL (**Figure 3**), and a representative transit lane between them.

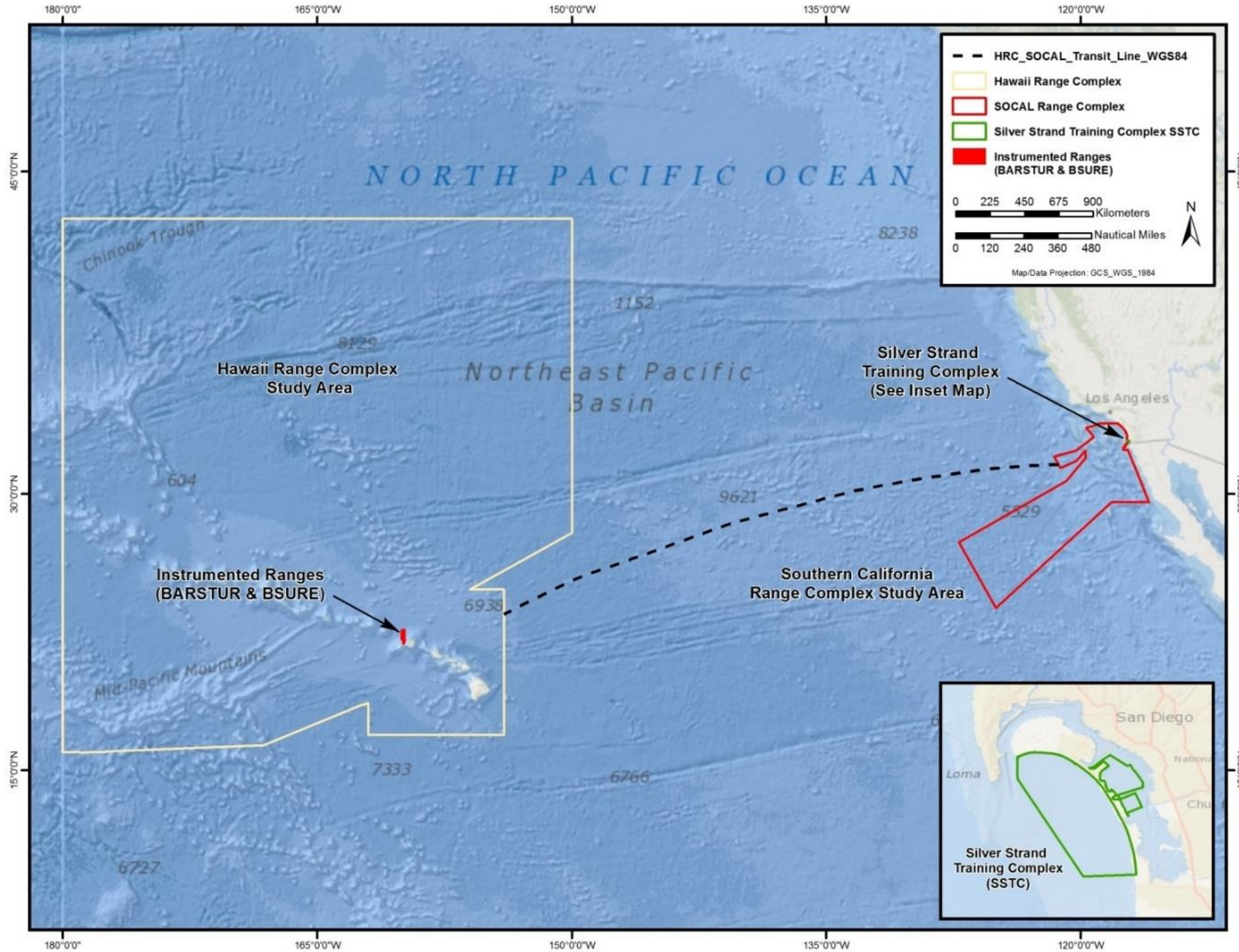

Figure 1. Hawaii-Southern California Training and Testing Study Area, showing Hawaii Range Complex, Southern California Range Complex, the transit lane between them, and Silver Strand Training Complex. From: DoN 2013a.

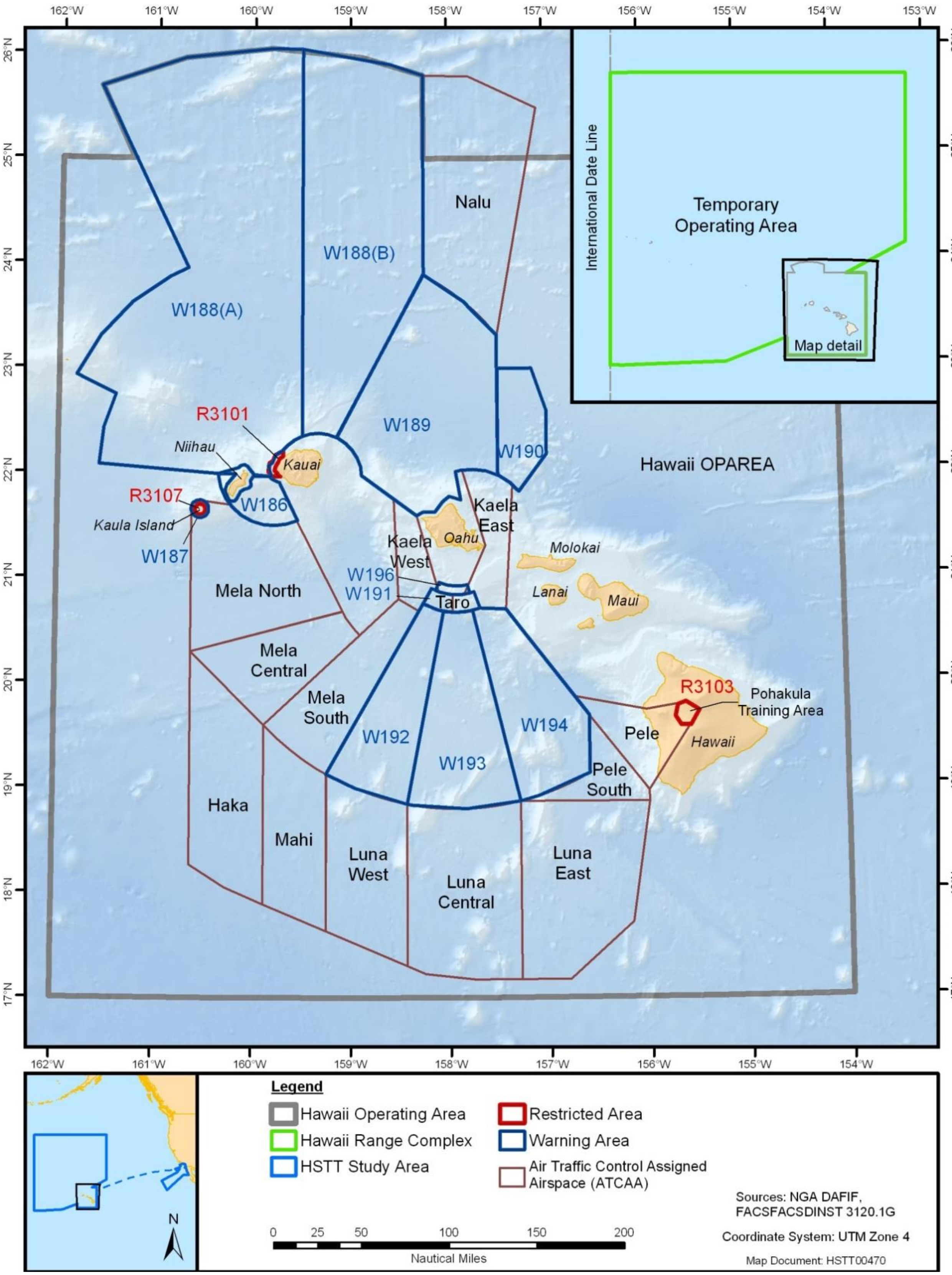

Figure 2. Hawaii Range Complex. From: DoN 2013a.

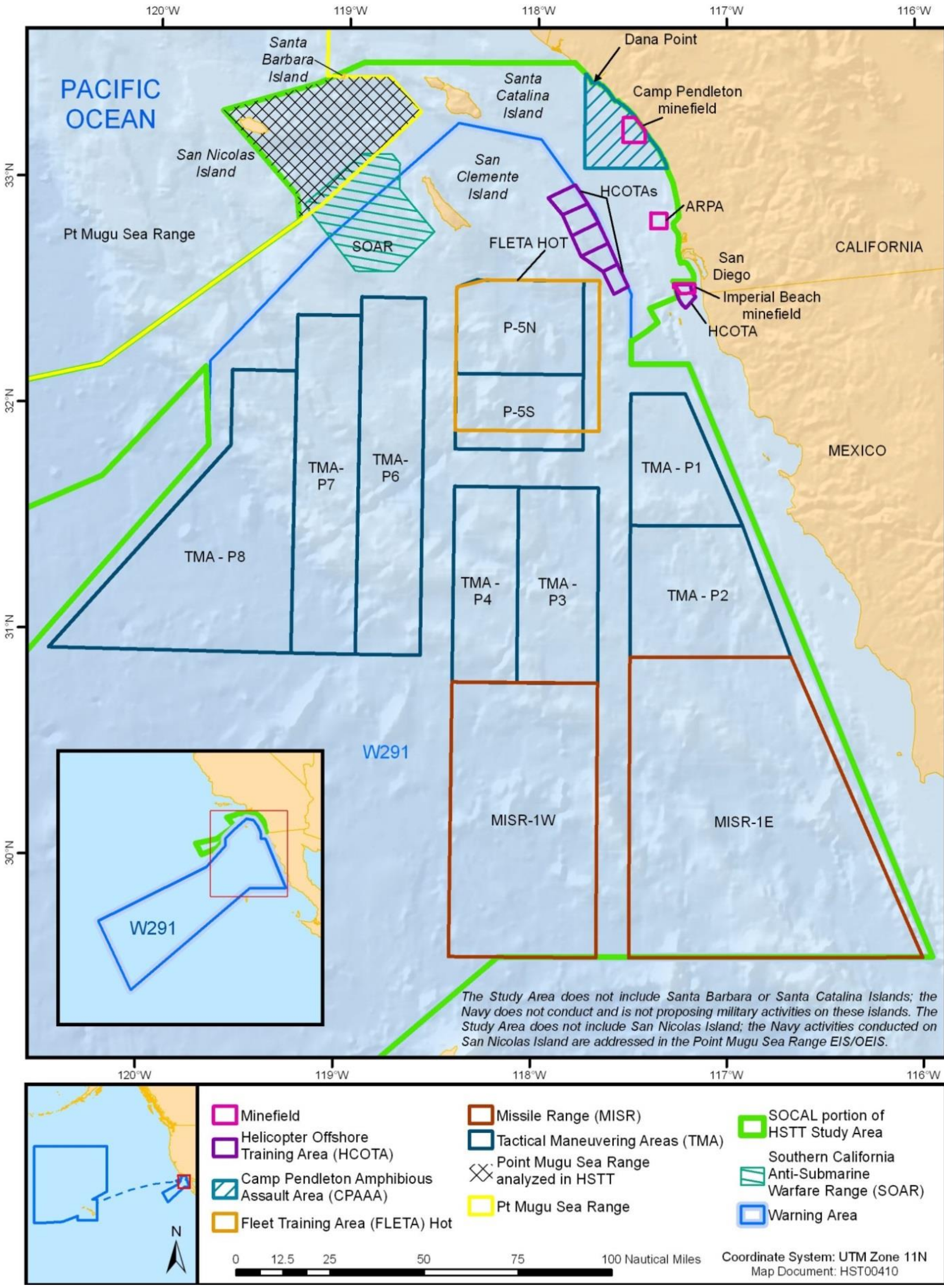

Figure 3. Southern California Range Complex. From: DoN 2013a.

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. Most mid-frequency active sonar (MFAS) occurs in SOCAL and HRC. The Hawaii OPAREA consists of 806,000 square kilometers (km^2) of special use airspace, and sea and undersea areas (**Figures 1 and 2, 4 and 5**), whereas SOCAL encompasses 411 km^2 of sea space and 387,579 km^2 of special use airspace (**Figures 1 and 3**).

Monitoring effort is often concentrated in geographic areas within the Study Area where the return on investment has proven to be high. For example, instrumented ranges (e.g., in HRC and SOCAL) provide a unique asset for use in marine species monitoring where training and testing is frequent and range products provide robust data for use in analysis.

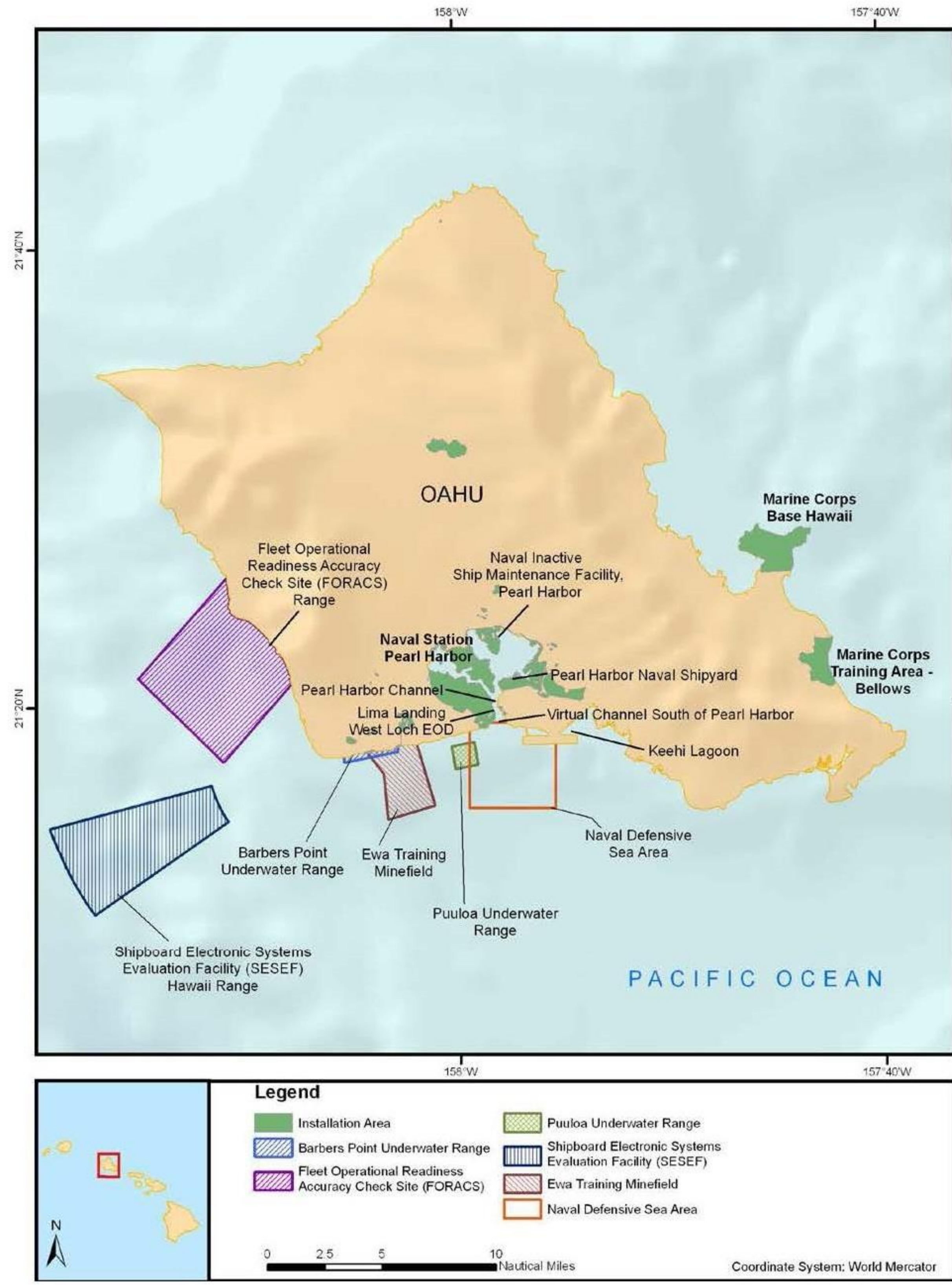

Figure 4. Oahu Training Areas, specifically the Puuloa Underwater Detonation Range. From: DoN 2013a.

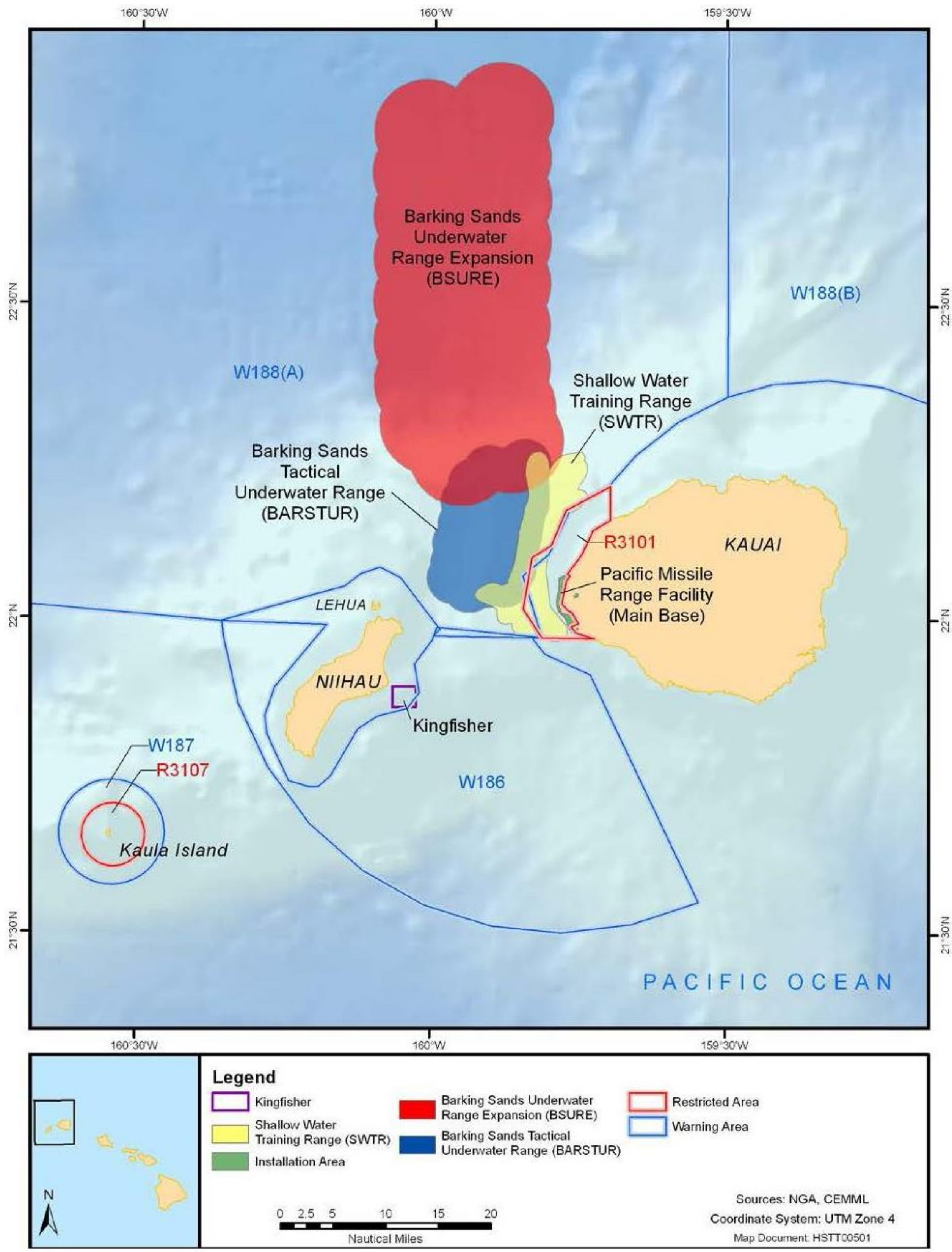

Figure 5. U.S. Navy Training Areas around Kauai, specifically the Pacific Missile Range Facility. From: DoN 2013a.

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]) (including Tinian, Rota, Saipan, and Farallon de Medinilla [FDM]), operating areas, and special use airspace in the region of the Mariana Islands that are part of the MIRC (**Figures 6 and 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. FDM is an uninhabited island in the Mariana Archipelago approximately 2.8 kilometers (km) long and is located 278 km north of Guam (**Figure 8**). FDM has been used by the Department of Defense as a live and inert range since 1971. The MITT Study Area also includes pier-side locations within Inner Apra Harbor, Guam 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 airspace 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 1.7 million km^2 of open ocean.

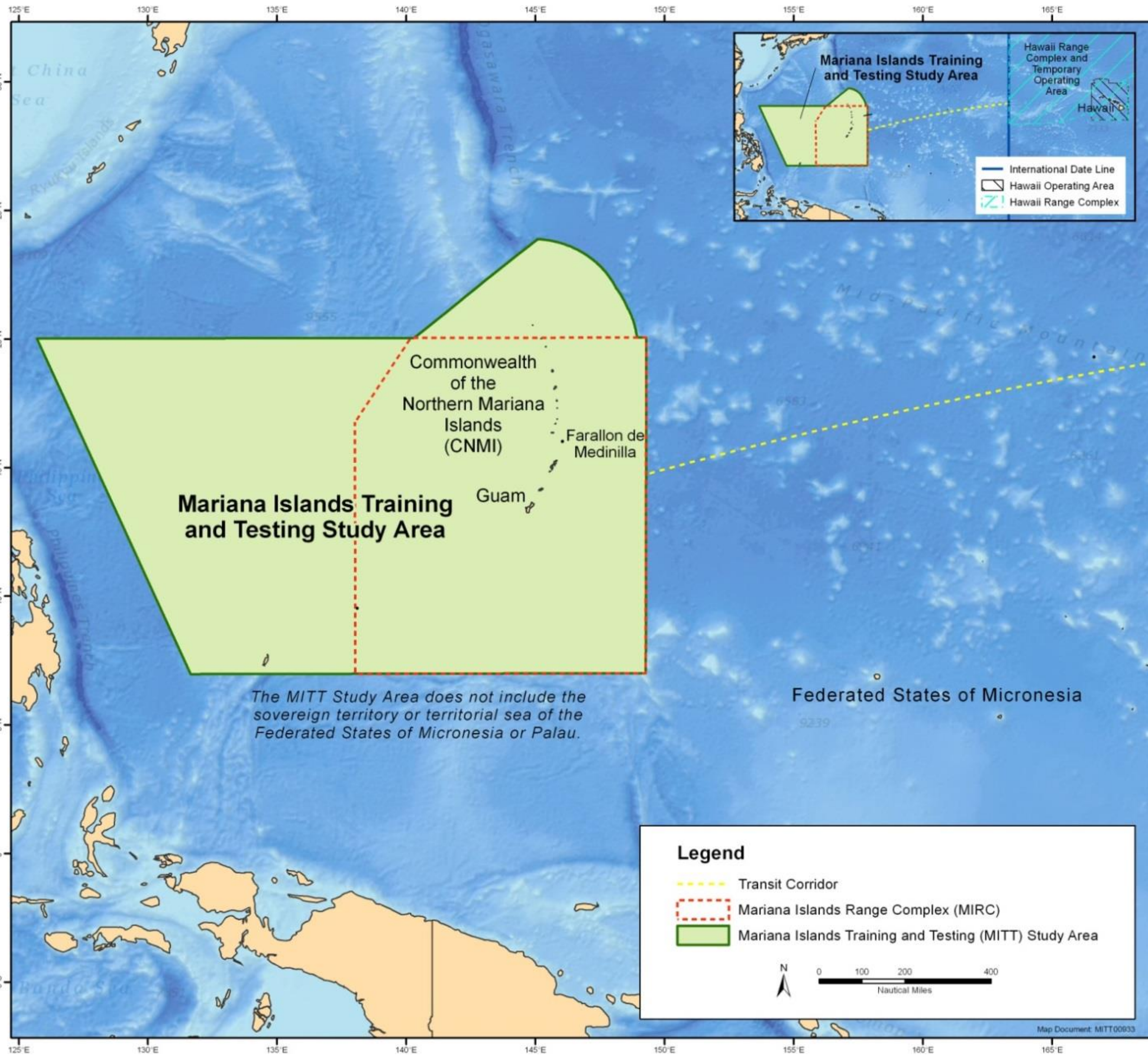

Figure 6. Mariana Islands Training and Testing Study Area. From: DoN 2015a.

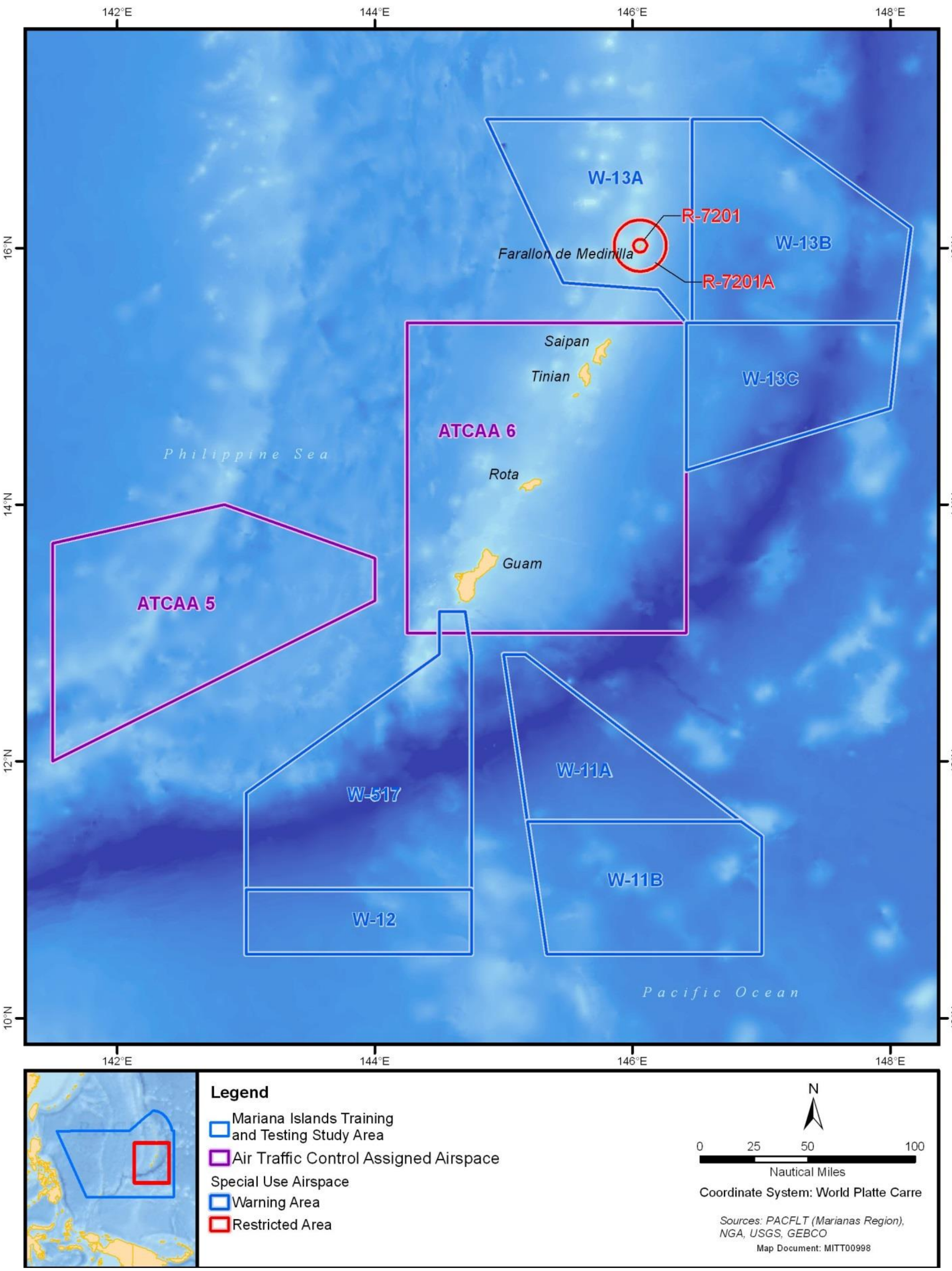

Figure 7. Mariana Islands Range Complex. From: DoN 2015a.

Figure 8. Farallon de Medinilla.

NWTT

The NWTT Study Area (DoN 2015b) (**Figure 9**) 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 22 km off the coast of Oregon and northern California (**Figures 9 and 10**). The NWTT 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 9**). In addition to these range complexes, the NWTT 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.

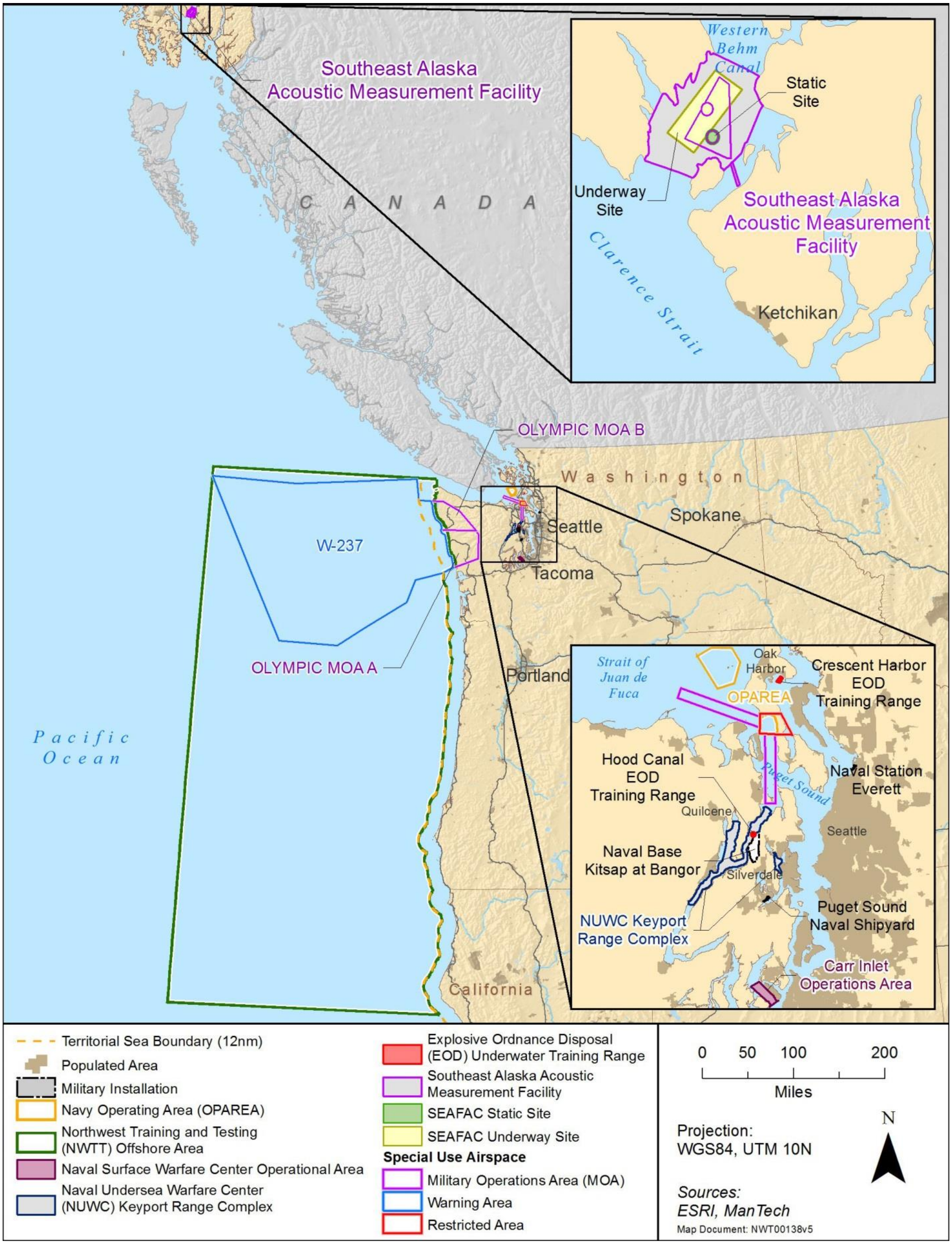

Figure 9. Northwest Training and Testing Study Area. From: DoN 2015b.

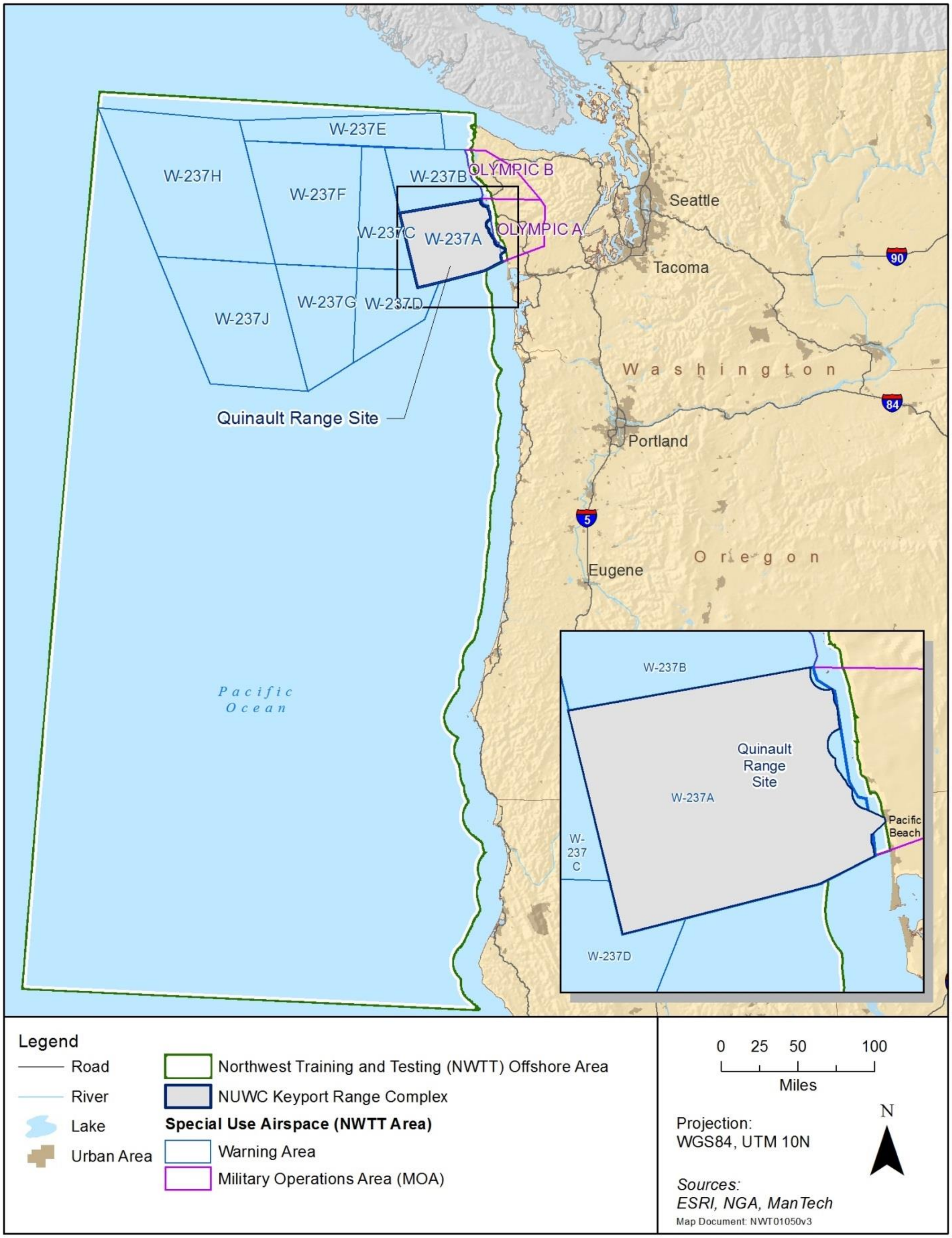

Figure 10. Offshore Area of the Northwest Training and Testing Study Area. From: DoN 2015b.

GOA TMAA

The GOA TMAA (DoN 2011a, 2016a) is a temporary area that is established in conjunction with the Federal Aviation Administration for up to 21 days (d) per year from April to October as needed to support the exercise Northern Edge, a joint training exercise. The TMAA is a surface, undersea space and airspace maneuver area within the GOA for ships, submarines, and aircraft to conduct training activities. As depicted in **Figure 11**, the TMAA is a polygon that roughly resembles a rectangle oriented from northwest to southeast, is approximately 560 (km) in length by 280 km in width, and is located south of Prince William Sound and east of Kodiak Island. With the exception of Cape Cleare on Montague Island located over 22 km from the northern point of the TMAA, the nearest shoreline (Kenai Peninsula) is located approximately 44 km north of the TMAA's northern boundary. The approximate middle of the TMAA is located 260 km offshore.

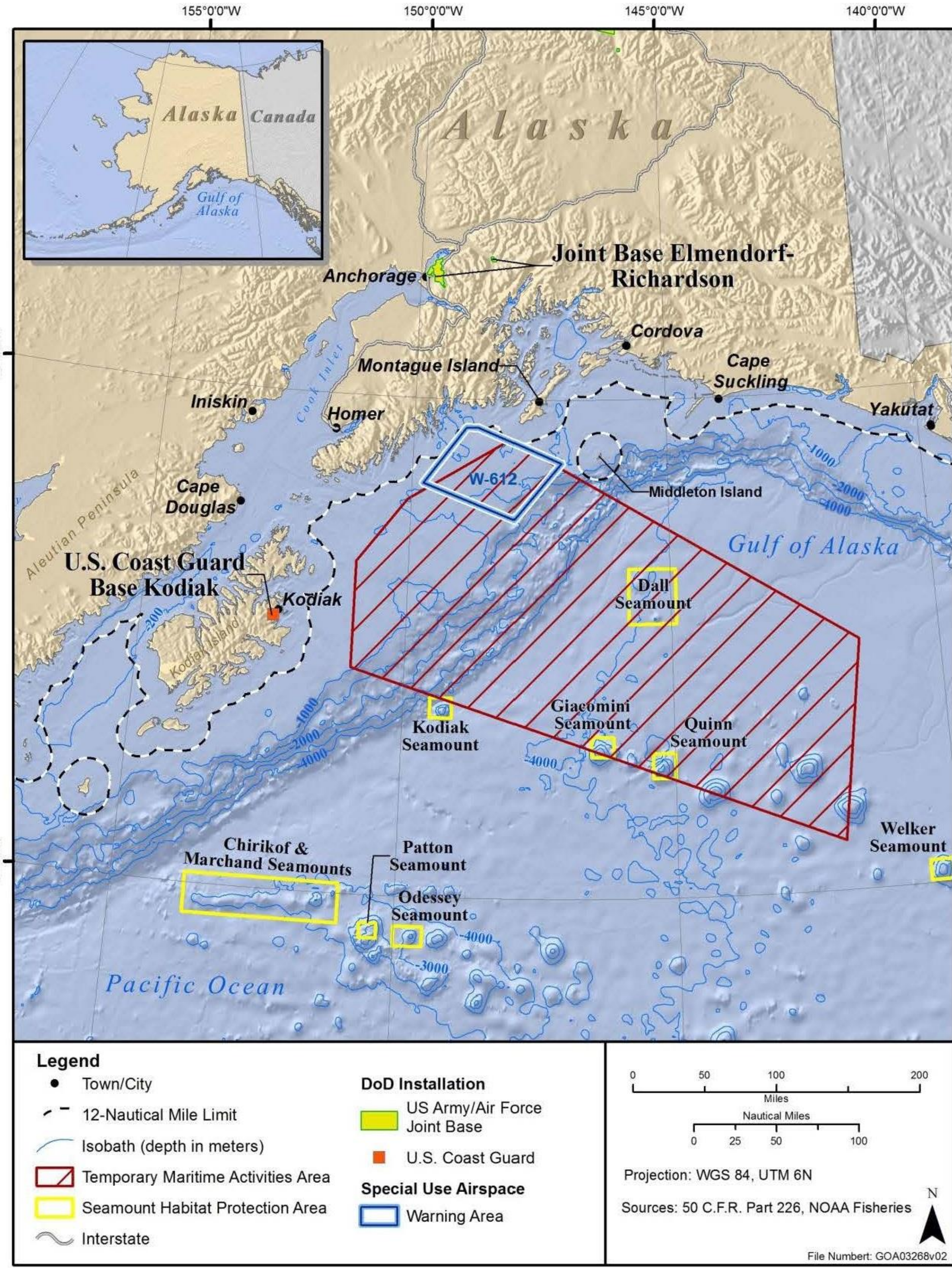

Figure 11. Gulf of Alaska Temporary Maritime Activities Area. From: DoN 2016a.

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) provides the overarching framework for coordination of the Navy's marine species monitoring efforts and serves as a planning tool to focus Navy monitoring priorities pursuant to ESA and MMPA requirements. The purpose of the Integrated Comprehensive Monitoring Program is to coordinate monitoring efforts across all regions and to allocate the most appropriate level and type of monitoring effort for each range complex based on a set of standardized objectives, regional expertise, and resource availability. Although the Integrated Comprehensive Monitoring Program does not identify specific field work or individual projects, it is designed to provide a flexible, scalable, and adaptable framework using adaptive management and strategic planning processes that periodically assess progress and reevaluate objectives.

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 d of aerial surveys) are not 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/.

Adaptive Management Review

The Integrated Comprehensive Monitoring Program is evaluated through the Adaptive Management Review process to (1) assess progress, (2) provide a matrix of goals and objectives, and (3) make recommendations for refinement and analysis of monitoring and mitigation techniques. This process includes conducting an annual adaptive management review meeting at which the Navy and NMFS jointly consider the prior-year goals, monitoring results, and related scientific advances to determine if monitoring plan modifications are warranted to more effectively address program goals. Modifications to the Integrated Comprehensive Monitoring Program that result from annual Adaptive Management Review discussions are incorporated by an addendum or revision to the Integrated Comprehensive Monitoring Program as needed.

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

The Strategic Planning Process for Marine Species Monitoring (Chief of Naval Operations 2013) serves to guide the investment of resources to most efficiently address Integrated Comprehensive Monitoring Program objectives and intermediate scientific objectives developed through this process.

The U.S. Navy marine species monitoring program has evolved and improved as a result of the adaptive management review process through changes that include:

- recognizing the limitations of effort-based compliance metrics;
- developing a Conceptual Framework based on recommendations from the Scientific Advisory Group (DoN 2011b). This Conceptual Framework is centered on gathering information within the categories of "*occurrence, exposure, response, and consequences"* as a progression of knowledge about marine species and their interaction with U.S. Navy training and testing activities.
- shifting focus to projects based on scientific objectives that facilitate generation of statistically meaningful results upon which natural resources management decisions may be based;
- focusing on priority species or areas of interest as well as best opportunities to address specific monitoring objectives in order to maximize return on investment; and
- increasing transparency of the program and management standards, improving collaboration among participating researchers, and improving accessibility to data and information resulting from monitoring activities.

As a result, the Navy's marine species monitoring program has undergone a transition with the implementation of the Strategic Planning Process under MMPA authorizations. Under this process, Intermediate Scientific Objectives serve as the basis for developing and executing new monitoring projects across Navy training and testing areas in the Atlantic and Pacific Oceans. Implementation of the Strategic Planning Process involves coordination among fleets, system commands, Chief of Naval Operations Energy and Environmental Readiness Division, NMFS, and the Marine Mammal Commission with five primary steps:

- **Identify overarching intermediate scientific objectives (ISOs).** Through the adaptive management process, the Navy coordinates with NMFS as well as the Marine Mammal Commission to review and revise the list of intermediate scientific objectives that are used to guide development of individual monitoring projects. Examples include addressing information gaps in species occurrence and density, evaluating behavioral responses of marine mammals to Navy training and testing activities, and developing tools and techniques for passive acoustic monitoring. The current list of thirteen ISOs applied for this monitoring report is included in **Figure 11** (located in **Section 2.1**).
- **Develop individual monitoring project concepts.** This step generally takes the form of soliciting input from the scientific community in terms of potential monitoring projects that address one or more of the ISOs. This can be accomplished through a variety of forums, including professional societies, regional scientific advisory groups, and contractor support.

- **Evaluate, prioritize, and select monitoring projects.** Navy technical experts and program managers review and evaluate all monitoring project concepts and develop a prioritized ranking. The goal of this step is to establish a suite of monitoring projects that address a cross-section of ISOs spread over a variety of range complexes.

- **Execute and manage selected monitoring projects. Individual** projects are initiated through appropriate funding mechanisms and include clearly defined objectives and deliverables (e.g., data, reports, publications).

- **Report and evaluate progress and results.** Progress on individual monitoring projects is updated through the Navy Marine Species Monitoring Program website as well as annual monitoring reports submitted to NMFS. Both internal review and discussions with NMFS through the adaptive management process are used to evaluate progress toward addressing the primary objectives of the Integrated Comprehensive Monitoring Program and serve to periodically recalibrate the focus of the monitoring program.

These steps serve three primary purposes: (1) to facilitate the Navy in developing specific projects addressing one or more ISOs; (2) to establish a more structured and collaborative framework for developing, evaluating, and selecting monitoring projects across all areas where the Navy conducts training and testing activities; and (3) to maximize the opportunity for input and involvement across the research community, academia, and industry. Furthermore, this process is designed to integrate various elements, including:

- Integrated Comprehensive Monitoring Program top-level goals,
- Scientific Advisory Group recommendations,
- Integration of regional scientific expert input,
- Ongoing adaptive management review dialog between NMFS and the Navy,
- Lessons learned from past and future monitoring at Navy training and testing ranges; and
- Leveraging of research and lessons learned from other Navy-funded science programs.

The Strategic Planning Process will continue to shape the future of the U.S. Navy Marine Species Monitoring Program and serve as the primary decision-making tool for guiding investments.

1.3 Report Objectives

This report presents NMFS and the public with monitoring results from, and progress made during, the period of 1 January 2017 to 31 December 2017. Reviewers are also urged to review prior –year reports and associated publications which are available on the website at http://www.navymarinespeciesmonitoring.us/. The report's results address the specified 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 § 218.155(f). This report is the third 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 2016b, 2017). These results are intended to iteratively inform future cycles of the ICMP AMR and Strategic Planning Processes and provide a comprehensive view of monitoring in the Pacific Ocean. In addition, detailed technical reports for the individual monitoring projects are provided as supporting documents to this report.

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2. Marine Species Monitoring in the Pacific

2.1 2017 Monitoring Goals and Implementation

The U.S. Navy training ranges in the Pacific are located in the HSTT Study Area, MITT Study Area, NWTT Study Area, and GOA TMAA (**Figures 1–11**). 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 2011a, 2011b, 2011c, 2011d, 2013a, 2013b, 2013c, 2013d, 2013e, 2013f, 2014a, 2014b, 2015a, 2015b, 2015c, 2015d, 2015e, 2015f, 2015g, 2015h, 2015i, 2016a, 2017a, 2017b, 2017c, 2017d).

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**.

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Table 1. Monitoring goals and accomplishments for training ranges in second cycle of 5-year authorizations (MITT, HSTT [HRC and SOCAL], NWTT, and GOA TMAA).

Project (Technical report for 2017)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 12)	Monitoring Questions	Accomplishments[1]
MITT				
[M1] Cetacean Monitoring (Hill et al. 2018) (This project includes "Small-Vessel Visual Surveys" and "Acoustic Analysis of High-frequency Acoustic Recording Package Data")	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. #5: Establish the baseline behavioral patterns (foraging, diving, etc.) of marine mammals 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 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?	*In 2017:* • This humpback whale catalog from the winter surveys increased the number of individuals to 35 non-calfs. Matches from 2017 included three resights, one from 2007, another from 2015, and the third seen in 2016 with calf. Genetic haplotype-based population analysis for thi sspecies from biopsied tissue samples ongoing. • For the first time in the month of May, a Bryde's whale was encountered off the west side of Saipan. All other sightings have occurred during the months of August and September (Hill et al. 2016a, 2017). • Photo-id and satellite tag data suggest that the population of short-finned pilot whales in the Marianas may include groups of individuals that are more island-associated within the southern portion of the archipelago, as well as those that are intermittent visitors to the nearshore waters of Guam, Rota, Saipan and Tinian. • Acoustic analysis of beaked whale call variability from PIFSC-funded HARPs and kernel density estimates from tagging telemetry are ongoing 2016-2017, with reporting expected in 2018. *In 2016:* • Began efforts to coordinate matching of individually-identifying fluke photographs from the winter survey effot Saipan to various western Pacific catalogs. Initial mtaches made with: previous years (2015) in this survey series, Marpi Reef CNMI from 2007 MISTCS survey, two matches to Ogasawara (both in 2004), and two matches to the Commander Islands, one of which matches to Okinawa.Presented this work at the International Whaling Commission meeting, "*Are humpback whales (Megaptera novaeangliae) breedign and calving in the Mariana Islands?"* (Hill et al. 2016b). • Satellite 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. • Initial genetic analysis of humpback whales not conclusive for the Western North Pacific DPS. Of 9 individuals, six haplotypes were common throughout the North Pacific, and three characterized as more localized toward the western Pacific but also present in eastern and central Pacific.,

Project (Technical report for 2017)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 12)	Monitoring Questions	Accomplishments[1]
[M2] Sea Turtle Tagging in the Mariana Islands Training and Testing Study Area (Martin and Jones 2018)	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 is the occurrence and habitat use of sea turtles in the MITT Study Area? • What is the exposure of 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 2017:* • Conducted sea turtle tagging surveys in nearshore waters of Saipan, Tinian, and Guam. • Deployed satellite tags on 17 sea turtles (15 green and 2 hawksbill) of different ages during the 6 days of field effort. • Satellite tagged juveniles and subadult sea turtles on the west Coast of Guam along the outer reef of Tumon Bay, and north and south of Tumon Bay; surveys or captures had not previously occurred at these sites. New areas surveyed off the western coast of Saipan include waters off of Wing Beach, Pau Pau Beach, Aqua Hotel Reef, and outside of Mañagaha Island with successful tagging of sea turtles at each site. • Published a second manuscript derived from this Navy/NOAA interagency agreement in Pacific Science “Demography of marine turtles in the near-shore environments of the Northern Mariana Islands” (Summers et al. 2017). • Two other manuscripts are currently in preparation: “Reef-dwelling turtles of the Mariana Archipelago: fine-scale habitat use revealed by multiple in-water surveys and GPS telemetry” due to be published in FY18 and the second will aim toward producing abundance estimates by integrating the survey data from this study with small-vessel cetacean surveys (Hill et al. 2016a) and presence/absence data collected during underwater towed-diver coral reef surveys (NOAA data). *In 2016*: • Conducted sea turtle tagging surveys in nearshore and coastal waters of Guam, Saipan, and Tinian, including 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. • Deployed 97 captures of turtles in the MITT Study Area and 60 satellite tags between 2013 and 2016. • 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. • Published first manuscript derived from this Navy/NOAA interagency agreement in Frontiers in Marine Science “Five Decades of Marine Megafauna Surveys from Micronesia” (Martin et al. 2016b).

Project (Technical report for 2017)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 12)	Monitoring Questions	Accomplishments[1]
MITT (continued)				
[M3] FDM Coral Survey (Carilli et al. 2018)	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] #3: Determine what species and populations of marine mammals and ESA-listed species are exposed to Navy training and testing activities.	• What is the occurrence of ESA-listed corals around FDM? • What in-water impacts to coralsfrom ordnance are observable at FDM?	*In 2017:* • Conducted coral reef surveys at Farallon de Medinilla from 27 September to 1 October 2017. • Observed four colonies of ESA-listed coral, one of *Acropora globiceps* and three of *Pavona diffluens.* • Searched for but did not find fresh ordnance (except for a single 50 cal. brass casing) or evidence of ordnance impacts such as craters or coral breakage.
HRC				
[H1] Humpback Whale Tagging at PMRF (Henderson et al. 2018)	Occurrence	#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.	• 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?	*In 2017*: • This project is heavily leveraged off the SPAWAR NISE program. • Conducted vessel-based satellite tagging and photo-ID visual surveys on humpback whales in offshore waters between Kauai and Niihau during March. • Deployed seven satellite tagson humpback whales presumed to be male and fluke photographs were collected. • Analyzed distance travelled, direction, rate of travel, dive depths and duration for the seven tagged individuals.

Project (Technical report for 2017)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 12)	Monitoring Questions	Accomplishments[1]
[H2] Behavioral Response of Marine Mammals to Navy Training and Testing at PMRF (Martin et al. 2018)	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 distribution 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[2]' 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 2017:* • Presented results of automated processing for all data collections throughout FY17 for relative abundance estimates for Blainville's and Cross Seamount-type beaked whale foraging dives and the number of vocalizing baleen whales for minke, humpback, and a combined category of low frequency species (fin, sei and Bryde's whales). • Updated beaked whale detector to increase the automated detections of Blainville's beaked whale clicks and improve distinguishing these from Cuvier's beaked whale and Cross Seamount-type beaked whale clicks. • Conducted disturbance analysis for the 31 minke whales tracked before and during the portion of the February SCC training event, resulting in a maximum estimated cumulative sound exposure. • Provided automated analyses of data collected between 2007 and 2011 using the new metric of numbers of individual whales present in each snapshot for minke and humpback whales. • Provided quick look analysis for species' abundances as the number of instantaneous snapshots taken every 10 minutes of the individual baleen species' tracks, an improvement from the number of localizations per hour. *In 2016:* • Estimated cumulative sound exposure level for 3 minke whales that were localized and tracked at PMRF during 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. • Presented results of fully automated processing 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. • Processed data automatically for 2007-2011 for beaked whales, humpback whales, and sperm whales, and presented plots of these. *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. Discovered possible Cross Seamount type beaked whale clicks during manual verification (confirmed in 2016 report). • 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 2017)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 12)	Monitoring Questions	Accomplishments[1]
HRC (continued)				
[H3] Long-term Trends in Abundance of Marine Mammals at PMRF (DiMarzio et al. 2018) (This is a joint project with [S3] "Cuvier's Beaked Whale Impact Assessment at SOAR")	Occurrence, Exposure, Response, Consequences	#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. #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 distribution 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 2017:* • Obtained the first extended PAM data archive at PMRF: six months of continuous data were recorded and analyzed for Blainville's beaked whale abundance and added to previous estimates. • Incorporated automated sonar detector performing on streaming data into the M3R software at PMRF, and detection reports were integrated into the M3R data archives. • Archived automated time-tagged cetacean detections and localizations on streaming data at PMRF. • Determined no decline in beaked whale abundance at PMRF from 2010 to 2017. *In 2016*: • Compared beaked whale detection archives from both SSC Pacific and M3R algorithms and determined baseline abundance at PMRF. • Completed packet recorder interface and new disk handling utilities; implemented sample rate decimation and undertaking testing. • Determined no 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] Navy Civilian Marine Mammal Observers on DDGs	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 2017:* Embark was scheduled in February 2017 and MMO boarded the DDG but, due to emergent mechanical difficulties of the ship; the ship did not participate in the training event and the embark was cancelled *In 2014–2016:* • Employed MMOs 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 (Vars et al. 2016). • Recorded marine mammal and sea turtle sighting data to determine which species and populations are exposed to U.S. Navy training events.

Project (Technical report for 2017)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 12)	Monitoring Questions	Accomplishments[1]
[H5] Cetacean Studies on PMRF (Baird 2018) (*Collected tag telemetry used in Project [H6]*)	Occurrence	#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 2017:* • Conducted small-vessel surveys prior to a SCC event in August 2017 on PMRF. • Sighted melon-headed whales for the first time on PMRF since 2008. • Deployed six satellite tags on 3 species: rough-toothed dolphins, melon-headed whales, and pantropical spotted dolphins. • Observed two melon-headed whales associating with rough-toothed dolphins on two occasions. One of the two individuals in the pair appeared to be a hybrid between a melon-headed whale and a rough-toothed dolphin. Collected a biopsy sample from the hybrid. Mitochondrial DNA analysis yielded melon-headed haplotype; nuclear DNA analysis in progress to confirm hybrid ancestry. • Concluded that current data combined with previous years tag deployments on rough-toothed dolphins suggests tagged group was from resident, island-associated population (Baird et al. 2017b). • Continuing analyses; the final report is expected during the FY18 reporting period. *In 2016:* • Sighted pantropical spotted dolphins on PMRF for the first time since 2003. • Deployed satellite tags on short-finned pilot whales, rough-toothed dolphins, and one pantropical spotted dolphin. • Determined that 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:* • Conducted small-vessel surveys (non-random and non-systematic) prior to a SCC event. • Located animals using M3R detections; collected high-resolution photographs for individual photo-ID. • Deployed satellite tags on short-finned pilot whales, bottlenose dolphins, and rough-toothed dolphins. *In 2014:* • Collected data from a satellite-tag track for a Blainville's beaked whale, which was the first detailed movement data available for this species around Kauai and Niihau. • Used M3R system to identify an acoustic detection of an encounter with false killer whales.

Project (Technical report for 2017)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 12)	Monitoring Questions	Accomplishments[1]
HRC (continued)				
[H6] Estimation of Received Levels of MFAS on Marine Mammals at PMRF	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 distribution 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 2017:* • In August 2017, prior to the tagging field effort, a second Wildlife Mote receiving station was installed near the instrumented range at PMRF for enhancing the quantity of satellite tag data. The new station was installed on Niihau, providing complementary coverage to the one previously installed February 2016 at Makaha Ridge in Kauai. • No cetaceans tagged off PMRF in summer 2017 prior to the August Navy training event remained in the area by the time event commenced. Analyses are deferred until after tagging off PMRF in summer 2018. *In 2016:* • Conducted vessel-based field efforts on three occasions between July 2013 and February 2015 that corresponded with MFAS use during SCCs (Baird et al. 2017a). • 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 2017)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 12)	Monitoring Questions	Accomplishments[1]
SOCAL				
[S1] Passive Acoustic Monitoring in SOCAL (Rice et al. 2018a; Širović et al. 2018)	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. #6: Establish the regional baseline vocalization behavior, including seasonality and acoustic characteristics of marine mammals where Navy training and testing activities occur.	• What is the seasonal occurrence and abundance of cetaceans within the Navy's Southern California Range Complex? • What, if any, are the spatial patterns in fin whale population structures within the Navy's Southern California Range Complex?	*In 2017:* • Analyzed fin whale song patterns from HARP data collected at four sites (Sites C, H, P, and Q) in the Southern California Bight collected between 2005 and 2014 (Širović et al. 2018). • Identified from preliminary results that the fin whale songs recorded between 2009 and 2010 across all four sites had the same doublet IPIs corresponding to “short doublet” song likely attributed to resident population (Širović et al. 2018). • Conducted PAM from April 2016–June 2107 to detect marine mammals and anthropogenic sounds using HARPs at three locations (Sites H, N and P) within SOCAL (Rice et al. 2018a). • Analyzed ambient noise and the presence of MFAS and explosions detected at all three sites Rice et al. 2018a). • Performed data analysis using automated computer algorithms and detected blue whale call types B and D, and fin whale 20 Hz calls (Rice et al. 2018a). • Detected frequency-modulated echolocation pulses from Cuvier’s beaked whales at sites H and N. Additional beaked whale-like frequency modulated pulse type, BW43, possibly produced by Perrin’s beaked whale (Baumann-Pickering et al., 2014), was detected infrequently during winter at site N (Rice et al. 2018a). *In 2016:* • Conducted PAM from June 2015–April 2016 to detect marine mammal and anthropogenic sounds using HARPs at three locations within SOCAL • Described differences between recording sites in the occurrence of blue whale B calls and D calls, and fin whale 20 Hz calls. *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 analysis 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 2017)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 12)	Monitoring Questions	Accomplishments[1]
SOCAL (continued)				
[S2] Cuvier's Beaked Whale and Blue Whale Impact Assessments at Non-Instrumented Range Locations in the SOCAL Range Complex (Baumann-Pickering et al. 2018)	Occurrence, Exposure, Response	#7: Determine what behaviors can most effectively be assessed for potential response to Navy training and testing activities. #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. #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?	*In 2017:* • Analyzed HARP data collected from four sites (Sites M, H, E, and N) from 2006 to 2015 (Baumann-Pickering et al. 2018) within SOCAL • Presented progress on the development of methods to investigate the potential impacts of sonar and other anthropogenic activities on calling animals, which resulted in 19 years worth of acoustic recording during 79 instrument deployments and 227 TB of acoustic recordings (Baumann-Pickering et al. 2018). • Reduced detection range for blue whale songs to a range of approximately 5 km by selecting for high received level calls, and focused analysis efforts on two different approaches: multi-spatial convergent cross mapping and generalized estimation equations (Baumann-Pickering et al. 2018). *In 2016:* • Described detections of explosions (many likely to be civilian use of mraine mammal deterrents (i.e., “seal bombs” used in fisheries) and MFAS. • Developed and utilized automated algorithms to detect blue and fin whale calls, Cuvier’s beaked whales and MFAS pings. • Conducted PAM to detect marine mammal and anthropogenic sounds using HARPs from four sites in 2006–2015 • Preparing for future multivariate statistical analyses (including natural and anthropogenic variables) to account for variability in call densities: data preparation 95 percent complete and method of resolving range ambiguity being developed. *In 2014–2016*: • Deployed HARPs at four locations in SOCAL to record marine mammal sounds and anthropogenic noise. • Continued detailed analysis on the presence of anthropogenic sources of sound for the study of impact of sonar on blue, fin, and beaked whales.

Project (Technical report for 2017)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 12)	Monitoring Questions	Accomplishments[1]
[S3] Cuvier's Beaked Whale Impact Assessment at SOAR (DiMarzio et al. 2018; Schorr et al. 2018) (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: Leverage existing data with newly developed analysis tools and techniques[2].	• 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 2017:* • Incorporating sightings of known reproductive Cuvier's beaked whale females with and without calves over time to provide critically needed calving and weaning rate data for PCoD models currently being developed for this species on SOAR (Schorr et al. 2018). • Updated Cuvier's beaked whale abundance estimates with data from 2015 through September 2017 (DiMarzio et al. 2018). • Incorporated automated sonar detector into the M3R software operating on streaming data at SOAR (DiMarzio et al. 2018). • Produced and archived in time-tagged cetacean detections and localizations and sonar detections made by automated system on streaming data at SOAR (DiMarzio et al. 2018). • Documented data show no decline in beaked whale abundance on SOAR from 2010 to 2017. *In 2016:* • Conducted survey effort 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. • Derived detection statistics (Probability of Detection and False Alarms) for M3Rs Auto-Grouper program and calculated correction factors from beaked whale detections at SOAR. • Completed initial risk function for Cuvier's beaked whales. • Documented at SCORE that 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:* • Continued 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 2017)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 12)	Monitoring Questions	Accomplishments[1]
SOCAL (continued)				
[S4] Marine Mammal Sightings during CalCOFI Cruises (Hildebrand et al. 2018)	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 2017:* • Reported on visual and acoustic monitoring for marine mammals aboard CalCOFI cruises during July and Novemer 2016, and January, April, and August 2017. • 20 species identified during on-effort observations. *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, abundance, 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 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 2017)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 12)	Monitoring Questions	Accomplishments[1]
[S5/N4] Blue and Fin Whale Tagging and Genetics (Mate et al. 2017a) (This project is also a component of NWTT tagging, N4)	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. #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 2017:* • Instrumented 28 blue and one fin whale with SPOT6 location-only and DM satellite tags. • Conducted analyses on blue, fin, and humpback whale tracking results which included tag deployments from 2016 and tracking information through 8 April 2017. • Analyzed dive characteristic data obtained from DM tags used in 2016 and compared 2016 data to ADB data from 2014 and 2015. • Genetic analysis of biopsy samples to determine sex of individuals, individual identification, and species and stock identification was conducted for all three years (2014-2016). *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 22 blue whales, 11 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 24 blue whales and 6 fin whales with location-only and ADB satellite tags. • Analyzed data from ADB tags and identified strong and consistent diel feeding patterns in blue whales.

Project (Technical report for 2017)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 12)	Monitoring Questions	Accomplishments[1]
SOCAL (continued)				
[S6] SOCAL Soundscape Study	Occurrence	#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 SOCAL?	*In 2017:* • Analysis in progress for metrics characterizing the underwater soundscape in the SOCAL range, based on multi-year recordings by HARPs of ambient biological, abiotic, and anthropogenic sound.
NWTT				
[N1] Humpback Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean (Mate et al. 2017b)	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 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)?	*In 2017:* • Instrumented 19 humpback whales with DUR or DM satellite tags (14 off southern and central California, 5 off Oregon); collected biopsy samples from 17 individuals. • Photo-ID and matching of photographs of tagged whales to existing photo-ID databases is ongoing. • Continued genetic analysis of biopsy samples to determine sex of individuals, individual identification, and species and stock identification and will be presented in the final report.

Project (Technical report for 2017)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 12)	Monitoring Questions	Accomplishments[1]
NWTT (continued)				
[N2] Modeling the Offshore Distribution of Southern Resident Killer Whales in the Pacific Northwest (Hanson et al. 2018)	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 2017:* • Completed review of acoustic data for 13 EARs recovered along the U.S. West Coast from 2011 to 2016. Over a third of the monitoring days were from sites within NWTRC W237. • Summarized detections for most years from 2011 through summer 2016 and updated annual predictive maps of the acoustic recorder detections. • Updated acoustic detection probability with data from two additional winter cruises (2015, 2016). • Conducted a simulation study to evaluate the effectiveness of alternative sampling designs with respect to acoustic recorder presence. Evaluated how densities of recorders affected the probability of detecting whales on daily time steps. *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. • Summarized detections 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 SPOT5 tag on one SRKW adult male, a member of K pod.

Project (Technical report for 2017)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 12)	Monitoring Questions	Accomplishments[1]
NWTT (continued)				
[N3] Modeling the Offshore Distribution of Chinook Salmon in the Pacific Northwest (Shelton et al. in review)	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]#4: Establish the baseline habitat uses and movement patterns of marine mammals and sea turtles where Navy training and testing activities occur. [3]	• 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)?	*In 2017:* • Constructed the first coastwide state-space model for fall Chinook salmon tagged fish released from California to British Columbia between 1977 and 1990 to estimate seasonal ocean distribution along the west coast of North America. • Compiled recovery information for each identified tag code from the Reginal Mark Information System and incorporated recoveries from multiple ocean fisheries. • Analyzed data and showed that Chinook salmon ocean distribution depends strongly on region of origin and varies seasonally while survival showed regionally varying temporal patterns.

Project (Technical report for 2017)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 12)	Monitoring Questions	Accomplishments[1]
NWTT (continued)				
[N4/S5] Blue and Fin Whale Tagging and Genetics (Mate et al. 2017a) (This project is also a component of SOCAL tagging, S5)	*See project S5/N4 (above, in SOCAL)*			
[N5] Tagging and Behavioral Monitoring of Sea Lions in the Pacific Northwest in Proximity to Navy Facilities (DeLong 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. #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 of California sea lions in Pacific Northwest using Navy facilities (and the surrounding areas)? • What is proportion of time that California sea lions hauled out when in the proximity of a Navy facility?	*In 2017:* • Estimated the abundance and monthly occurrence of California sea lions using four Navy facilities in the inland waters of Washington. • Estimated daily locations of adult male California sea lion males occurring within the NWTT. • Conducted kernel density analyses of estimated hourly satellite tag locations of adult male California sea lions. • Analyzed dive depth and duration for 26 individual sea lions. • Determined a correction factor that corrected 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. *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. • Used satellite telemetry instruments to gather data on 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 2017)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 12)	Monitoring Questions	Accomplishments[1]
NWTT (continued)				
[N6] Harbor Seal Density Estimation (Jefferson 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 density of harbor seals in Hood Canal, Washington?	*In 2017:* • Calculated in-water density and abundance of harbor seals by using conventional and multiple covariate line-transect approaches. • Produced seasonal estimates of density and abundance for each of the 6 sub-regions. *In 2016:* • Used Navy-funded line-transect aerial survey data (collected from 2013 to 2016 by Smultea Environmental Sciences, Smultea et al. 2017) from Hood Canal to enable direct estimation of harbor seal in-water density and abundance for six geographic sub-regions of Hood Canal. *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 sub-regions within Puget Sound.

GOA TMAA					
[G1] PAM of Marine Mammals in the Gulf of Alaska Temporary Maritime Activities Area using Bottom-Mounted Devices (Wiggins and Hildebrand 2018; Rice et al. 2018b)	Occurrence	#1: #2: #6:	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. 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. Establish the regional baseline vocalization behavior, including seasonality and acoustic characteristics of marine mammals where Navy training and testing activities occur.	• What is the occurrence of marine mammals and anthropogenic noise in the Gulf of Alaska?	*In 2017:* • Analyzed PAM data from 3 HARP deployment April-Sept 2017 for anthropogenic sound, beaked whales and ESA-listed baleen whales • Tracked a pair of fin whales from their 40-Hz calls recorded on an array of PAM instruments in May 2015.This is the first report of tracked 40-Hz fin whale calls, and the animals were shown to be moving while producing calls. • Measured call and swimming parameters (depth, location, recording duration, swim speed, souce levels) for localized 40-Hz calls from whales A and B. *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.

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

[2] Primary Research & Development and Demonstration-Validation (DEMVAL) investments for tools and techniques supported by the Office of Naval Research Marine Mammal and Biology and the Living Marine Resource programs.

[3] For projects [M3] and [N3], ISOs related to sea turtles have been expanded to be applied more broadly to ESA-listed species.

Key: ADB = advanced dive behavior; ASW = anti-submarine warfare; BW = beaked whale; CalCOFI = California Cooperative Oceanic Fisheries Investigations; dB re 1 µPa = decibels referenced to 1 micro Pascal; DDG= guided missile destroyer; DM = Dive Monitoring; DNA = deoxyribonucleic acid; DoN = Department of the Navy; DUR = Dive Duration Monitoring; 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; hr = hour(s); HRC = Hawaii Range Complex; HSTT = Hawaii Southern California Training and Testing; Hz = Hertz; km = kilometer; LIMPET = Low Impact Minimally Percutaneous Electronic Transmitter; m = meter; M3R = marine mammal monitoring on U.S. 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; NWTRC = Northwest Training Range Complex; 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 Command 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; TB = terabyte; UNDET = Underwater Detonation; U.S. = United States; W237 = Warning Area 237.

Figures 12 and 13 provide an overview of all monitoring projects and goals across all the Pacific ranges. **Figure 12** 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 to illustrate which ISOs are addressed by each monitoring project. **Figure 13** illustrates the relative number of monitoring questions associated with each CFC, and how this varies by range. 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 naval ranges. Because of their connection to population trends, though not comparable to the fully-realized modeling of population consequences, these were tabulated in **Figure 13** under *consequences*.

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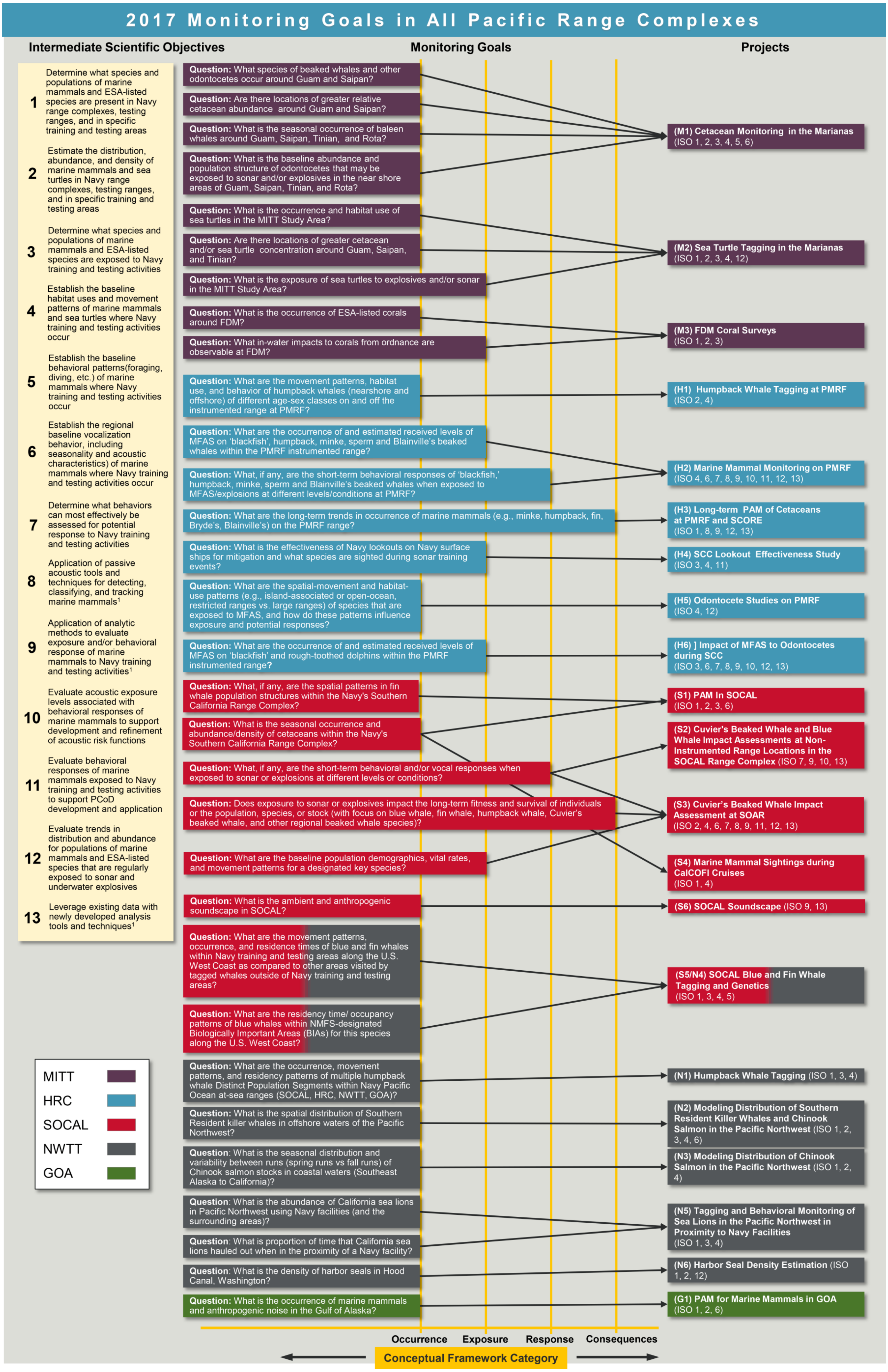

Figure 12. 2017 Monitoring goals in all Pacific range complexes. Primary research-and-development and demonstration-validation (DEMVAL) investments for tools and techniques supported by ONR Marine Mammal and Biology and Living Marine Resource programs.

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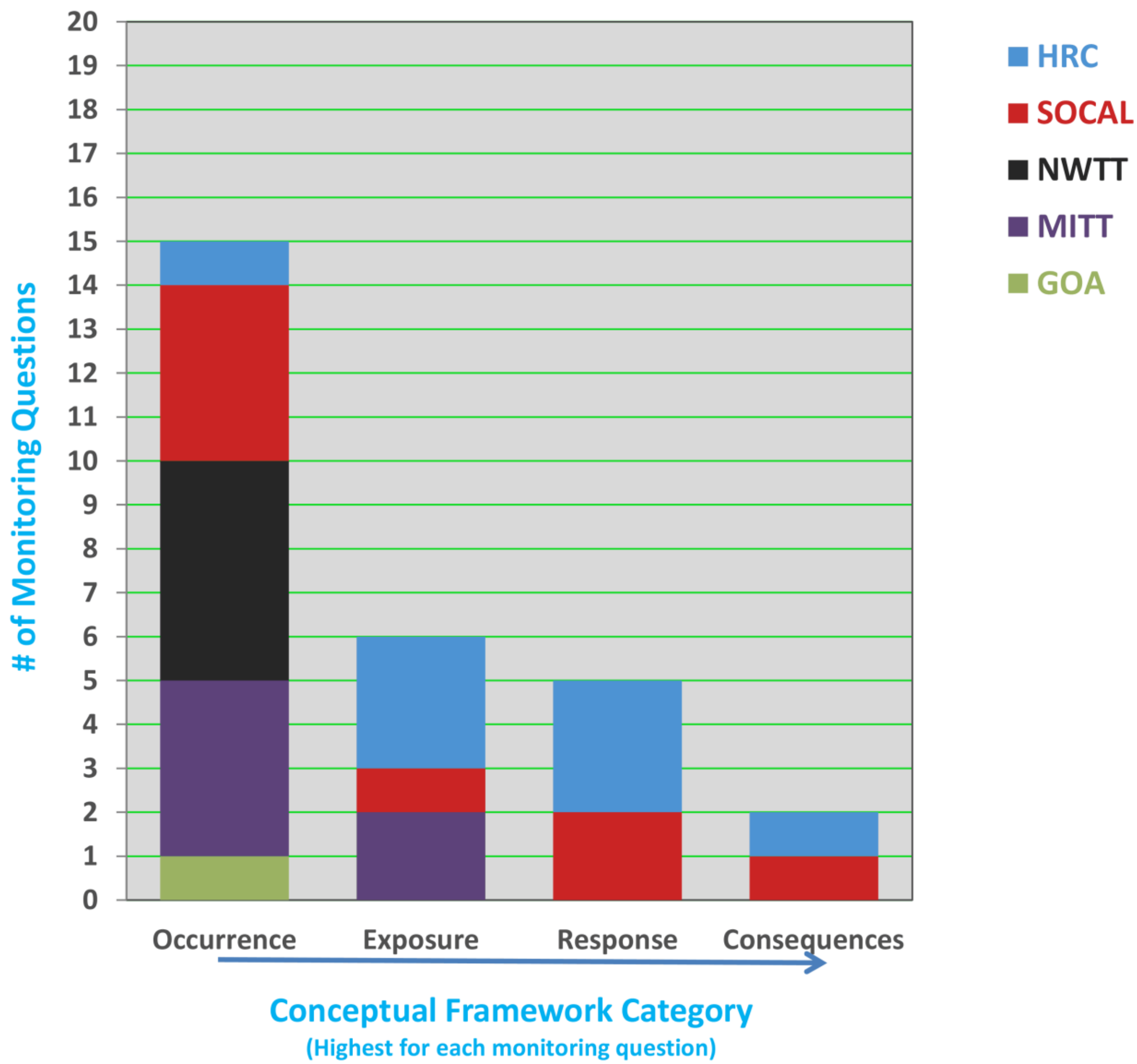


Figure 13. Number of monitoring questions and goals in all Pacific range complexes that address the four progressive Conceptual Framework Categories for monitoring knowledge outlined by the Scientific Advisory Group. Additional Navy-funded effort under *Response* (not represented here) has been conducted in SOCAL under the ONR Marine Mammal and 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 2017 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).

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 2017 is illustrated in **Figure 14**. Detailed project summaries follow below.

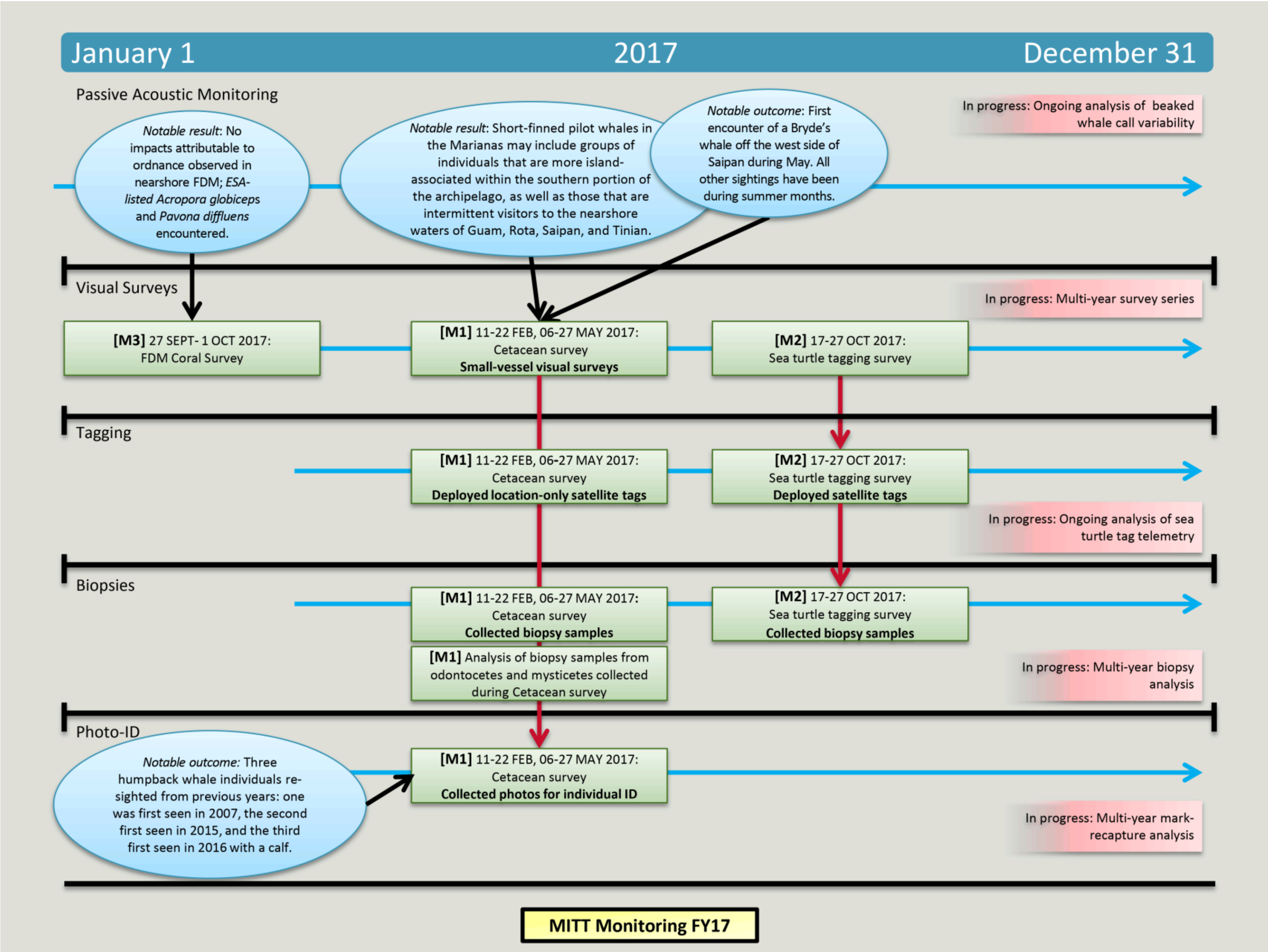


Figure 14. Timeline of 2017 projects in the Mariana Islands Training and Testing Study Area.

[M1] Cetacean Monitoring in the Mariana Islands Range Complex, 2017 [Hill et al. 2018]

Winter and spring/summer small-vessel surveys were conducted by Pacific Islands Fisheries Science Center (PIFSC) Cetacean Research Program (CRP) in a multi-year collaborative effort with the U.S. Pacific Fleet, Oregon State University, and Southwest Fisheries Science Center.

From 11 to 22 February 2017, a vessel-based winter survey off Saipan was conducted to search for humpback whales (*Megaptera novaeangliae*). Vessel effort focused on shallow waters offshore of Saipan, particularly Chalan Kanoa and Marpi Reefs and was conducted on a small (<39 feet [ft]; <12 meters [m]) vessel.

Spring/summer-season visual surveys were conducted in the waters surrounding Saipan, Tinian, and Guam from small (<9 m) vessels on 19 d from 6 to 25 May 2017. Survey effort off Aguijan and Rota were discontinued in 2017 due to unreliable and intermittent flight availability. Photo-identification, biopsy sampling, and satellite tagging protocols were the same as those described by Hill et al. (2015, 2016, 2017). During small-vessel surveys, the occurrence and locations of sea turtles were recorded, but photographs and biopsy samples were not collected. Wildlife Computers (WC) Smart Position and Temperature (SPOT)-5 location-only (LO) satellite tags (see **Appendix A**) were deployed on priority species (i.e., short-finned pilot whales [*Globicephala macrorhynchus*], melon-headed whales [*Peponocephala electra*], and bottlenose dolphins [*Tursiops truncatus*]) to investigate individual movements throughout the broader region of the Mariana Archipelago (Hill et al. 2015, 2016, 2017). Multi-year mark-recapture, photo-ID, kernel density estimates of habitat use, and genetic analyses of biopsy samples are ongoing.

[M2] Sea Turtle Tagging in the Mariana Islands Training and Testing (MITT) [Martin and Jones 2018]

During the period of 17 to 27 October, sea turtle surveys and in-water captures were conducted in the nearshore and coastal waters of Guam, Saipan, and Tinian (**Figures 6 and 7**). In 2017, survey efforts were expanded from previous years to include Tumon Bay and the surrounding area, off the western coast of Guam, and off the western coast of Saipan, and the team surveyed waters off Wing Beach, Pau Pau Beach, Aqua Hotel Reef, and outside of Mañagaha Island. This research was conducted 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, and CNMI Department of Lands and Natural Resources.

Green (*Chelonia mydas*) and hawksbill (*Eretmochelys imbricata*) turtles were captured by hand, when encountered while snorkeling or diving. Turtles were instrumented with metal Inconel tags (i.e., ‘flipper tags’) and with Passive Integrated Transponder (PIT) tags (see **Appendix A**). Skin samples were obtained for deoxyribonucleic acid (DNA) and stable isotope analysis. Blood samples were taken for hormone and metabolite studies of reproduction and feeding/nutritional state. Turtles were measured and those with an appropriate size and body condition (see Jones et al. 2013) were outfitted with satellite tags (WC SPLASH tags).

Turtle tracks were created using all available Global Positioning System (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 (CA) and home range (HR), respectively.

Cetacean sightings were recorded opportunistically during 2016-2017. Spinner dolphins (*Stenella longirostris*) and possibly bottlenose dolphins were the only species observed. During 2013-2015, cetacean observations were not recorded during the turtle surveys.

[M3] FDM Coral Survey [Carilli et al. 2018]

Coral reef habitat surveys were performed at FDM from 27 September to 1 October 2017 (**Figures 8 and 15**) in accordance with the Terms and Conditions in the MITT BO (NMFS 2015c). The U.S. Navy surveyed coral reef habitat around FDM within waters 20 meters deep. Study goals were to:

1. Confirm presence or absence and abundance of ESA-listed corals,
2. Assess general trends in coral reef species composition, percent coral coverage, condition (disease, predators, extent of breakage, etc.),
3. Record incidental observations of other ESA-listed species (e.g., scalloped hammerhead sharks [*Sphyrna lewini*], marine mammals, sea turtles, etc.), and
4. Search for any in-water effects to corals from high-explosive bombs.

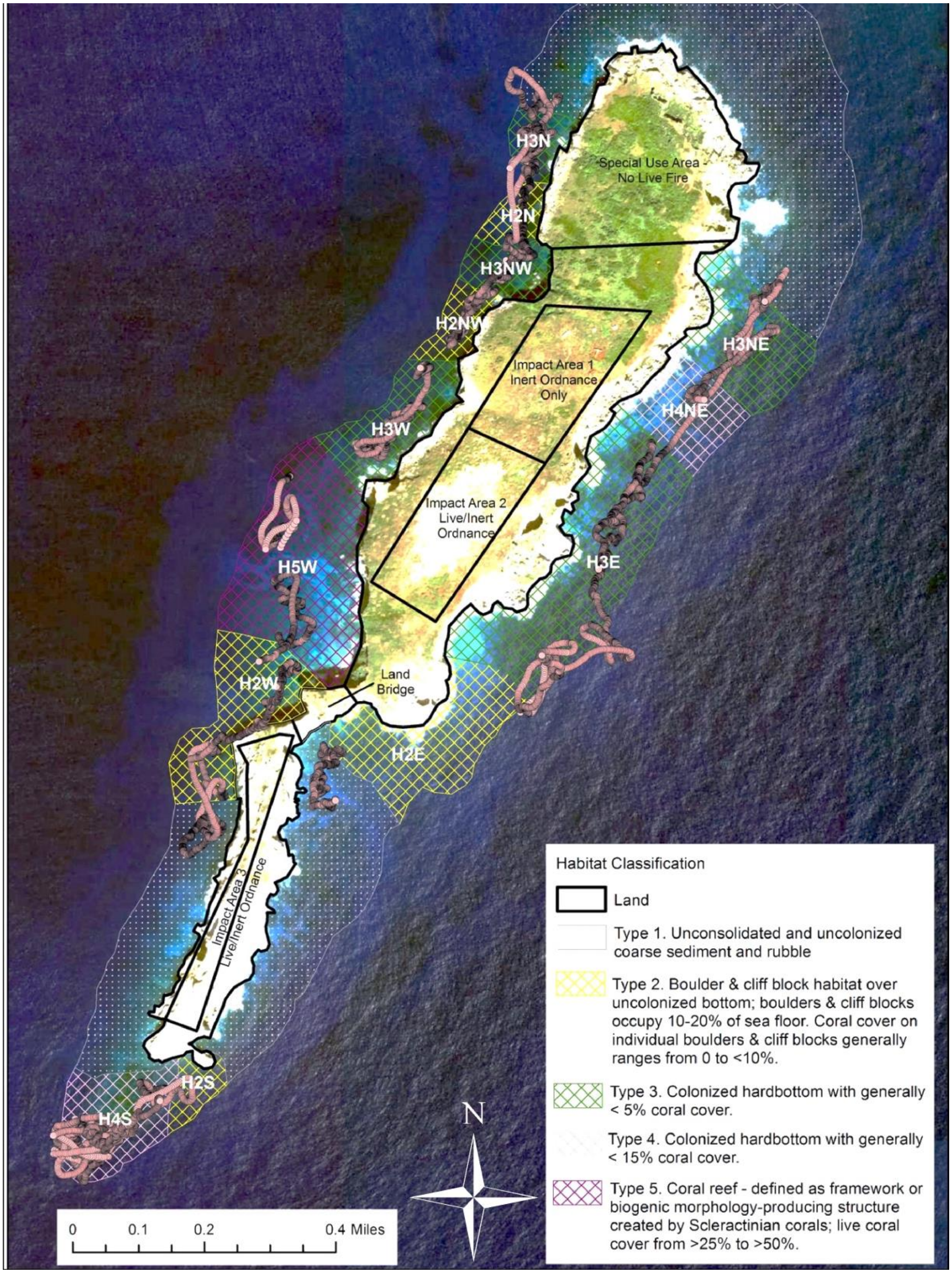


Figure 15. Map of FDM with approximate locations of different habitat types, defined based on historical coral cover. Pink dots with gray outlines were plotted from Latitude/Longitude positions of divers queried and saved by the SeaTrac acoustic system and associated software every two seconds, showing total area surveyed in 2017. From: Carilli et al. 2018 [Project M3]

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 2017 is illustrated in **Figure 16**. Note that for two of these HRC tasks, field work and data collection occurred prior to or during 2016, but data analysis occurred within the 2017 reporting period. Detailed project summaries follow.

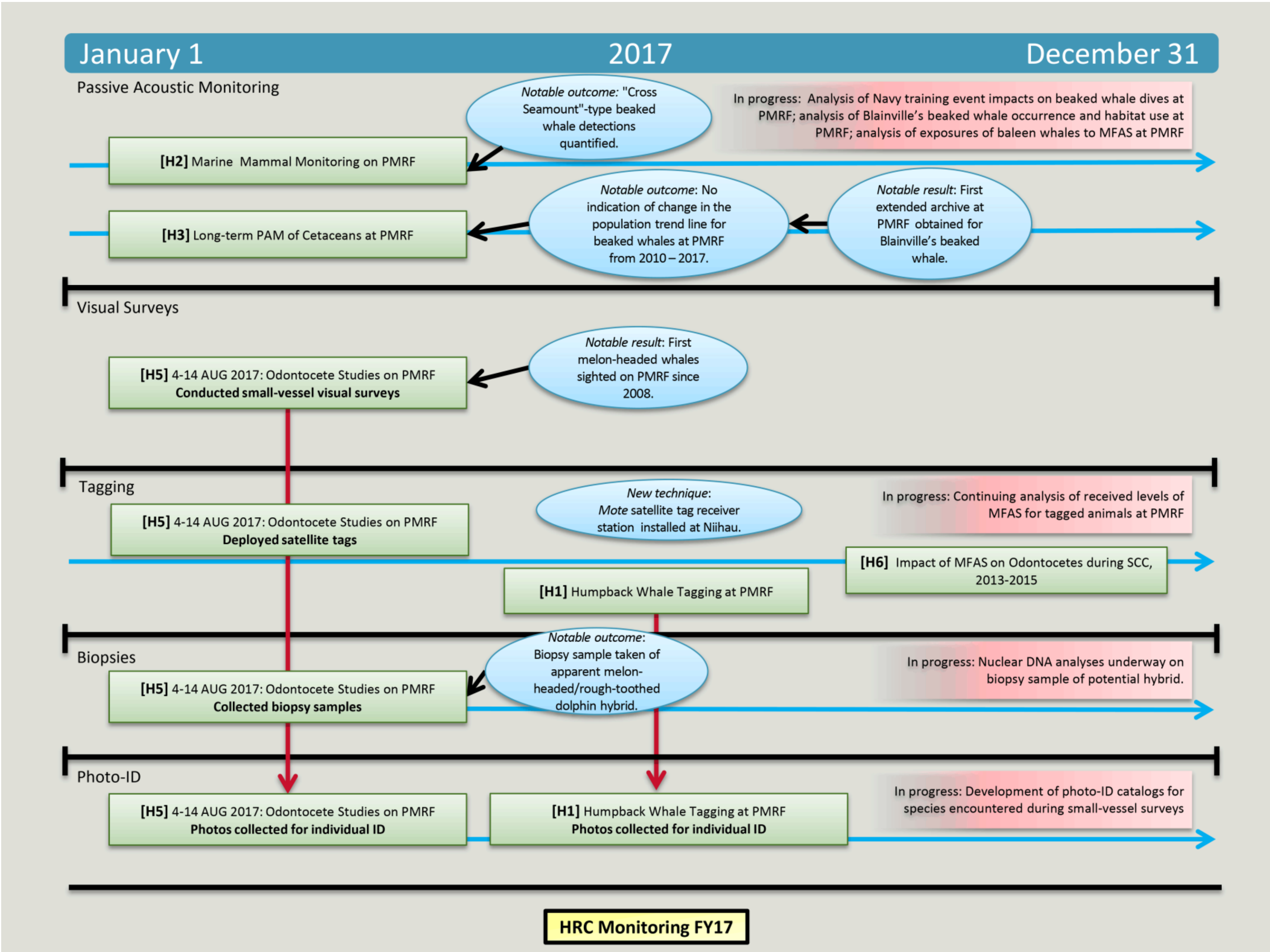


Figure 16. Timeline of 2017 projects in the Hawaii Range Complex.

[H1] Humpback Whale Tagging at PMRF [Henderson et al. 2018]

To better understand the behavior of humpback whales in the HRC, vessel-based satellite tagging and photo-ID were conducted in offshore (>6 km) waters between Kauai and Niihau during March 2017 (**Figure 17**). Low Impact Minimally Percutaneous Electronic Transmitter (LIMPET)-configured SPLASH tags (see **Appendix A**) were deployed on humpback whales presumed to be males. The goal of the project is to attach acoustic pingers and satellite tags to humpback whales, in order to demonstrate that the whales can be tracked by pinger emissions using the bottom-mounted range hydrophones at PMRF. This approach allows species confirmation, localization of whales even when they are not actively vocalizing, and evaluation of automated tracking accuracy, as well as some initial cue rate information and evidence for the amount of time individual whales spend on PMRF. Opportunistic observations of behavioral responses to Navy training activity may also be possible. Results will provide insight into the offshore and migratory behavior of humpback whales in Hawaii, and build a baseline of behavior against which to compare potential responses to Navy training activity in this area.

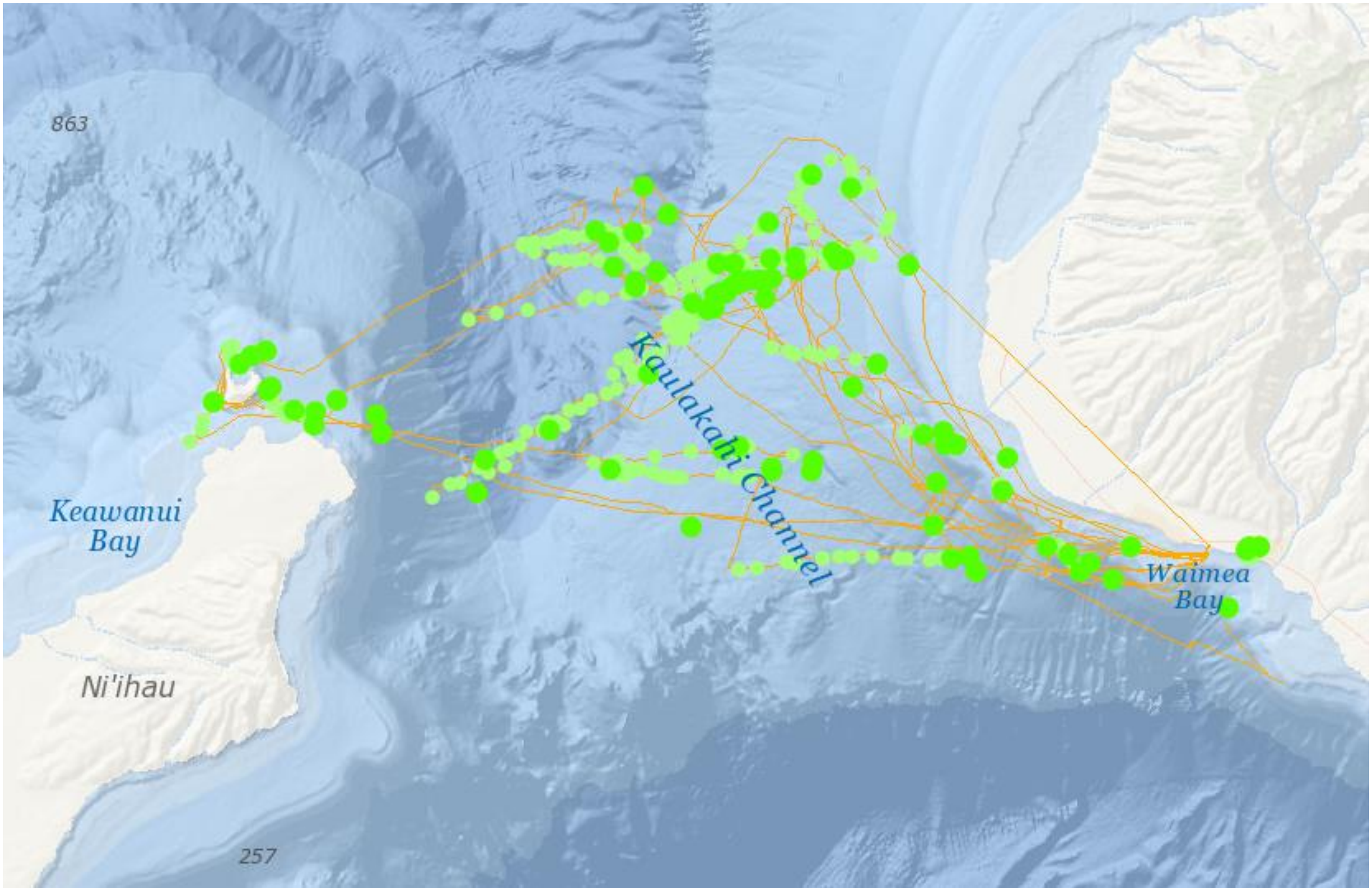


Figure 17. Map of survey area in the Kaulakahi Channel between the islands of Kauai and Niihau. Daily effort tracklines shown in orange, with initial humpback whale group sightings as dark green circles and group resights in light green. From: Henderson et al. 2018 [Project H1]

[H2] SSC Pacific FY17 Annual Report on PMRF Marine Mammal Monitoring [Martin et al. 2018]

Since 2003, marine mammal activity has been acoustically monitored using bottom-mounted hydrophone arrays on the U.S. Navy's PMRF. During FY17, research efforts continued at the Space and Naval Warfare Systems Center Pacific (SSC Pacific) Detection, Classification, Localization, Tracking, and Density Estimate (DCLTDE) Laboratory to detect and localize several species of marine mammals and to estimate received levels (RLs) from MFAS transmissions from these collected acoustic data (**Figure 5**), using automated algorithms. For this annual reporting period, information is presented on the data available post processing, which is from 9 September 2016 to 26 August 2017, and included two Submarine Command Courses (February and August 2017) (Martin et al. 2018). Results of automated processing (i.e., quick looks) are presented for all data collections throughout Fiscal Year 2017 (FY17), documenting relative abundance estimates for Blainville's (*Mesoplodon densirostris*) and Cross Seamount-type beaked whale foraging dives and the number of vocalizing baleen whales for minke (*Balaenoptera acutorostrata*), humpback, and a combined category of low-frequency species (fin [*Balaenoptera physalus*], sei [*B. borealis*], and Bryde's [*B. brydei*] whales.

The previous year's annual monitoring report (Fiscal Year 2016 (FY16): Martin et al. 2017) introduced the new disturbance analysis, which included calculated cumulative sound exposure levels (CSELs) and ship-whale geometries for the duration of an animal's track in the presence of multiple ships transmitting hull-mounted MFAS. That effort was conducted manually, while in FY17, the disturbance analysis process was semi-automated in collaboration with the ONR-funded effort, titled "Behavioral Response Evaluations Employing robust baselines and actual Navy training" (BREVE), project. Disturbance analysis is an initial step for the BREVE project. The goal of BREVE is to conduct statistical analysis of metrics such as track kinematics in an attempt to quantify any significant changes between animal track kinematics during times with and without MFAS training.

[H3] Long-term Passive Acoustic Monitoring of Cetaceans at PMRF and SCORE [DiMarzio et al. 2018]

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 U.S. 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 S3**). 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.

In 2016, an initial risk function for Cuvier's beaked whales (*Ziphius cavirostris*) 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 project (Moretti 2017). 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}). In 2017, these estimates were updated with data from 2015 through September 2017.

Detection statistics (i.e., 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. 2018).

FY17 goals include making data available and applying data to study 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 the precise location of sonar sources, a risk function for behavioral disruption of Blainville's beaked whales at AUTEC was developed.

[H4] Navy Civilian Marine Mammal Observers on DDGs

Since 2014, MMOs have embarked on U.S. Navy warships during Submarine Command Course (SCC) training events (in February 2014, 2015, and 2016), and a Koa Kai event (January 2014) (Dickenson et al. 2014; Shoemaker et al. 2014; Vars et al. 2016; Watwood et al. 2016). During these embarks, MMOs follow 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 record marine mammal and sea turtle sightings in order to help determine the species and populations observed relative to U.S. Navy training events in the HRC.

[H5] Odontocete Studies on the Pacific Missile Range Facility in August 2017: Satellite-tagging, Photo-identification, and Passive Acoustic Monitoring [Baird 2018]

This long-term marine mammal monitoring project has been conducted since 2011, and leverages earlier surveys through 2003, by Cascadia Research Collective (CRC) and SSC Pacific, utilizing combined vessel-based field efforts and passive acoustic monitoring (PAM) on and around PMRF. In 2017, efforts occurred immediately prior to a SCC event to allow for assessment of exposure and response of satellite-tagged individuals to MFAS. Surveys were conducted in conjunction with the M3R PAM system streaming from the instrumented PMRF Range (Moretti 2017; DiMarzio et al. 2018). 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 the SCC; using data obtained from satellite tags (see Baird 2018). (Note: although tags are deployed prior to the training event, the tags can 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 [H6]**, below.)

[H6] Impact of MFAS to Odontocetes during SCC, 2013–2015

In an effort to assess both exposure and responses to MFAS, data were analyzed from 20 satellite tags deployed on odontocetes between July 2013 and February 2015 (Baird et al. 2017a). Whales were tagged prior to three SCCs held on PMRF during that time period. Details about field methods are available in Baird et al. (2017b). Tags used were either location-only (WC SPOT5) or location-dive (WC Mk10A) tags (see **Appendix A**) in the 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 August 2013 were previously described (Baird et al. 2014a). The methods used here were similar in several areas, with improvements in the area of incorporating an estimate for the animal location accuracy along with using 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. Analyses are ongoing and the final report is expected during the FY18 reporting period.

SOCAL

SOCAL is depicted in **Figure 3**. A timeline of all U.S. Pacific Fleet-funded monitoring tasks implemented in SOCAL in 2017 is illustrated in **Figure 18**. Detailed project summaries follow.

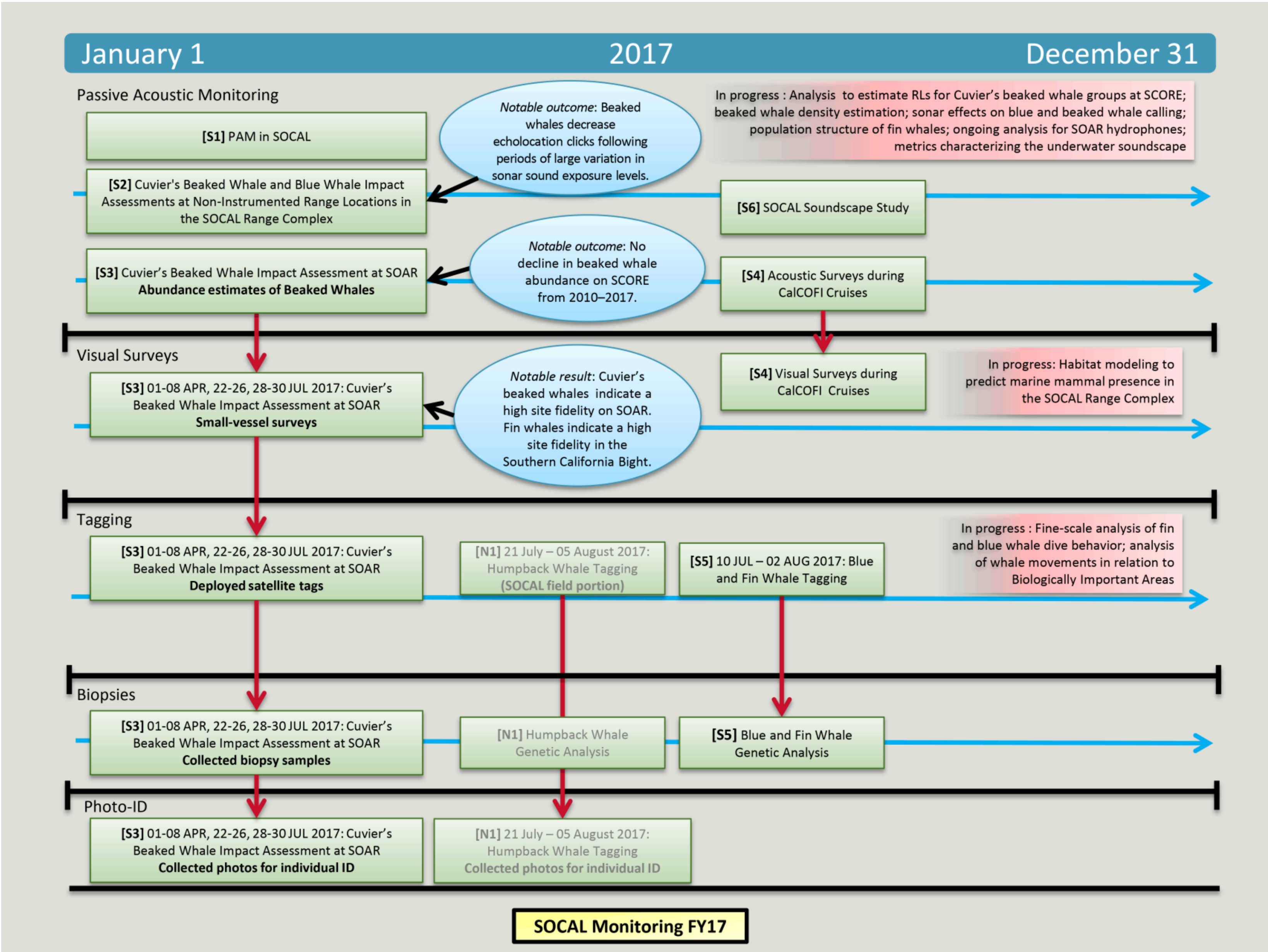


Figure 18. Timeline of 2017 projects in the Southern California Range Complex.

[S1] Passive Acoustic Monitoring in SOCAL [Rice et al. 2018a, Širović et al. 2018]

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 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 kilohertz (kHz) and are capable of approximately 300 d of continuous data storage. All analyses are conducted using automated detectors for whale and anthropogenic sound sources.

Rice et al. (2018a) analyzed data collected during April 2016 to July 2017 from HARPs deployed at three locations: west of San Clemente Island (Site H), southwest of San Clemente Island (1,200-m depth, Site N), and west of La Jolla, California (Site P) (**Figure 19**). Only a select sub-set of species including blue whales, fin whales, and beaked whales were analyzed.

Širović et al. (2018) analyzed fin whale song patterns from PAM data collected between 2005 and 2014 by HARPs deployed at four sites (500-m depth, Site P; 670-m depth, Site Q; 770-m depth, Site C; 1,000-m depth, Site H) (Širović et al. 2015) (**Figure 19**). Data collection at two Sites, H and C, occurred over multiple years starting as early as 2005, while at Sites P and Q it was shorter (analysis thus far is for 2009-2010). The 20-Hz pulse (i.e., fin whale vocalization) start times were picked from 2 d a month of data, and interpulse intervals (IPIs) were calculated for each picked sequence. This analysis of singing behavior across the Southern California region is being conducted to better understand regional population dynamics of fin whales.

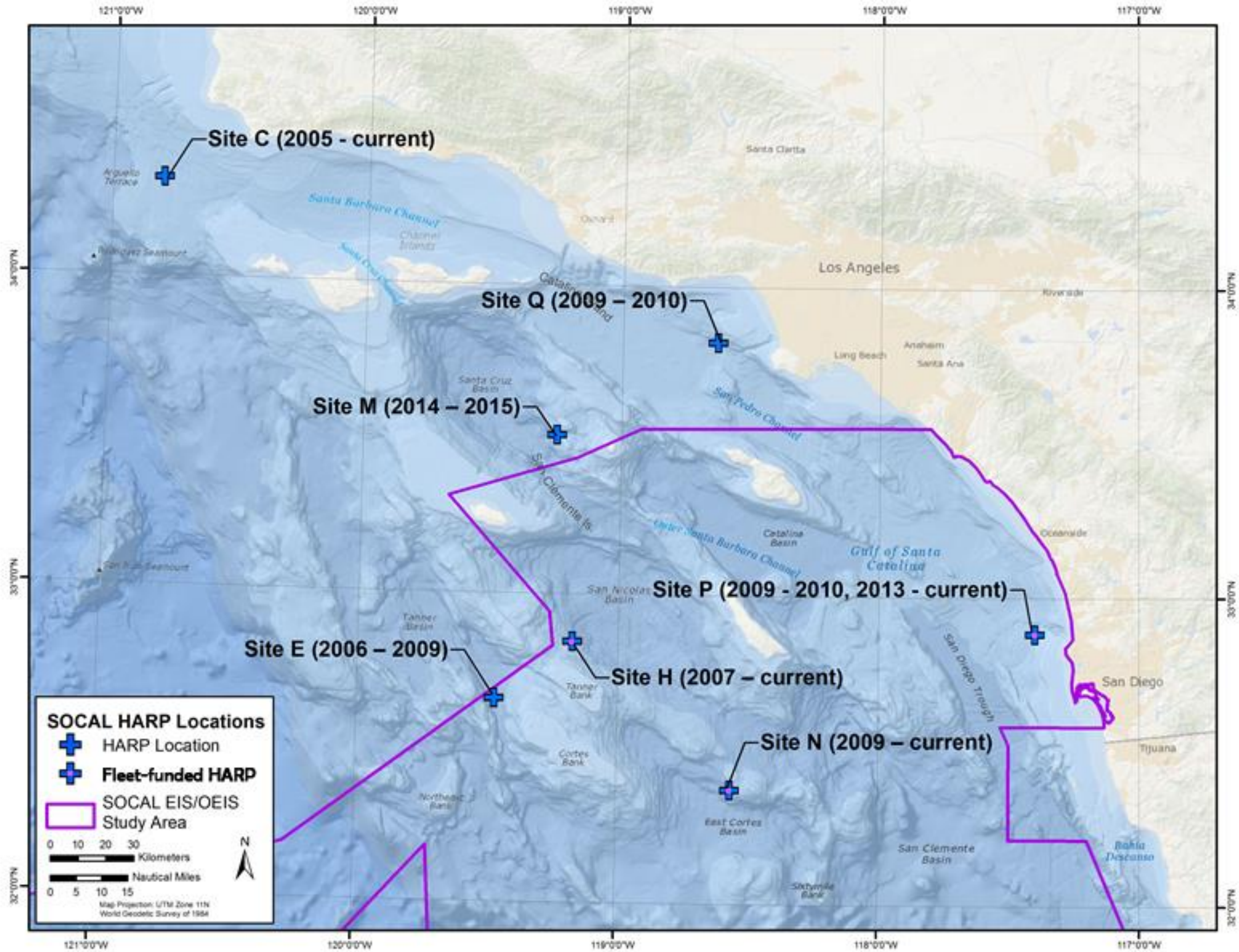


Figure 19. High-frequency Acoustic Recording Packages currently deployed in the Southern California Range Complex. Since January 2009, sites H, N, and P have been Pacific Fleet-funded deployments [Projects S1 and S2]

[S2] Cuvier's Beaked Whale and Blue Whale Impact Assessments at Non-Instrumented Range Locations in the SOCAL Range Complex [Baumann-Pickering et al. 2018]

As noted under **Project [S1]**, SIO is using PAM to assess potential behavioral response (i.e., vocal activity) by marine mammals to MFA sonar and explosive sounds (as well as other anthropogenic sounds). Analyses for **Project [S2]** focused on blue whale and Cuvier's beaked whale acoustic detections at four sites (designated E, H, N, and M) (**Figure 19**) for which there are long-term recordings (funded by ONR) and assorted historic detection levels of MFA sonar (high (H, N), medium (M), or low (E) numbers).

Automated methods were established and/or refined to detect vocalizations from blue and Cuvier's beaked whales, MFAS pings, and explosions. Data preparation for all four sites was completed in 2017 (Ŝirović et al. 2017, Baumann-Pickering et al. 2018). Ambiguity in detection ranges was also reduced for blue whale songs, MFAS pings, and Cuvier's beaked whales. SIO collaborated with the Centre for Research into Ecological and Environmental Modelling to develop generalized estimating equation (GEE) models, which is one approach to analyze the impact of sonar on marine mammals. As part of initial modeling efforts, Baumann-Pickering et al. (2018) focused on one site (Site N) and signal type (blue whale D calls, and beaked whale clicks in 1-min segments). Planned efforts for 2018 include (1) developing GEEs for the three other sites; (2) adding blue whale calls to the impact analyses; and (3) employing a multi-spatial convergent cross mapping approach for analysis of impact of sonar on blue and beaked whales.

[S3] Cuvier's Beaked Whale Impact Assessment at the Southern California Offshore Antisubmarine Warfare Range (SOAR) [Schorr et al. 2018]

Ongoing studies of the distribution and demographics of several key marine mammal species within SOCAL were conducted by MarEcoTel during 16 d of survey effort in April and July 2017. Survey effort was focused on SOAR (**Figure 20**) with a primary goal to collect sighting data, photographs, and biopsy samples from Cuvier's beaked whales and fin whales.

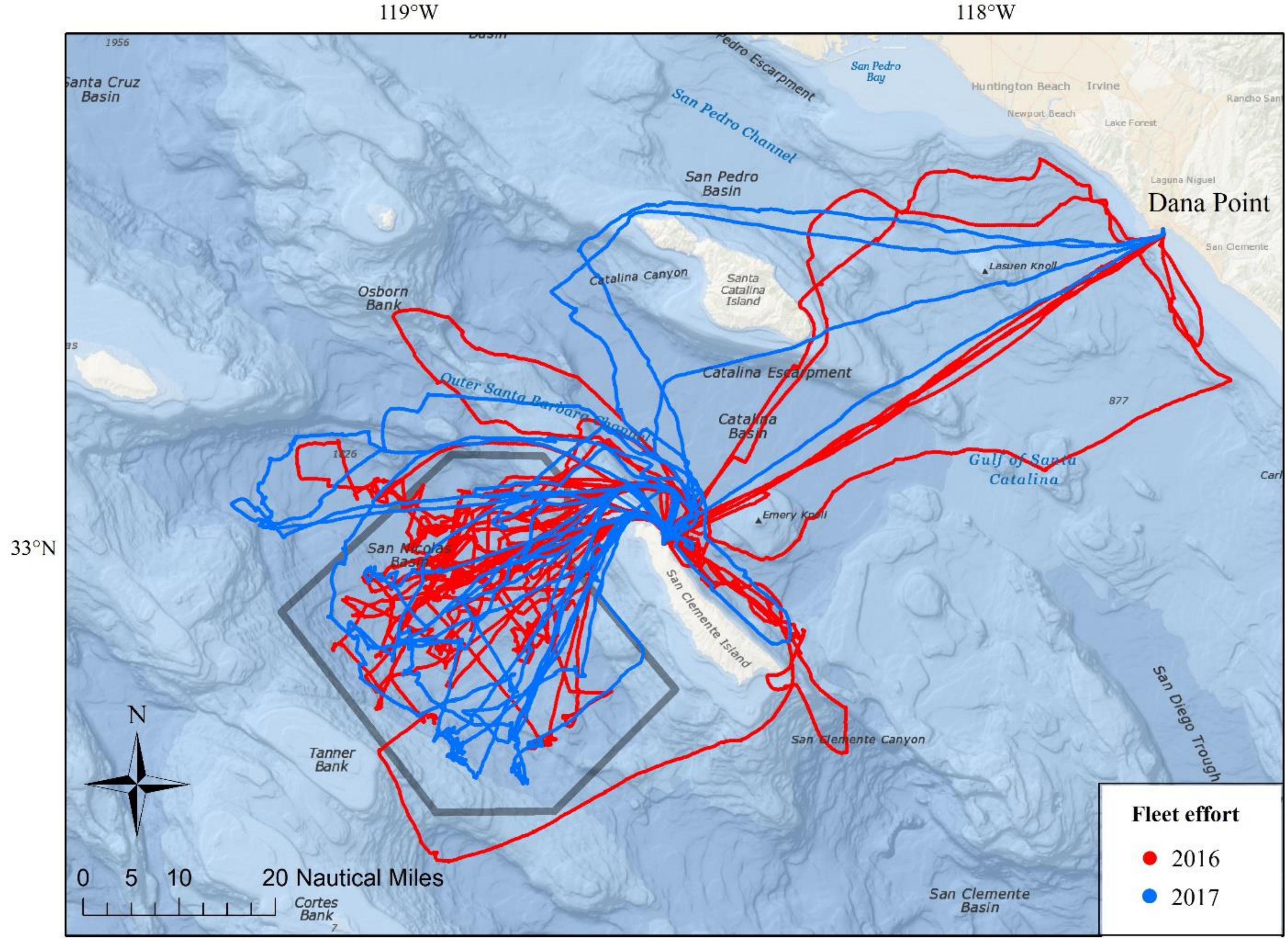


Figure 20. Vessel track lines from surveys conducted January 2016 through November 2017. Black lines west of San Clemente Island depict the Southern California Offshore Antisubmarine Warfare Range (SOAR) range boundaries. From: Schorr et al. 2018 [Project S3]

Staff from the NUWC M3R program monitored hydrophones from the Range Operations Center on Naval Air Station North Island in San Diego and directed 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 Beaufort sea state 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 identification was 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 and Risso's dolphins [*Grampus griseus*]). Remote tissue biopsies were collected from species of interest both to this study (Cuvier's beaked whales and fin whales), and also on behalf of collaborators at the Southwest Fisheries Science Center (SWFSC) for use in ongoing assessments of offshore populations and stress hormone analyses. Finally, a limited number of satellite tags (LIMPET SPLASH10-A design) (see **Appendix A**) were deployed, as this effort was focused more on population monitoring that is better supported by photo-ID and biopsy data.

[S4] Marine Mammal Surveys on CalCOFI Cruises [Hildebrand et al. 2018]

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 (Campbell et al. 2014, 2015; Debich et al. 2017; Hildebrand et al. 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; Jefferson et al. 2015). Each CalCOFI cruise consists of sampling the same survey tracklines including coverage offshore (>185 km). Visual and acoustic data are used to characterize spatial and temporal distribution and habitat use 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).

[S5] Blue & Fin Whale Tagging and Analysis in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas

Oregon State University's Marine Mammal Institute tagged blue and fin whales in the offshore areas of SOCAL for the fourth year in a row (see Mate et al. 2015, 2016, 2017a). The objective of this study is to collect information on long-range movement and occurrence patterns within NMFS-designated Biologically Important Areas (BIAs) (Calambokidis et al. 2015; Ferguson et al. 2015) and details of individual animal use of U.S. Navy testing and training areas and subareas in terms of residence time. This information includes movements in and through

SOCAL, NWTT, and Naval Air Systems Command's Point Mugu Sea Range (PT MUGU). Information about foraging and dive behaviors for blue and fin whales was also obtained (Mate et al. 2017a). During the course of this project, three types of satellite-monitored radio tags were deployed on blue and fin whales: location only (LO), dive monitoring (DM), and advanced dive behavior (ADB) tags. LO tags provide long-term tracking information via the Argos satellite system, and generate metrics to define HRs and CAs; DM tags provide intermediate duration Argos tracking and dive behavior (duration, depth, number of feeding lunges per dive), and ADB tags provide short-term, fine scale dive profile information and GPS-quality locations (see **Appendix A**). All three tag types therefore provide complimentary information and improve our understanding of how and when these whales use U.S. Navy training areas. In 2017, 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, 2016, and 2017 (Mate et al. 2015, 2016, 2017a). Analyses are ongoing and the final report is expected during the FY18 reporting period.

This is the same project completed for NWTT **[N4]**.

[S6] SOCAL Soundscape Study

Archived passive acoustic data from the U.S. Navy-funded HARP deployments in the SOCAL range by SIO is in progress for metrics characterizing the underwater soundscape in the SOCAL range, based on multi-year recordings by HARPs of ambient biological (including sounds produced by whales), abiotic, and anthropogenic sound. The processing of ambient soundscape includes calculating long (multi-year) spectrograms, sound pressure spectrum level percentiles, and average sound pressure spectrum levels over the recording periods. Detections of anthropogenic sources such as broadband ship, MFAS, LFAS, and explosions will be characterized.

NWTT

The NWTT Study Area including offshore areas is depicted in **Figures 9 and 10**. A timeline of all U.S. Pacific Fleet-funded monitoring tasks implemented in the NWTT in 2017 is illustrated in **Figure 21**. For four of these NWTT projects, field work and data collection occurred prior to or during 2016, but data analysis occurred within the 2017 reporting period. See below for detailed project summaries.

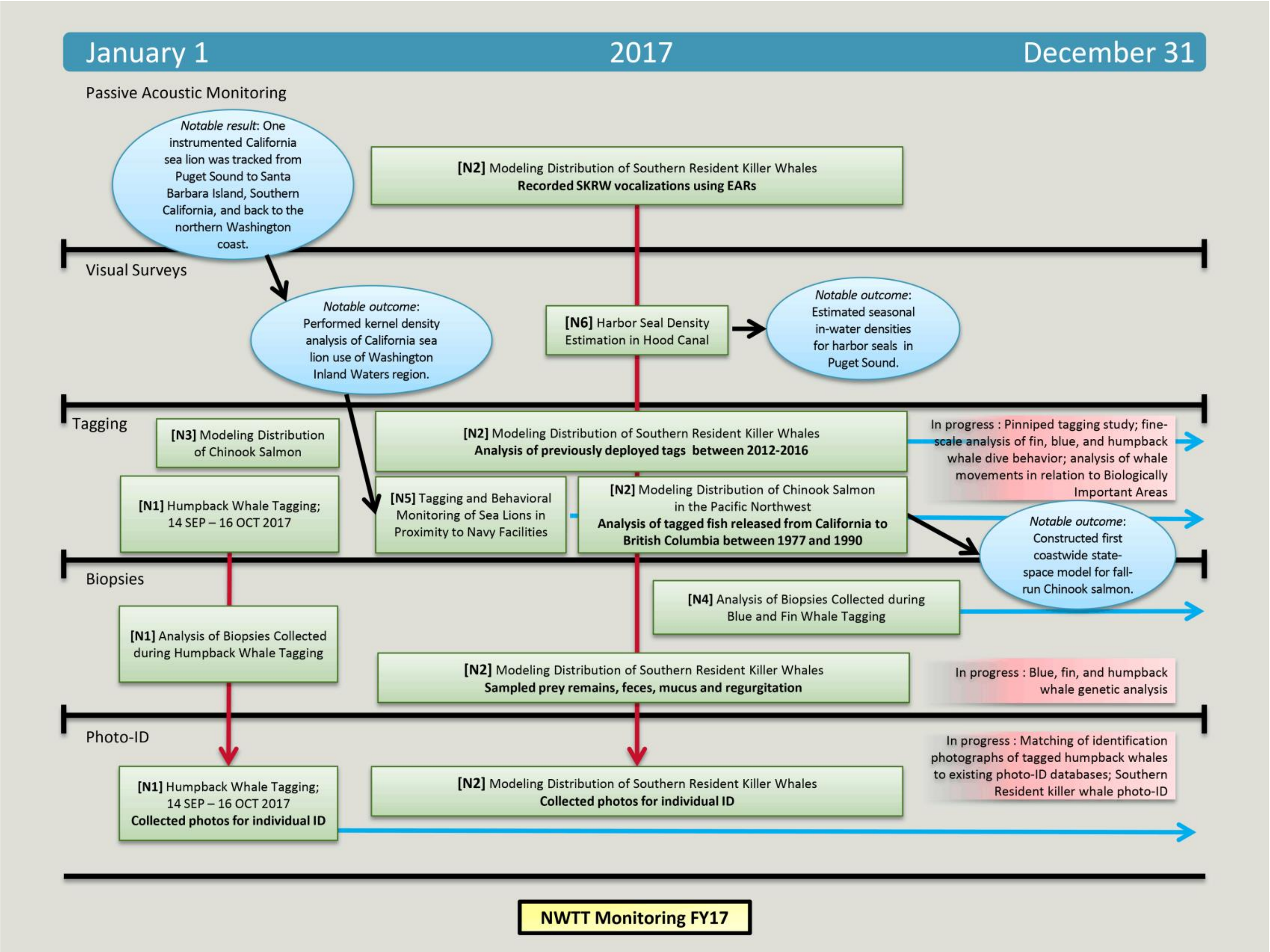


Figure 21. Timeline of 2017 projects in the Northwest Training and Testing Study Area.

[N1] Humpback Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean [Mate et al. 2017]

Under a Cooperative Agreement between the U.S. Navy and the Marine Mammal Research Institute of Oregon State University, researchers are satellite tagging humpback whales and conducting genetic analyses on tissue collected during tag placement. The objective is to collect more information on what portion of each humpback whale distinct population segment (DPS) uses the naval operational areas in the North Pacific, as well as the proportion of time spent there. In 2017, two types of satellite-monitored radio tags were deployed on humpback whales—intermediate DM tags (see **Project [S5]** methods above) and dive duration monitoring (DUR) tags, which monitor longer-term movements and dive durations (see **Appendix A**). Using a RHIB, 14 tags (seven Telonics RDW-665 DM, and seven Telonics RDW-640 DUR) were deployed off southern and central California from 21 July to 4 August. Five DUR tags were deployed off Oregon/Washington during 14 September to 16 October. Seventeen biopsy samples were collected and efforts are underway to determine sex of individuals, individual identification, and species and stock identification; these will be presented in the final report. Photo-ID was conducted and the task of matching photographs of tagged whales to existing photo catalogs is ongoing. Some additional tagging of humpback whales was leveraged under Project **[S5]**, and will be tabulated and analyzed in final reporting.

[N2] Modeling Offshore Distribution of Southern Resident Killer Whales [Hanson et al. 2018]

The NMFS Northwest Fisheries Science Center (NWFSC) conducts a portion of its research efforts with funding support from the U.S. Navy, which requires information about marine mammal occurrence on and in waters surrounding military bases in the region for their permitting requirements.

To assess the seasonal occurrence of endangered Southern Resident killer whales (SRKW) relative to naval training ranges in Puget Sound or in the coastal waters of Washington and Oregon, satellite tags were deployed and visual and acoustic detections compiled (Hanson et al. 2017, 2018; **Figure 22**). The area of interest included waters encompassing the U.S. Navy's NWTRC Warning Area 237 (W237) and the Olympic Military Operations Area (MOA). Satellite-linked tags (WC, SPOT5) (see **Appendix A**) were deployed on eight adult males from the J, K, and L pods between 2012 and 2016. Tagging data span from late December to mid-May. Whale K25 had the longest tag duration (96 d); his track is depicted in **Figure 22**. Stereotypic calls of SRKW were detected by as many as 13 autonomous passive acoustic devices (EARs) deployed off the coast of California, Oregon, and Washington deployed by NWFSC from 2011 to 2016. Although the focus of the PAM effort was from January to June of each year, some acoustic data were collected in every month of the year. Opportunistic (i.e., 'citizen science') visual sightings from 2006 to 2011 were integrated with the output from a state-space movement model fit to the locations from several satellite-tagged individuals, in order to enhance the limited acoustic detections. For the winters of 2007 to 2011 when SRKWs were not tagged, these results make better predictions of coastal habitat use. This project illustrates how movement data from satellite tags integrated with detection data (visual and acoustic) can be used to construct maps of habitat use when fine-scale location data are not available.

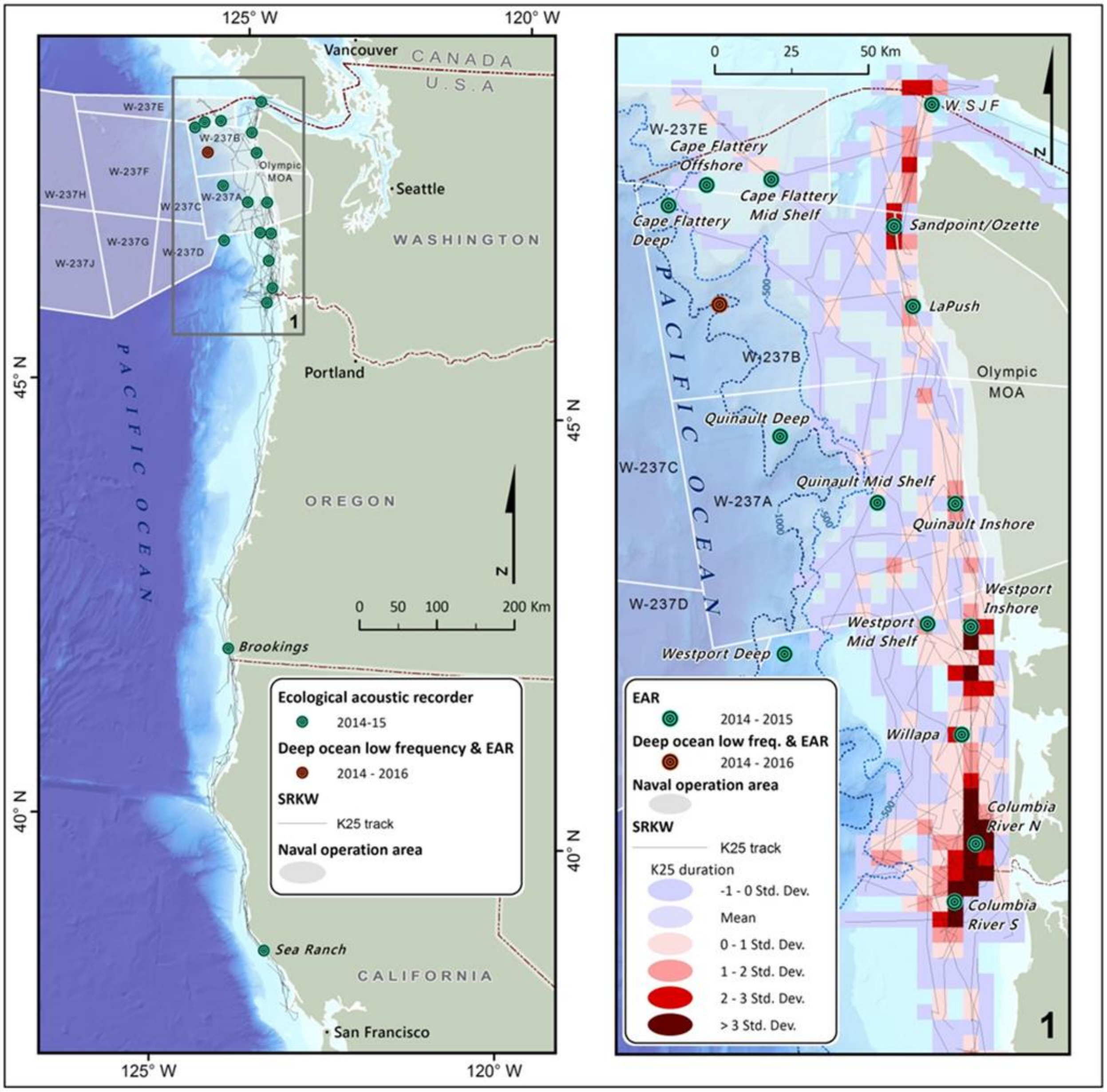


Figure 22. Locations of Ecological Acoustic Recorders (EARS) deployed in 2014 through 2016 and 2013 track of satellite-tagged SRKW K25 relative to naval operational areas. Density 5x5 km grid cells based on duration of occurrence are shown in red. From: Hanson et al. 2018 [Project N2].

[N3] Modeling Offshore Distribution of Chinook Salmon [Shelton et al. in review]

This project leverages existing work funded by the U.S. Navy and NMFS (specifically, the Northwest Fisheries Science Center). Chinook salmon (*Oncorhynchus tshawytscha*) is an important component of the diet of SRKWs. In order to better understand seasonal changes in distribution of Chinook salmon in the eastern North Pacific, Shelton et al. (in review) constructed a state-space model. Although there are multiple Chinook salmon run types in this area, fall-run salmon were chosen for use in the model, because they are abundant and there is a wealth of data (both in terms of population size and tagging programs). The analysis included 1) data from tagged fish released from 43 major hatcheries spanning central California to British Columbia between 1977 and 1990 (**Figure 23**); 2) fish tag recovery information compiled from tag code (e.g., recovery date, location code, and port at which the fish were sampled); and 3) commercial and recreational fishing effort from the United States and Canadian government sources. A state-space model was constructed that provided a joint estimate of salmon spatial distribution, juvenile mortality, and spatio-temporal estimates of fish mortality.

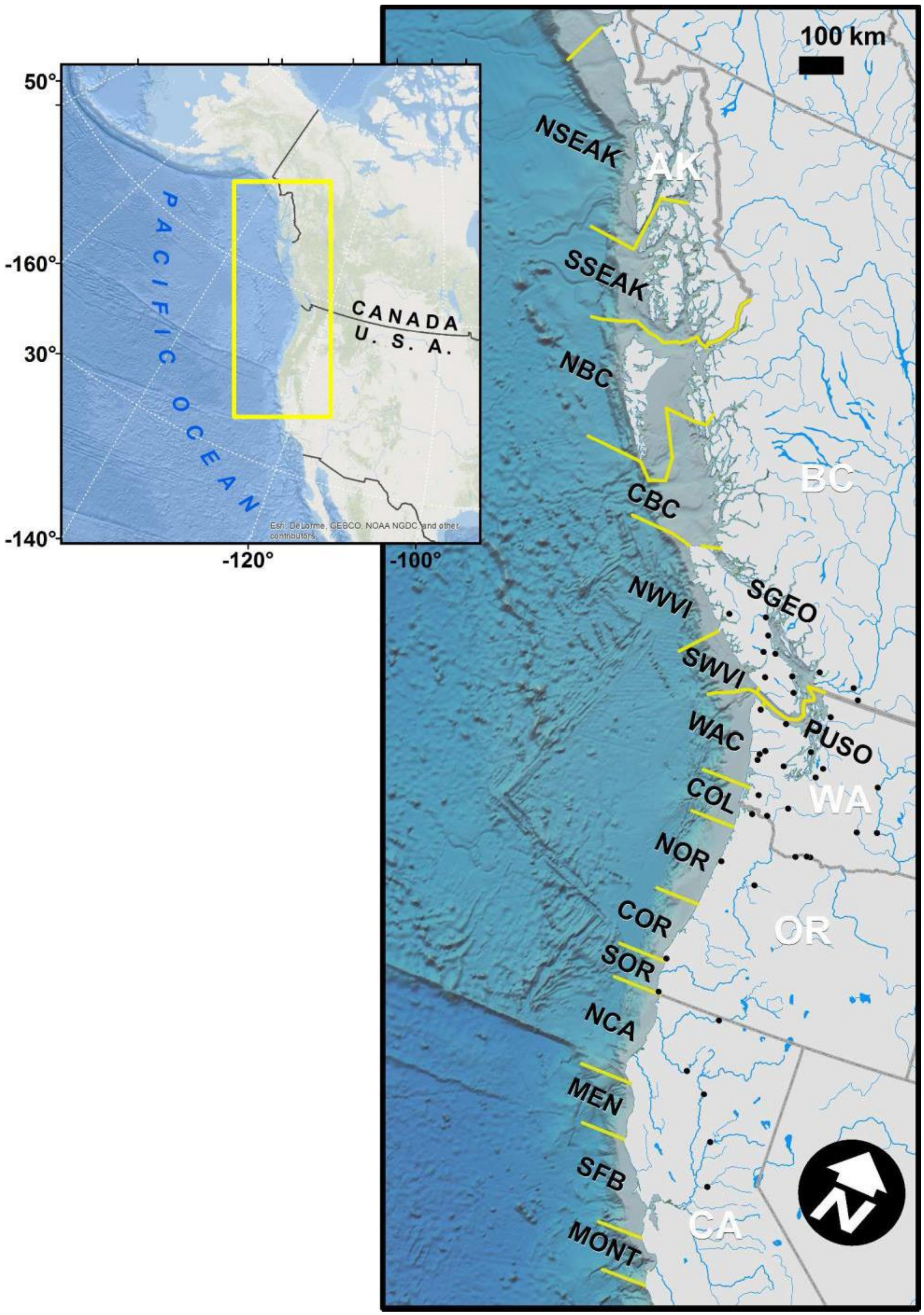


Figure 23. Salmon hatchery locations (black dots) and 17 coastal regions. From: Shelton et al. in review [Project N3].

[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 completed for SOCAL, refer to **Project S5**.

[N5] Tagging and Behavioral Monitoring of Sea Lions in the Pacific Northwest in Proximity to Navy Facilities [DeLong et al. 2017]

From late 2014 through June 2016, scientists from NMFS (National Marine Mammal Laboratory and Alaska Fisheries Science Center) in collaboration with Washington Department of Fish & Wildlife (WDFW), funded by U.S. Pacific Fleet, collected sea lion behavioral data, including the percentage of time individuals haul-out each month on structures and assets near Puget Sound naval facilities at Everett, Bremerton, Bangor, and Clam Bay, adjacent to the Navy Fuel Depot at Manchester (**Figure 24**). Floats were anchored in place at Bremerton and Everett in 2014; however, due to lack of use, and the fact that animals preferentially haul out on the port security barriers, the Everett float was removed in 2015. Traps were installed on the floats to allow the agencies the ability to capture adult male California sea lions (*Zalophus californianus*) and instrument 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. The purpose of this study was to describe the haulout behavior, proportion of time hauled out on Navy facilities, and regional marine habitat usage by California sea lions, relative to Navy activities. The end objective was for NMFS and WDFW to determine a correction factor that adjusts the in-water density estimates to more accurately reflect the amount of time spent in the water versus the amount of time hauled out, based on their behavior (i.e., tag wet [animal in-water] or tag dry [animal hauled out]; see **Appendix A**). 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.

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.

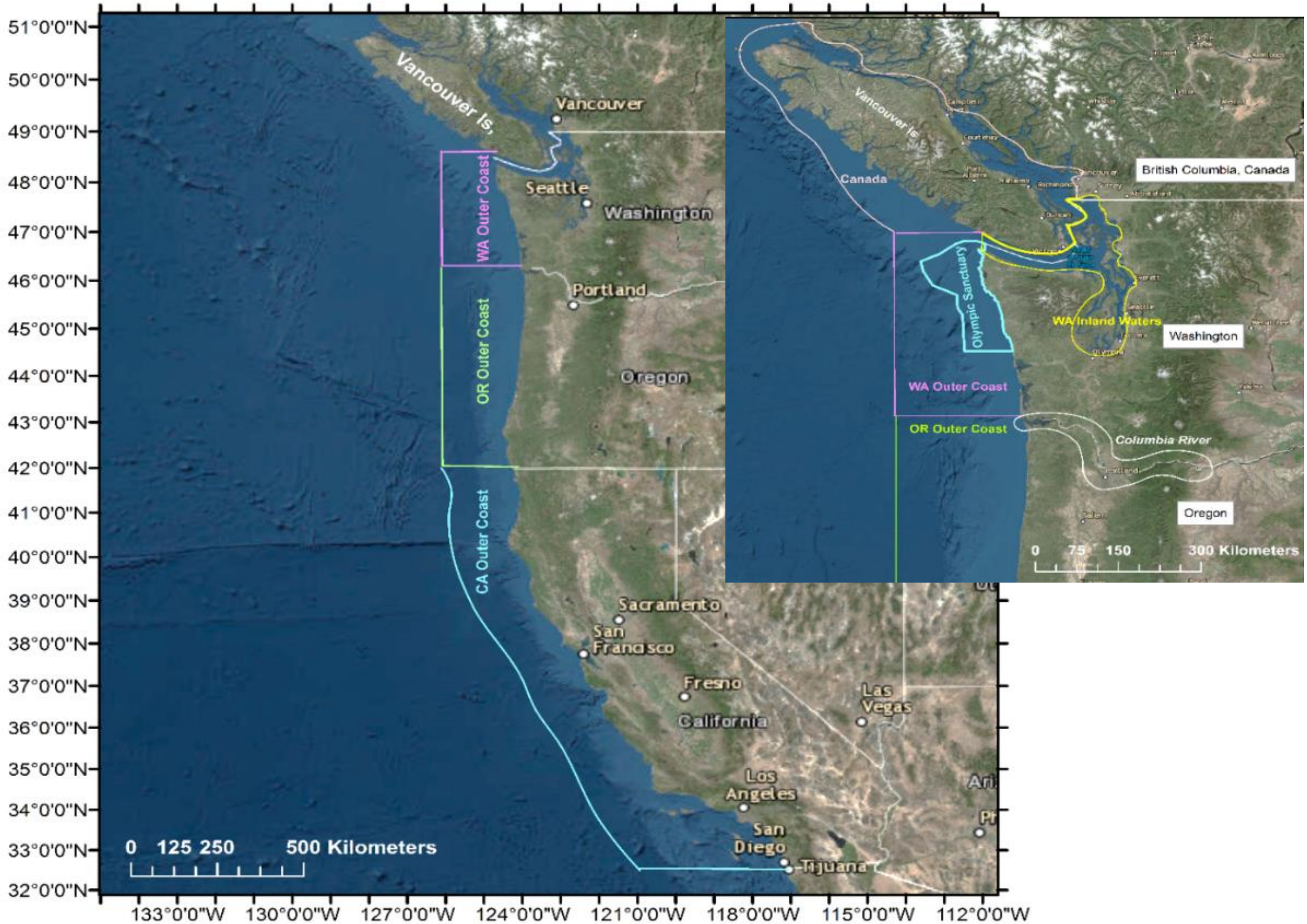


Figure 24. Geographic regions used in analysis of satellite telemetry data collected from adult male California sea lions. From: DeLong et al. 2017 [Project N5]

[N6] Harbor Seal Density Estimation [Jefferson et al. 2017]

In order to evaluate impacts and estimate exposure to U.S. Navy activities that may cause acoustic disturbance, abundance and in-water densities were derived for harbor seals in six sub-regions of Hood Canal, Washington. Navy-funded line-transect aerial survey data, collected from 2013 to 2016 by Smultea Environmental Sciences (Smultea et al. 2017), were used to directly estimate harbor seal density and abundance in the water (by season and sub-region [**Figure 25**]) with associated variance factors. A correction factor [trackline detection probability–g(0)] was estimated from dive and surface time data from seal tagging studies in Hood Canal. This project was a collaboration between Clymene Enterprises, HDR, Inc., Smultea Environmental Sciences, NMFS-Alaska Fisheries Science Center (National Marine Mammal Laboratory), and WDFW.

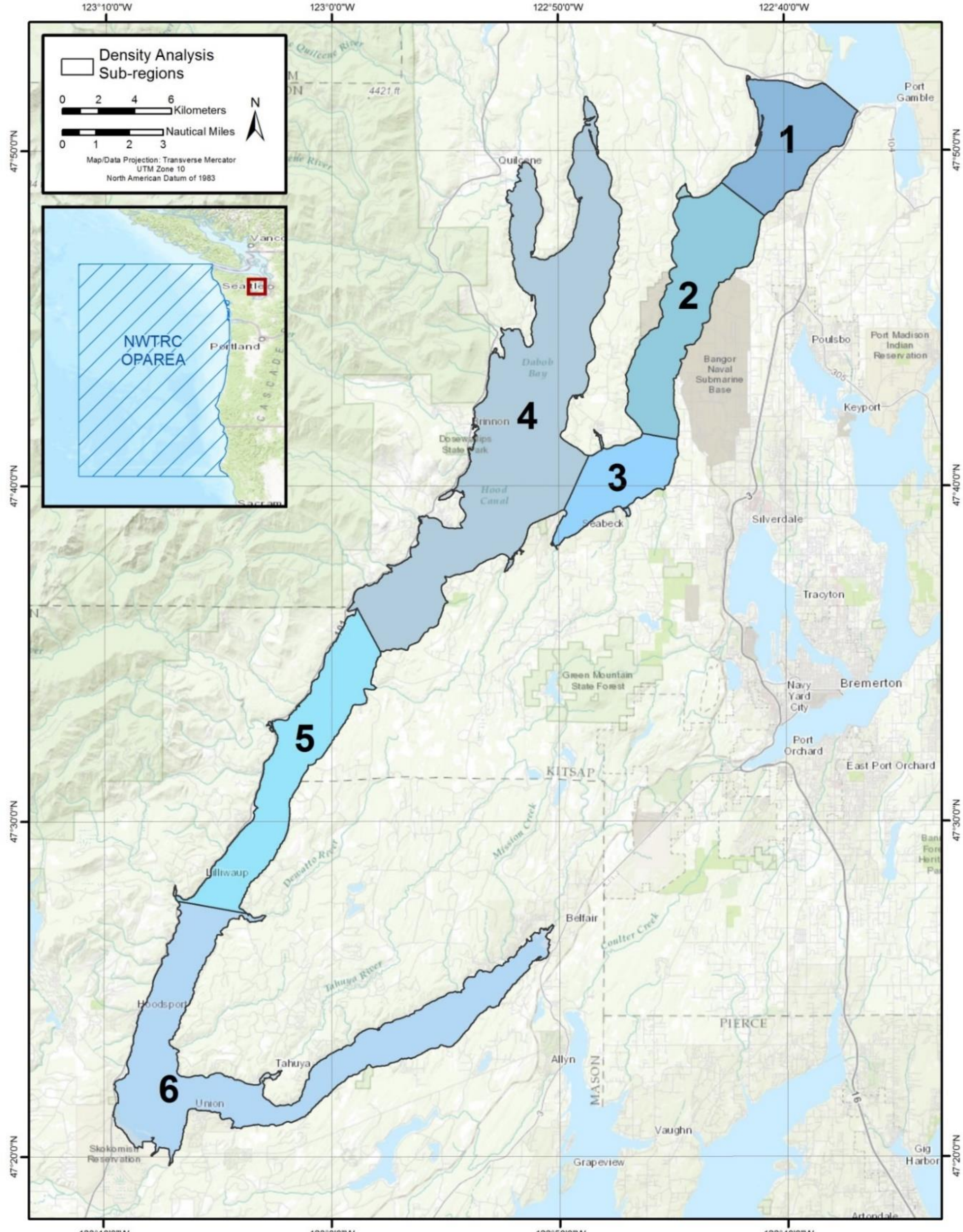


Figure 25. Density analysis sub-regions. Sub-region 1: Hood Canal Bridge to Navigation Marker #8 and #9, Sub-region 2: Area 1 to Hazel Point to Marker #11, Sub-region 3: Area 2 to Oak Harbor to Misery Point, Sub-region 4: Area 3 to Trident Head (green Marker #9 to Teku Point), Sub-region 5: Area 4 to Lilliwaup Bay to Duwato Bay, Sub-region 6: Area 5 around the Great Bend to Belfair. Navigational markers correspond to those of National Oceanic and Atmospheric Administration chart 18476. From: Jefferson et al. 2017 [Project N6]

GOA TMAA

The GOA TMAA is depicted in **Figure 11**. A timeline of all U.S. Pacific Fleet-funded monitoring tasks implemented in the GOA TMAA in 2017 is illustrated in **Figure 26**. It should be noted that for the GOA TMAA project, field work and data collection occurred during 2015, but data analysis occurred within the 2017 reporting period. Detailed project summaries follow.

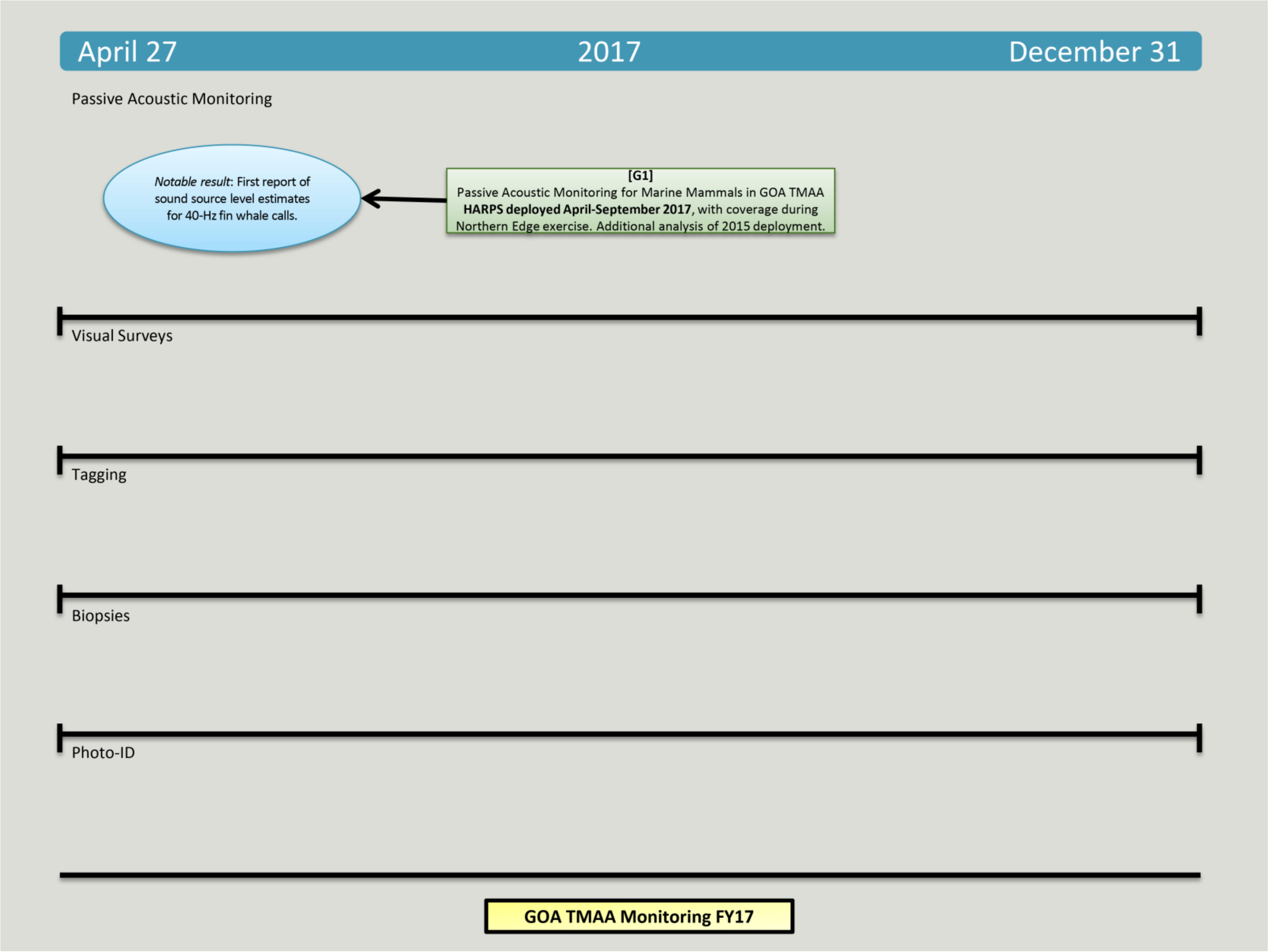


Figure 26. Timeline of 2017 Gulf of Alaska Temporary Maritime Activities Area monitoring projects. The Letter of Authorization (NMFS 2013d) for GOA TMAA was effective starting 27 April 2017.

[G1] Passive Acoustic Monitoring of Marine Mammals in GOA TMAA using Bottom-Mounted Devices [Wiggins and Hildebrand 2018; Rice et al. 2018b]

U.S. Navy-funded HARP deployments by SIO in the GOA TMAA have taken place since 2011, using two to five HARPs (Baumann-Pickering et al. 2012; Debich et al. 2013, 2014; Rice et al. 2015; Wiggins et al. 2017; Wiggins and Hildebrand 2018). In 2015, passive acoustic data were collected from three deployment locations in the GOA during May to September (**Figure 27**). The three HARPs were configured in an equilateral triangle approximately 1 km per side (**Figure 27**) utilizing recorder clock synchrony to enabale marine mammal call localization and tracking. Two types of HARPs were used: a single-hydrophone (10 Hz – 100 kHz) system at the north site (Site 1), and two four-hydrophone (10 Hz – 50 kHz) systems (Wiggins et al. 2012) at the southern, downslope sites (Sites 2 and 3). Site 1's recording was over four months; whereas, Sites 2 and 3 were over three month period (**Figure 27**).

Concurrent with the US Navy's Northern Edge 2017 exercise in the GOA TMAA from 1-12 May 2017, three HARPs were deployed in GOA from 27 April to 14 September 2017 (Rice et al. 2018b) (**Figure 27**). Two deployment sites, one on the continential slope and another at the offshore Quinn Seamount, were sites for similar HARP deployments between July 2011 and August 2015. A new abyssal plain site was added in 2017 with the location approximately halfway between the slope and seamount HARPs. The abyssal plain HARP was tethered to a bottom anchor at 4,400 m with the hydrophones deployed at 1,150 m.. Data from all three 2017 HARP locations were analyzed for ambient sound as well as detections of anthropogenic sound and the vocalizations of beaked whales and ESA-listed baleen whales. Final analysis and reporting is still ongoing.

In FY17, data analysis consisted of detecting marine mammal and anthropogenic sounds by analyst scans of long-term spectral averages and spectrograms, and by automated computer algorithm detection when possible. Recordings were processed and analyzed using Triton (Wiggins and Hildebrand 2007) and custom software routines in MATLAB (MathWorks Inc., Natick, MA).

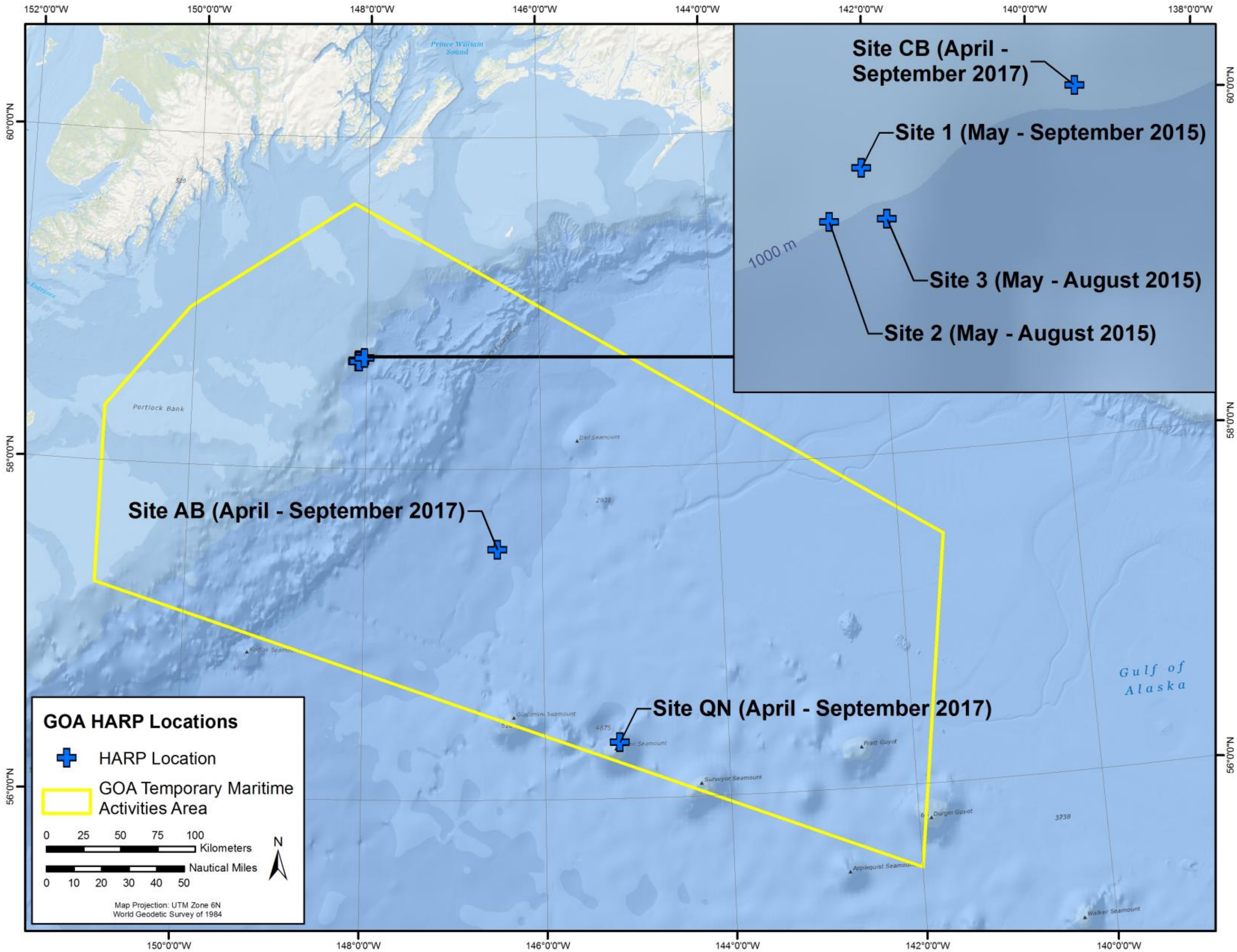


Figure 27. High-frequency Acoustic Recording Package locations in the Gulf of Alaska Temporary Maritime Activities Area. [Project G1]

2.2 Results

Cumulative results and key conclusions from the Pacific monitoring projects are summarized below. Project results are organized by 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 projects 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 to address the conceptual framework category of *occurrence* of protected marine species in the four Pacific training and testing study areas: HSTT (HRC and SOCAL), MITT, NWTT, and GOA TMAA. Progress is treated by means of monitoring questions and objectives related to *occurrence*, and within this grouping, is ordered by range complex.

In 2017, 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. 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?

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

From 2015 through 2017, 154 cetacean sightings (12,662 individuals) were recorded and 17 satellite tags deployed on animals in the waters surrounding Saipan, Tinian, Rota, Aguijan, and Guam. A total of 72 biopsy samples were collected and 40,802 photographs taken. Confirmed species include: bottlenose dolphin, pantropical spotted dolphin (*Stenella attenuata*), spinner dolphin, melon-headed whale, false killer whale (*Pseudorca crassidens*), pygmy killer whale (*Feresa attenuata*), Blainville's beaked whale, humpback whale, and Bryde's whale. Sightings not confirmed to species include unidentified beaked whales, sei/bryde's whale, and unidentified whale.

Species observed during small-vessel surveys in February and May 2017 off Saipan, Tinian, and Guam were bottlenose dolphins, spinner dolphins, and short-finned pilot whales (**Figures 28 and 29**) (Hill et al. 2018). In May, an unidentified beaked whale was observed and the encounter was similar to those in previous years (**Figure 29**) (Hill et al. 2014, 2015, 2017), although, two encounters occurred with *Mesoplodon* beaked whales in the waters surrounding Rota and Guam in May and June 2016. The first sighting of a beaked whale (or any cetacean species) at Galvez Banks (Guam) during PIFSC CRP's small-vessel surveys occurred in 2016. Pantropical spotted dolphins, rough-toothed dolphins (*Steno bredanensis*), sperm whales (*Physeter macrocephalus*), dwarf sperm whales (*Kogia sima*), bottlenose dolphin, and pygmy killer whales were encountered during similar surveys performed in 2015 and 2016. Most marine mammal species predicted to occur in the waters off Guam and CNMI have been encountered and positively identified by the PIFSC CRP's small vessel survey series ongoing since 2010.

In 2017, satellite tags were deployed on a short-finned pilot whale, bottlenose dolphins, and melon-headed whales. Two bottlenose dolphins tagged during separate encountered off Saipan during May appeared to travel together for several days and spent 6 d moving off the west sides of Saipan and Tinian and north to Marpi Reef. From there, the pair traveled north-northwest to East Diamante (a submarine volcano) where one of the individuals spent another 6 d (**Figure 29**). The short-finned pilot whale encounter location was similar to those of previous encounters; however, the depth was much shallower (Hill et al. 2014, 2015, 2017). The preliminary photo-ID data indicate that the individuals were seen on one other occasion in 2012. The satellite tag location and depth data varied from previously tagged short-finned pilot whales as the median distance from shore and depth was greater during 2017. Photo-ID and satellite tag data suggest that the short-finned pilot whale population in the Marianas may include groups of individuals that are more island-associated within the southern portion of the archipelago, as well as those that are intermittent visitors to the nearshore waters of Guam, Rota, Saipan, and Tinian.

In summary, habitat use and encounter rates revealed varying patterns for species occurring around Guam, Rota, Saipan, Tinian, and Aguijan. Patterns of habitat use by spinner dolphins and bottlenose dolphins evident from the 2017 visual surveys were similar to those described in previous years by Hill et al. (2014, 2015, 2016, 2017), while new information emerged for short-finned pilot whales as discussed above.

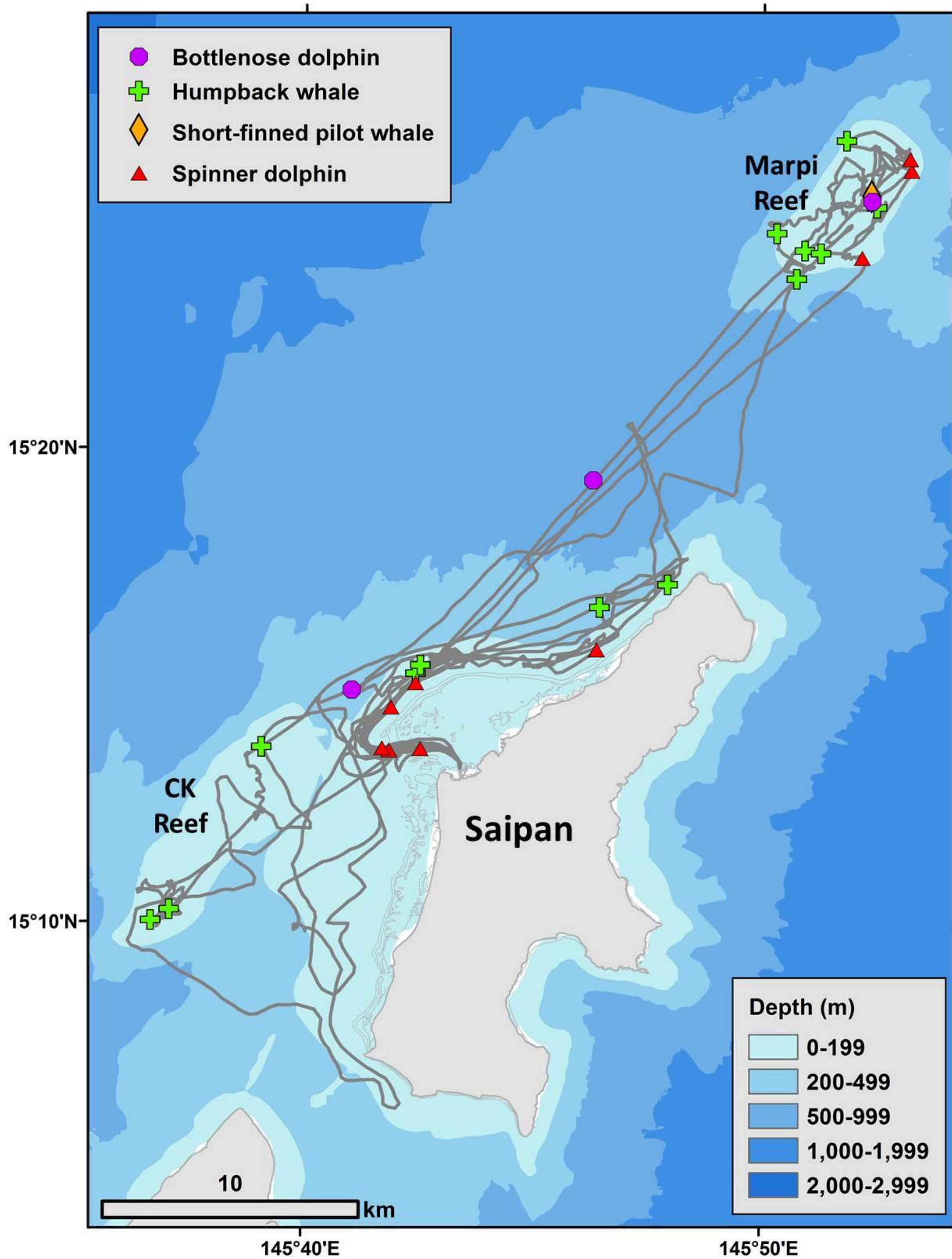


Figure 28. Tracklines and cetacean encounter locations during the 2017 PIFSC CRP Marianas winter (February) small-vessel surveys off Saipan, Tinian, and Guam. From: Hill et al. 2018 [Project M1]

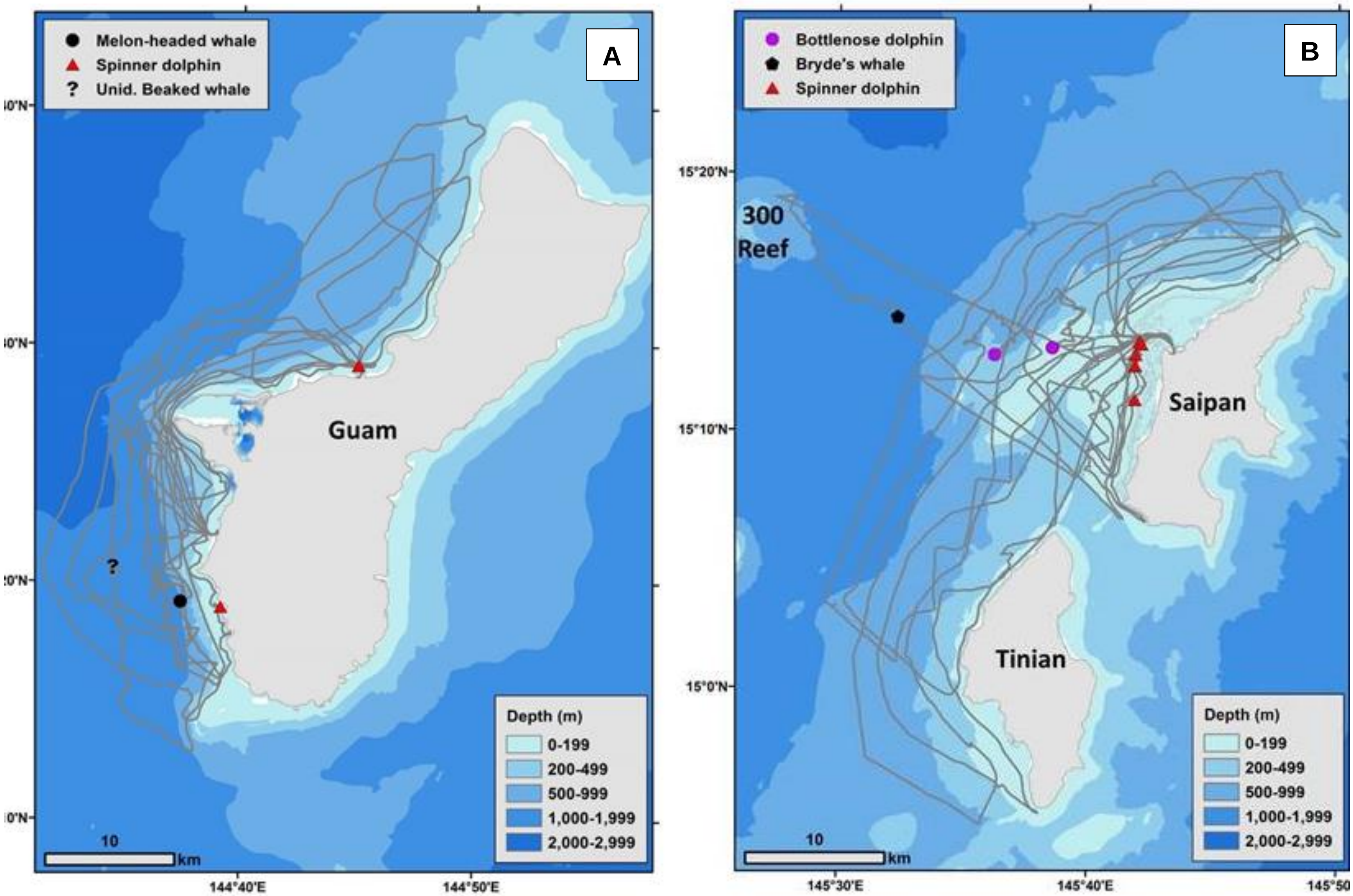


Figure 29. Tracklines and cetacean encounter locations during the 2017 PIFSC CRP Marianas summer (May) (A-B) small-vessel surveys off Saipan, Tinian, and Guam. From: Hill et al. 2018 [Project M1]

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

During small-vessel surveys performed since 2015, 42 humpback whales, one sei/Bryde's whale, and four Bryde's whale sightings have been recorded around Guam, Saipan, Tinian, and Rota.

Small-vessel surveys conducted in February 2017 coincided with the known seasonal occurrence of humpback whales off Saipan and Tinian based on previous surveys (Hill et al. 2015, 2016, 2017). Surveys were made on five days between February 11-22. During 13 humpback whale encounters off Saipan during the small-vessel surveys (**Figure 28**), three were with competitive groups and two included mother-calf pairs (calves being young-of-the-year, including a neonate), one of which one was accompanied by an escort. Four mother-calf pairs were observed in 2015, and five such pairs were also observed in 2016 and 2017. Nineteen individual fluke photographs were obtained, resulting in the addition of 18 individuals to the photo-ID catalog, which now has 35 non-calf individuals. Three individuals were re-sighted from previous years during the 2017 study period and one of those was first sighted during the Navy's 2007 MISTCS line transect survey. Further photo-ID matching with Western Pacific humpback whale photo-ID catalogs is ongoing, including the Commander Islands, Okinawa, and Ogasawara, as well as genetics analyses of mitochondrial haplotypes from biopsies for comparison against known populations.

Despite mother-calf pair sightings, encounter rates of humpback whales were low overall during the 2015, 2016, and 2017 small-vessel visual surveys. This, along with the lack of sightings during the shore-based observations that occurred in 2016, may reflect low numbers of whales using the area during the survey period.

In May, one encounter of a Bryde's whale occurred off the west coast of Saipan (**Figure 29**) and approximately 200 photographs were taken for photo-ID. Previous sightings have occurred during the months of August and September (Hill et al. 2016a) No other baleen whales were observed in 2017.

2.2.1.1 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 continues to build photo-ID catalogs for cetacean species in the Marianas, such as spinner dolphins, bottlenose dolphins, short-finned pilot whales, pygmy killer whales, false killer whales, rough-toothed dolphins, sperm whales and humpback whales, encounter rates and numbers of distinctive individuals within each catalog are still too small to conduct robust abundance analyses (Hill et al. 2018). Ongoing analyses are being conducted on the 2017 winter and summer season photographs.

2.2.1.2 MONITORING QUESTION: WHAT IS THE OCCURRENCE AND HABITAT USE OF SEA TURTLES IN THE MITT STUDY AREA? [PROJECT M2]

With assistance from regional partners, PIFSC Marine Turtle Biology and Assessment Program conducted sea turtle surveys and in-water captures of green turtles and hawksbill turtles in October 2017 (**Figure 30**) (Martin and Jones 2018). Satellite tags were deployed on 17 sea turtles (15 green turtles and 2 hawksbill turtles) of different ages during the 6 d of field effort (**Figure 30**).

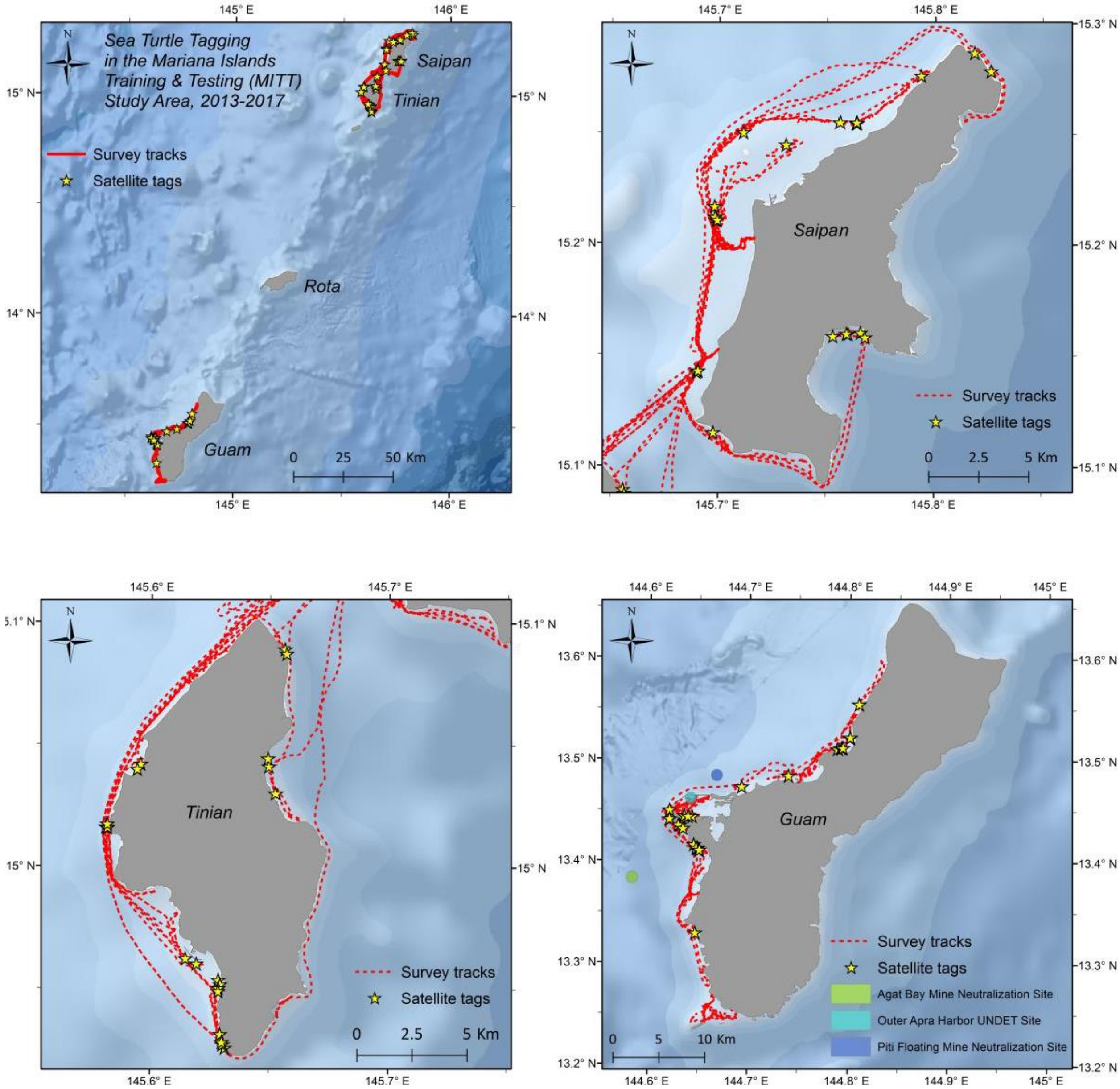


Figure 30. Marine turtle surveys and satellite tag deployment locations in the Mariana Islands Training and Testing (MITT) Study Area. Red lines in are small-vessel GPS tracks from sea turtle surveys conducted in the nearshore waters of Saipan, Tinian, and Guam in 2013-2017. Yellow stars indicate locations of satellite tag deployments on green and hawksbill turtles captured during surveys. U.S. Navy underwater detonation sites on Guam are depicted with colored circles. From: Martin and Jones 2018 [Project M2]

Turtles were observed in most locations that the team has surveyed around Guam, Saipan, and Tinian (**Figure 30**). Over the course of this multi-year project (2013–2017), 38 d were spent in the field and 375 turtles encountered. Of the total of 252 observations, 50 were captured but not instrumented with a tag, and 73 turtles were captured and outfitted with a satellite tag (23 Saipan, 23 Tinian, 27 Guam). 69 percent were identified as green turtles, 4 percent as hawksbill turtles, and 27 percent as "unknown" species, but either green or hawksbill turtles. The demographic data for green and hawksbill turtle captured from 2013 to 2017 are typical for turtles throughout the Marianas Archipelago. The growth rate analysis from the capture-mark-recapture data estimates residency time of 17 years (13–28, 95 percent CI) from recruitment to maturity. Most of the turtles captured during these field efforts are juveniles and subadults, which are on their developmental foraging grounds.

Tagged green and hawksbill turtles, mostly juveniles and sub-adults, spent most of their time in waters shallower than 25 m and with temperatures of 28 to 31 degrees Celsius. While both species made dives to 100 m, hawksbill turtles spent more time in deeper and cooler waters with longer dive durations than green turtles.

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

Consistent with previous years of survey effort (e.g., Jones et al. 2013; Martin et al. 2016; Martin and Jones 2017), the areas of highest turtle density continue to be: 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 (**Figure 31**); (2) in Saipan, the area stretching from the Balisa Channel to Managaha Island, as well as Lao Lao Bay; and (3) off the west coast of Tinian. Patch reef communities dominate these areas where turtles both rest and feed. Based on KIWB estimates, tagged green and hawksbill turtles exhibit high site fidelity and limited movements off Guam, Tinian, and Saipan. While most tagged individuals remained within a 1 to 3 km^2 area for the life of the tag, diversity exists in turtle movement patterns, with several long-range movements. For example, one turtle tagged off Tinian moved more than 2,000 km to Ant Atoll adjacent to Pohnpei, Federated States of Micronesia (**Figure 32**). In related work, from an analysis of over 500 in-water captures from 2006 to 2014, Summers et al. (2017) suggest that turtles recruit to the nearshore waters of the Mariana Islands around 34-36 cm straight-carapace-length (SCL) and depart to adult foraging and nesting grounds around 78-81 cm SCL, remaining in the nearshore waters for an estimated 17 years between recruitment and departure at maturity.

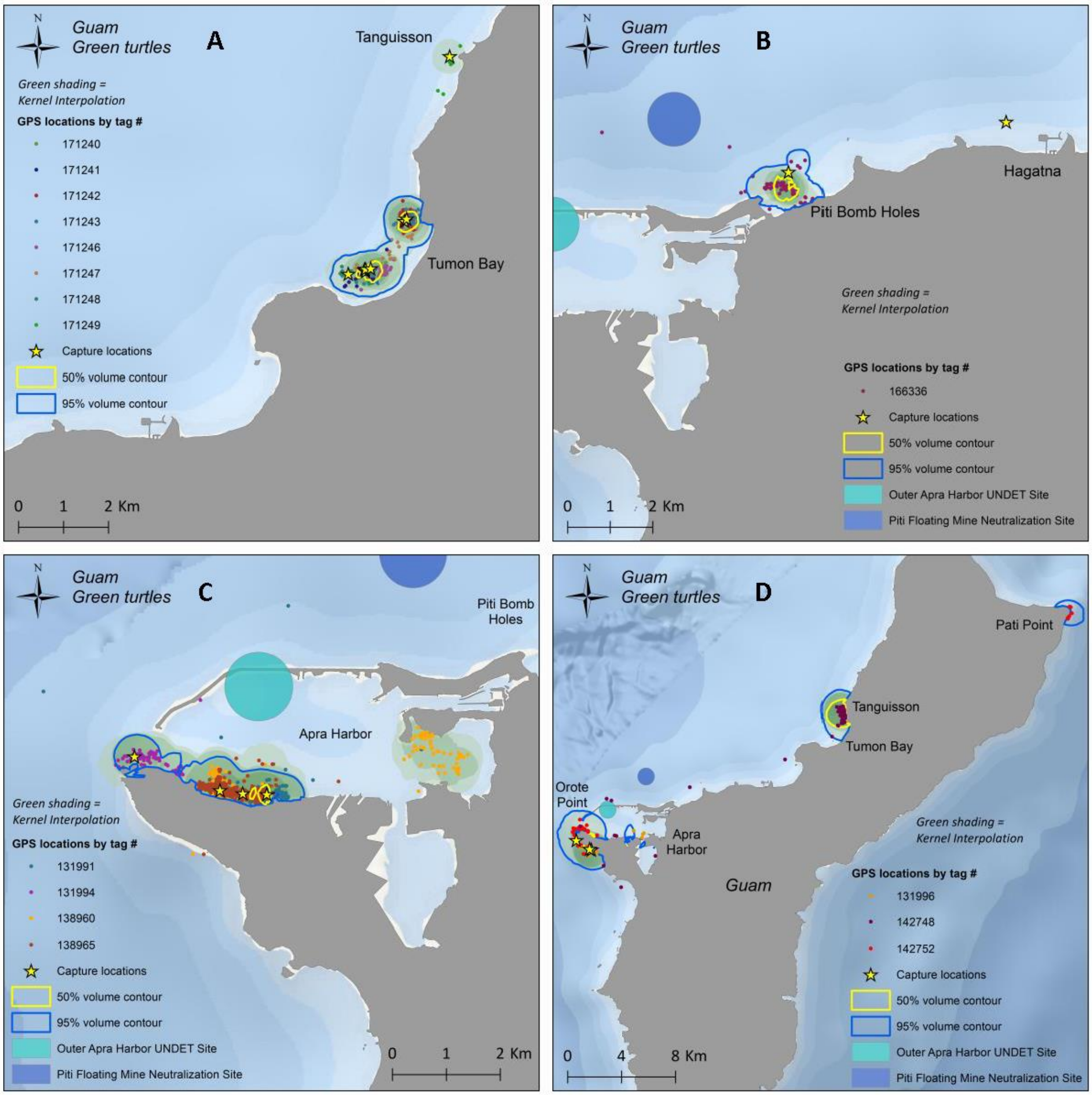


Figure 31. Habitat use map for green turtles tagged in western Guam (sites: Tanguisson, Tumon Bay, Piti Bomb Holes, Apra Harbor, and Orote Point). GPS location data were analyzed using a Kernel Interpolation with Barriers method. Darker shades of green (green turtles) or red (hawksbill turtles) indicate higher density of GPS location points, with the 50 percent (core area) and 95 percent (home range) volume contours outlined in yellow and blue, respectively. From: Martin and Jones 2018 [Project M2]

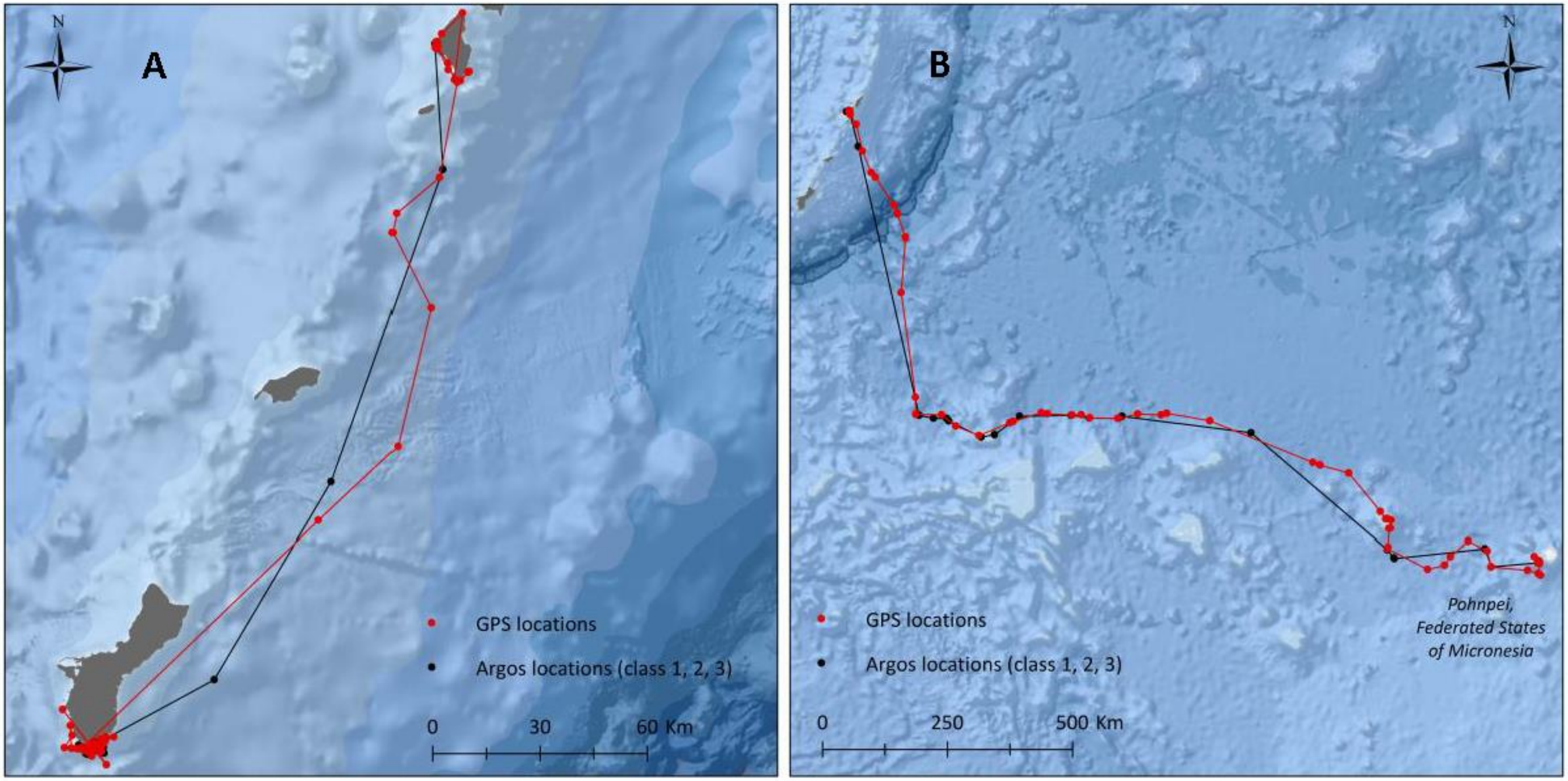


Figure 32. Migration of hawksbill turtles from Tinian to Guam and Pohnpei. (A) A 61.7 cm hawksbill turtle (Argos ID: 85493) was tagged 20 August 2013 at Fleming Point, Tinian. (B) A 72.3 cm hawksbill turtle (Argos ID: 138963) was tagged 21 July 2014 at Fleming Point, Tinian. From: Martin and Jones 2018 [Project M2]

2.2.1.4 MONITORING QUESTION: WHAT IS THE OCCURRENCE OF ESA-LISTED CORALS AROUND FDM? [PROJECT M3]

Coral reef surveys were conducted at FDM from 27 September to 1 October 2017. The 2017 survey was the first coral survey conducted since 2012. Identification of coral to species in the field is very challenging due to coral morphology and differing opinions on taxonomy, and frequently cannot be confirmed from photographs. Within the Mariana archipelago, four ESA-listed coral species have been confirmed to species: *Acropora globiceps, Acropora retusa, Acropora speciosa,* and *Seriatopora aculeata* (Fenner and Burdick 2016), and potentially *Pavona diffluens*. Of these, previous field surveys identified only *A. globiceps* as being present at FDM (Smith and Marx, 2016). Many colonies from the 2017 survey have thus far been identified only to genus level; further efforts for identification to species level are ongoing through FY18.

Analysis and species identification by coral taxonomy experts is still underway, but at this writing, two ESA-listed coral species could be confirmed from photographs from the 2017, four colonies of *Pavona diffluens*, and one colony of *Acropora globiceps* (**Figure 33**). This survey represents the first published confirmation of *P. diffluens* in the Marianas.

A single specimen of *A. humilis*, which closely resembles *A. globiceps*, was also positively identified. A number of specimens of an unidentified *Acropora* sp., closely resembling *A. globiceps* were seen in photographs (**Figure 34**). A meticulous inspection of those photographs and comparisons with specimens from Samoa, Tonga, Fiji, and CNMI suggest this may be a new species, closely resembling *A. globiceps*, but differing in important distinguishing characteristics. No *Acropora retusa, A. speciosa*, or *Seriatopora aculeata* were seen.

Figure 33. Confirmed ESA-listed *Acropora globiceps* colony. From: Carilli et al. 2018 [Project M3]

Figure 34. Two *Acropora* spp. colonies that might be *A. globiceps*, but for which identification was not confirmed. From: Carilli et al. 2018 [Project M3]

2.2.1.5 MONITORING QUESTION: 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? [PROJECT H1]

In late March, Henderson et al. (2018) satellite-tagged seven humpback whales in offshore waters (>6 km) between Kauai and Niihau. The individuals were presumably male, based on their behavior (i.e., escorts in competitive pods, in adult or subadult dyads, or solitary). Over the course of the time that the tags transmitted (1.6 to 12.3 d, with an average of 5.1 d), tagged whales traveled daily distances of 62.8 to 142.5 km.

After being tagged these individuals continued to travel, spending no time over the PMRF hydrophone range. The movements of six of the whales appeared to follow the Hawaiian archipelago toward Kaula and Middle Bank, with the seventh departing directly northward across abyssal waters (**Figure 35**). The whales traveled slower (median speed = 1.1 km/hr) and appeared to mill when they were in shallow water close to the islands or swimming in waters over the seamounts (**Figure 36**). When tagged whales moved across open water with more directed travel, they traveled at moderate speeds (median speed = 5.5 km/hr). Whales made shallow dives in shallow waters and made deeper dives and increased speed and directivity when moving between shallow areas. The deepest dives for the most part happened at night, but only if the whales were in offshore, deep waters.

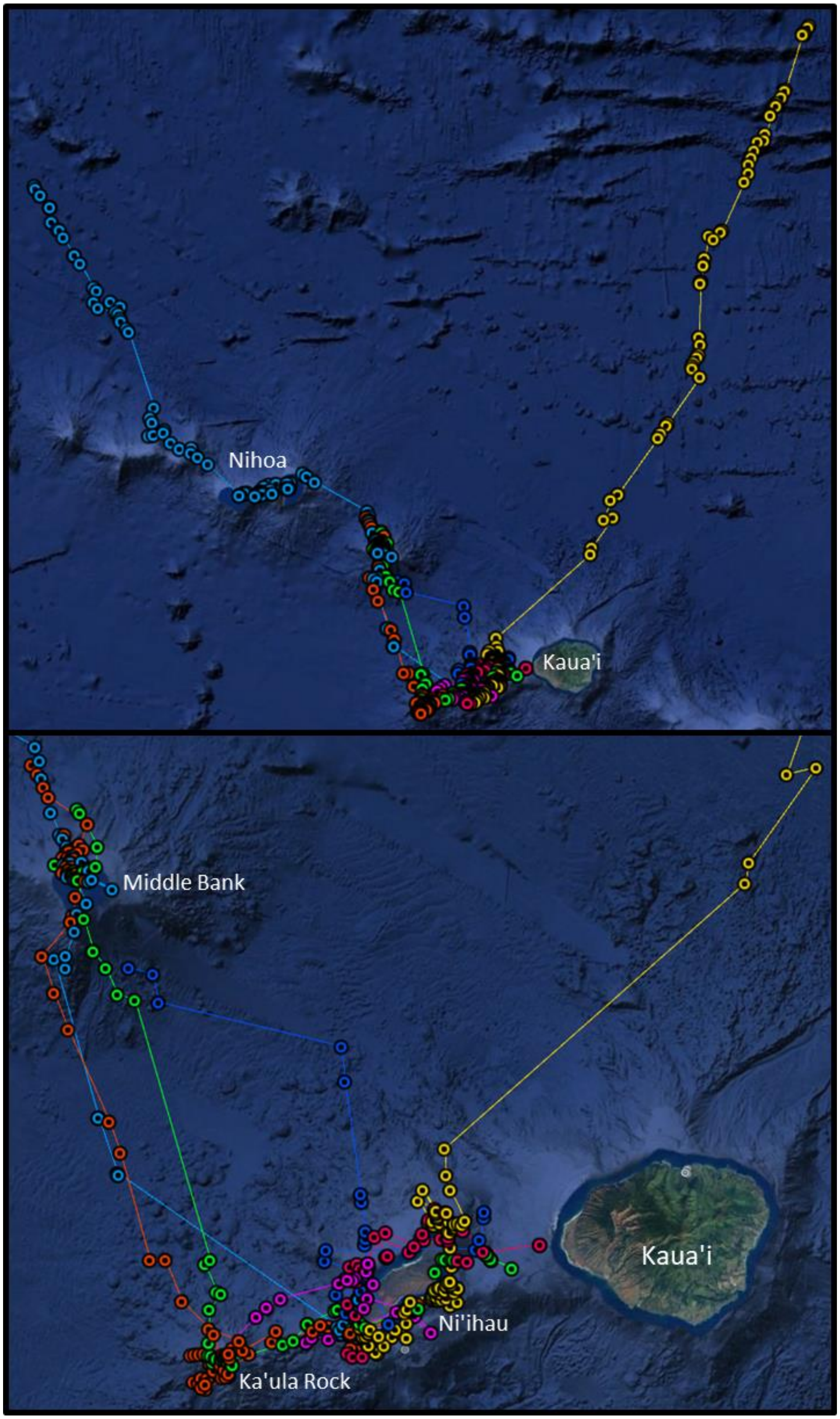


Figure 35. Satellite-derived filtered location positions and tracks of all seven tagged humpback whales (top); same tracks zoomed in (bottom) to show movement around Niihau, Kaula, and Middle Bank. From: Henderson et al. 2018. [Project H1]

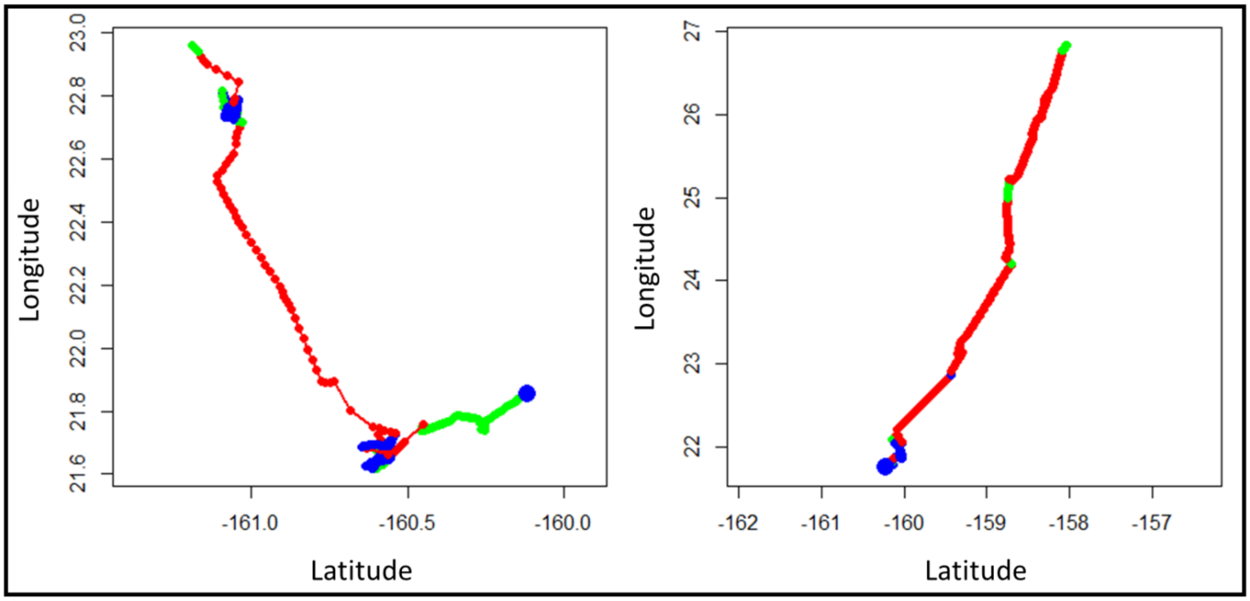


Figure 36. Track of tagged humpback whales 158670 (left) and 164791 (right) with Markovian behavioral states based on distance per 20 min interval shown with colors corresponding to different states (blue locations have a mean distance of 0.002 degrees, green tracks 0.01 degrees, and red tracks >0.02 degrees). The tracks were modeled with 14 and 16 segments, respectively, with shorter distances and slower speeds occurring when the whales are near islands or seamounts, and longer distances and faster speeds as the whales move across deeper water. From: Henderson et al. 2018. [Project H1]

Only one individual (Tag #164792) (**Figure 35**) was resighted, twice in the vicinity of the range (these distances were not provided in the report). This individual was the only one to return to the channel once tagged. Henderson et al. (2018) speculated that individual humpback whales may generally spend little time on or near PMRF, minimizing individuals' exposure to ship movement or MFAS; however the specific timing of this survey in 2017 may not provide results representative of the broader winter season, and Martin et al. (2018) noted that that future surveys will be necessary to determine if these movement patterns prove to be consistent across years. Because the tagged animals did not remain resident on PMRF, and because pinger tags were not deployed this season, the project goals of evaluating automated tracking accuracy by M3R, tracking movements when not vocalizing, and establishing call rates for different age/sex classes were not able to be addressed in this pilot season.

2.2.1.6 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 H5]

During 4–14 August, small-vessel visual surveys were confined to the southern-most part of PMRF and areas south of PMRF, due to high seas associated with easterly trade winds. Most (84 percent) of the survey effort was conducted in waters less than 1,000 m in bottom depth (median depth = 575 m) (**Figure 37**; Baird 2018). The rough-toothed dolphin was the most frequently sighted species (*n* = 22), which is consistent with observations made during CRC research efforts off Kauai and Niihau (e.g., Baird et al. 2014b, 2015, 2016, 2017a). Other species observed included the bottlenose dolphin (*n* = 5), melon-headed whale (*n* = 4), spinner dolphin (*n* = 2), and pantropical spotted dolphin (*n* = 1).

Melon-headed whales have been documented off Kauai or Niihau four times, once in June 2003 and three times over a 6-day period in June 2008. In August 2017, there were four sightings: two sightings of a large group seen two days in a row, and two that were composed only of the same pair of individuals seen four days apart, once mixed in with approximately 20 rough-toothed dolphins, and the second time mixed in with approximately 28 rough-toothed dolphins. Based on pigmentation patterns and head morphology, one of the two individuals in the pair appeared to be a hybrid between a melon-headed whale and a rough-toothed dolphin. A biopsy sample collected from the putative hybrid was sent for analyses to the SWFSC. The sample was genetically confirmed as being from a male and with the mitochondrial haplotype of a melon-headed whale. Nuclear DNA analyses are underway with this sample to determine whether it shows signs of hybrid ancestry.

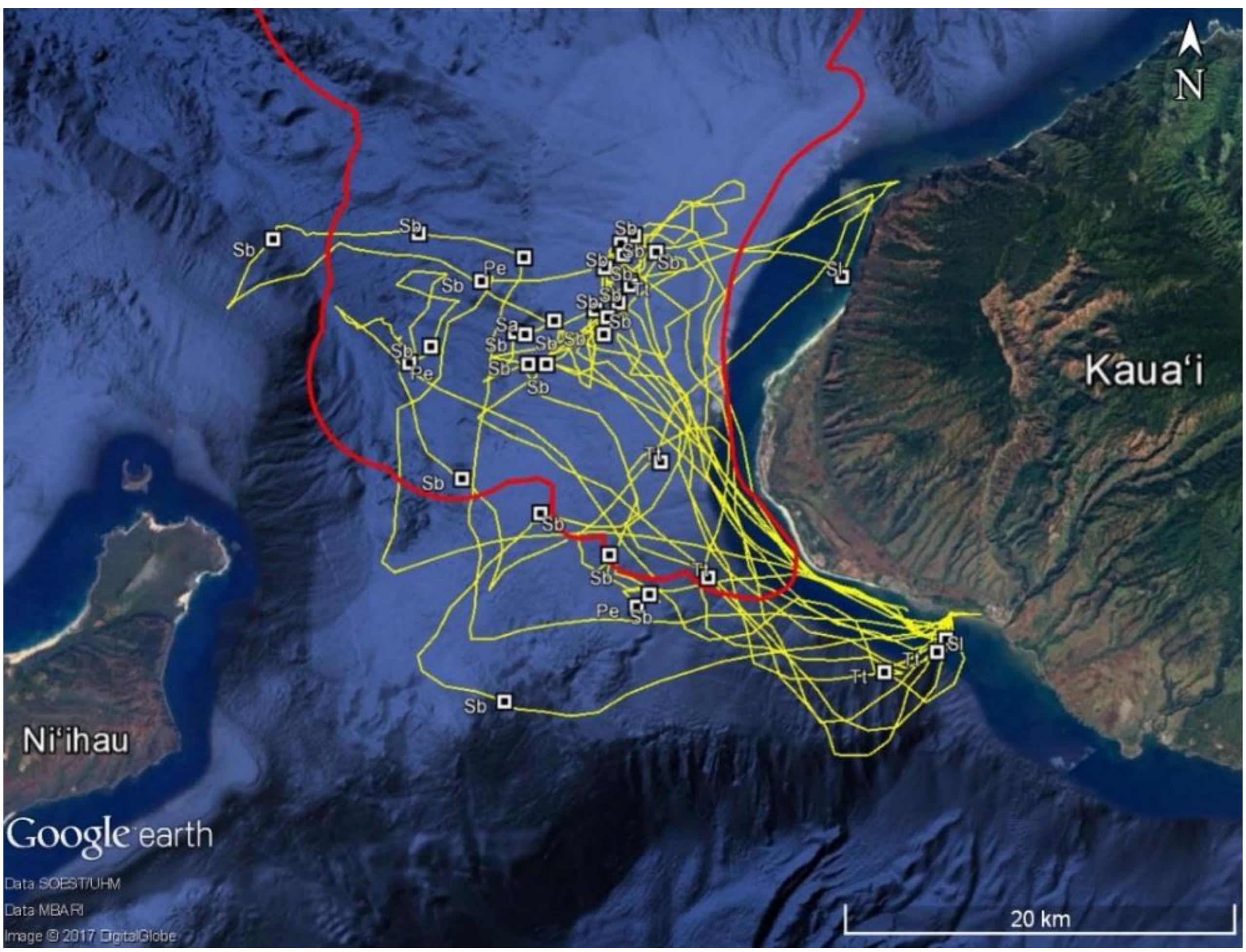


Figure 37. Search effort (yellow lines) and odontocete sightings (white squares) during 11 days of effort in August 2017. Species are indicated by two-letter codes (Sb = *Steno bredanensis*,

Tt = *Tursiops truncatus*, Sl = *Stenella longirostris*, Pe = *Peponocephala electra*, Sa = *Stenella attenuata*). The PMRF outer boundary is indicated in red. From: Baird 2018 [Project H5]

Six satellite tags were deployed on three species: melon-headed whale, rough-toothed dolphin, and pantropical spotted dolphin. No information is available for response to MFAS, since all tagged individuals had either left the vicinity of PMRF prior to the training event or the tags had stopped transmitting by that time.

Only one of the two tags deployed on rough-toothed dolphins was functional and provided location data. During the 7 d during which data was transmitted, the tagged dolphin remained off the west and northwest coasts of Kauai (**Figure 38**), moving off and on PMRF ten times, at a median distance from shore and depth of 12.0 km and 797 m, respectively. Combined with the tag deployments on rough-toothed dolphins during the previous reporting period (Baird et al. 2017), this tagged animal is likely from the resident, island-associated population.

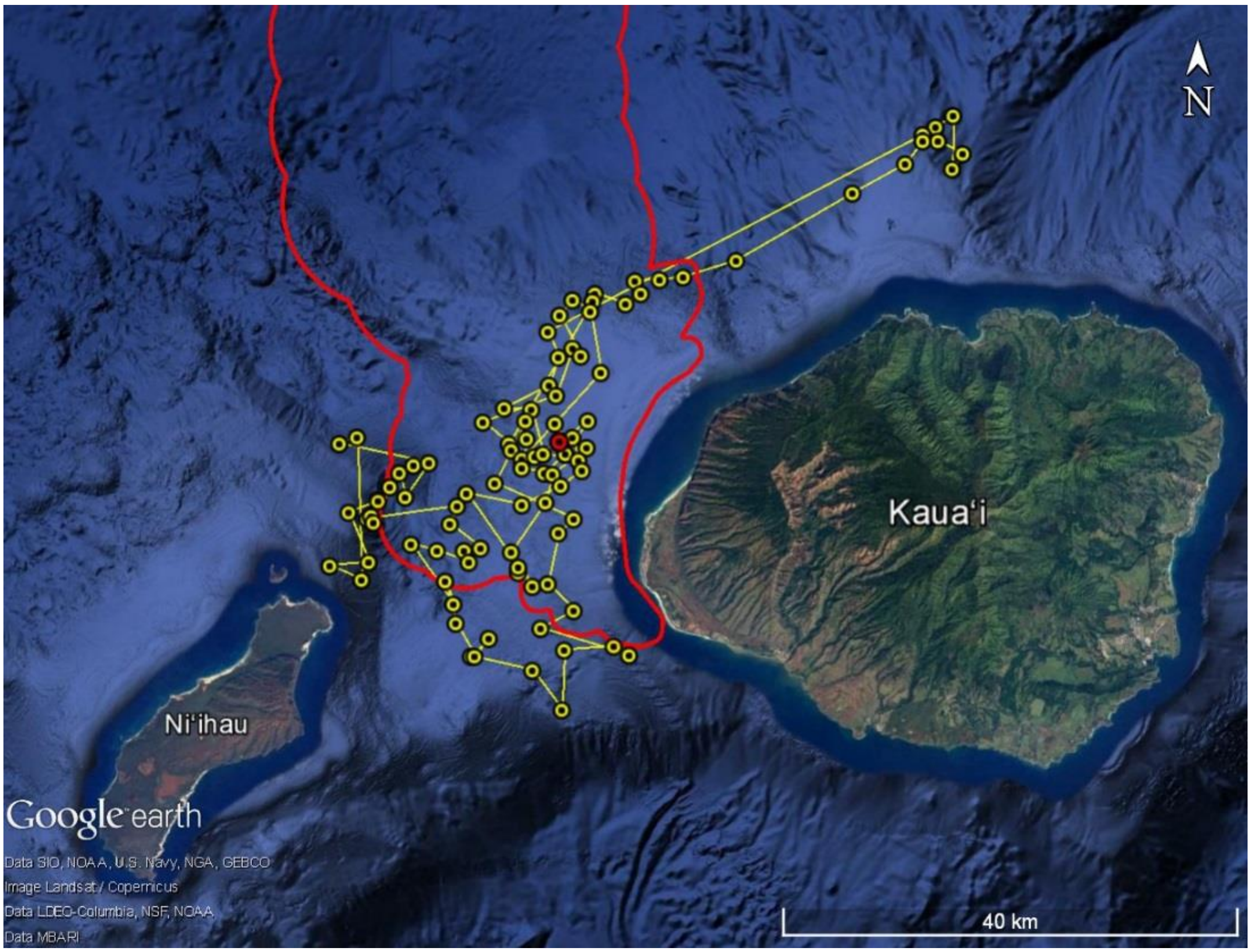


Figure 38. Movements of a satellite-tagged rough-toothed dolphin over a seven-day period during August 2017. The tagging location is depicted with a red circle, and consecutive locations are joined by a yellow line. The PMRF boundary is outlined in red. From: Baird 2018 [Project H5]

Two satellite tags were deployed on melon-headed whales from the same group. The two individuals remained together during the time of tag transmission. The whales moved off and back onto PMRF in the first day after tagging, then south and then to east of Kauai before tag data ended (**Figure 39**). Over the 8 d of tag data, the individuals moved 786 km, with a median depth and distance from shore of 3,053 m and 44.3 km, respectively. These movements away from Kauai are unrelated to Navy stressors as they occurred prior to the commencement of the Navy training event at PMRF. The only other time that melon-headed whales were tagged off Kauai or Niihau was during June 2008 prior to the Rim of the Pacific training exercise (Baird et al. 2008).

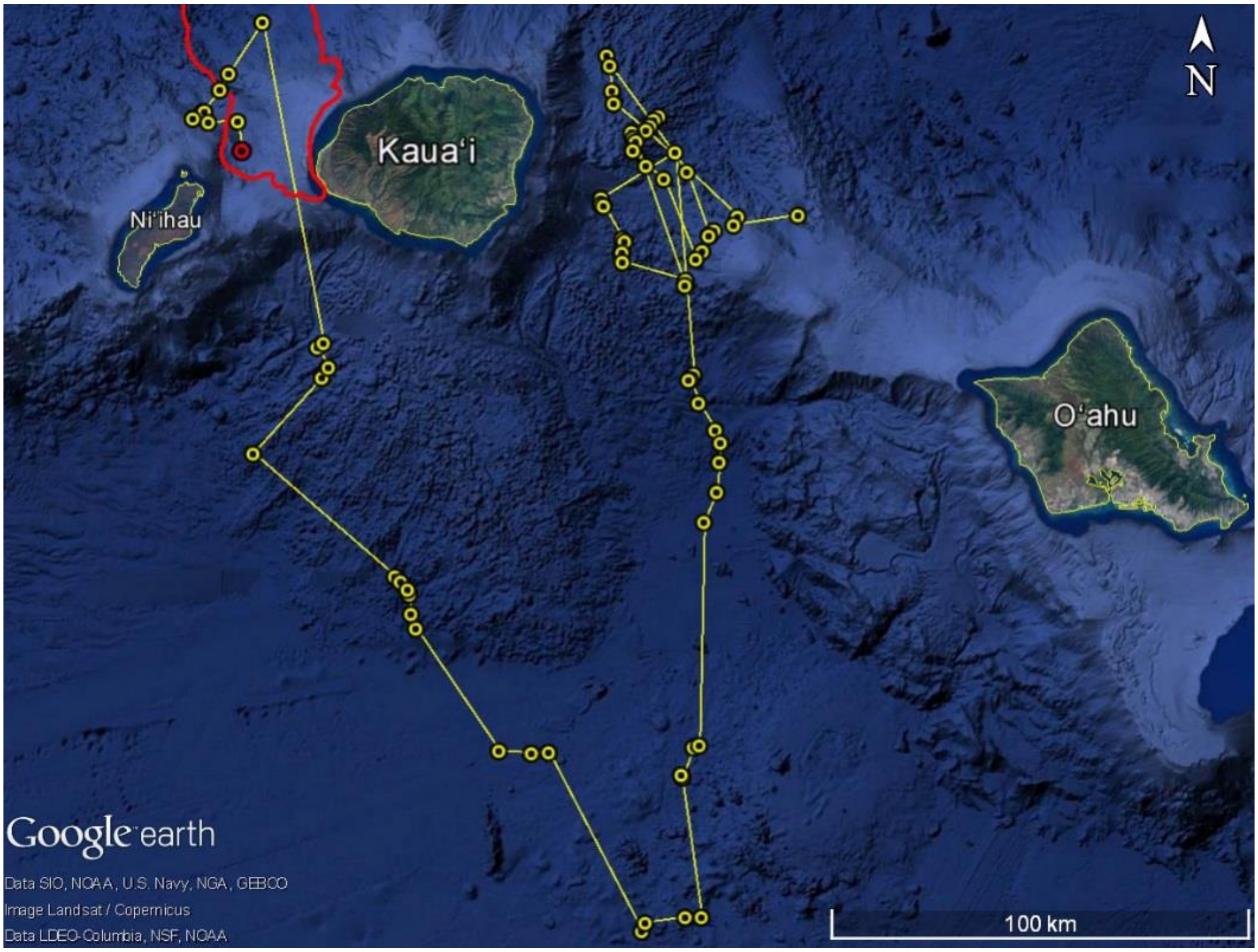


Figure 39. Movements of a satellite-tagged melon-headed whale over an eight-day period during August 2017. The tagging location is depicted by a red circle, and consecutive locations are joined by a yellow line. The PMRF boundary is outlined in red. From: Baird 2018 [Project H5]

Two satellite tags were deployed on pantropical spotted dolphins in the one sighting of this species. The tagged individuals within the first 2 d moved off and on PMRF three times, before moving south of Kauai, eventually moving far to the north of Oahu (**Figure 40**). Over the 14 d of tag data, the dolphins had a median depth and distance from shore of 3,603 m and 49.5 km, respectively. Baird (2018) speculated that these dolphins were from the pelagic stock of pantropical spotted dolphins and that, unlike other islands in the Main Hawaiian Islands, there is no island-associated population of pantropical spotted dolphins off Kauai or Niihau.

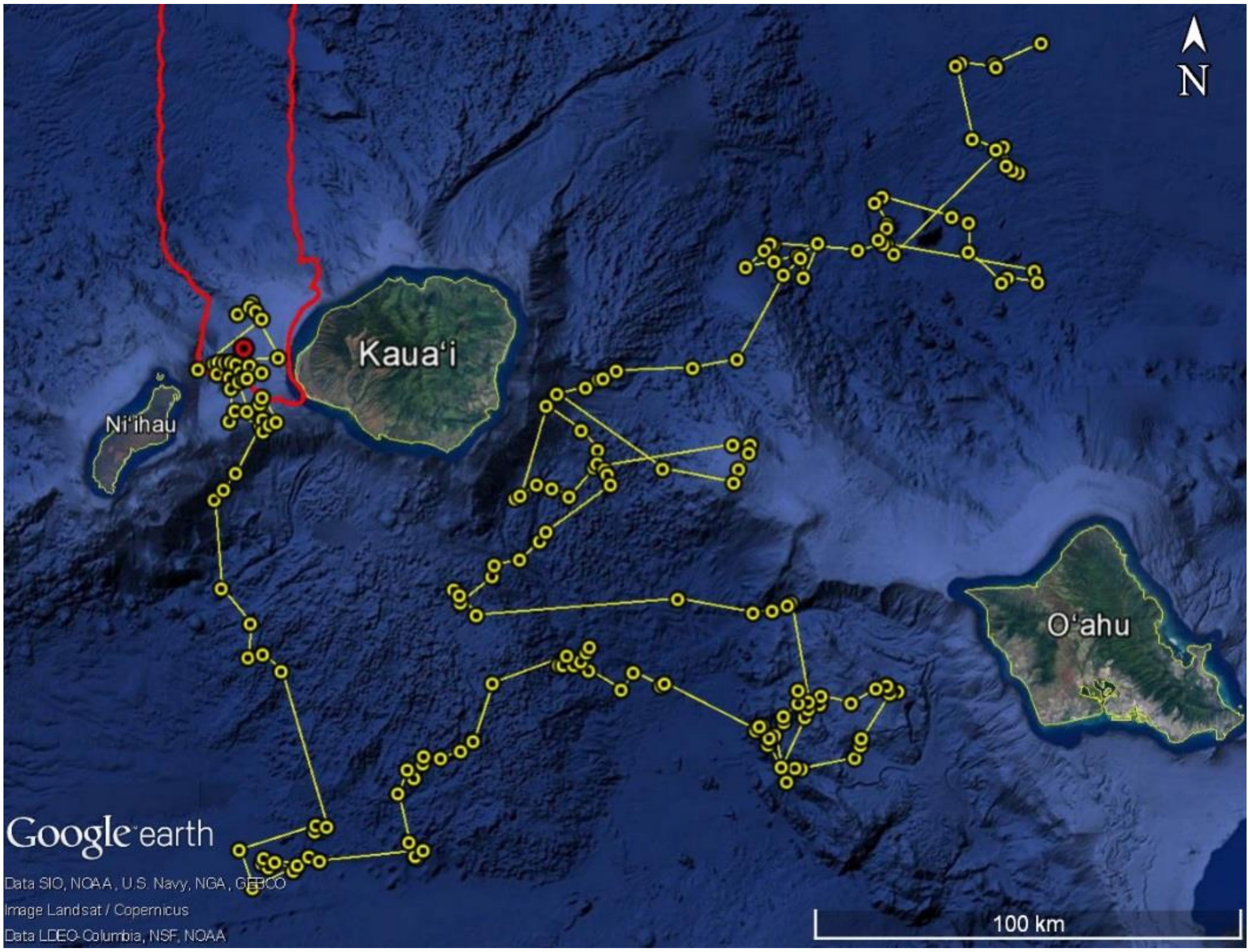


Figure 40. Movements of a satellite-tagged pantropical spotted dolphin over a 14-day period during August 2017. The tagging location is depicted by a red circle, and consecutive locations are joined by a yellow line. The PMRF boundary is outlined in red. From: Baird 2018 [Project H5]

The telemetry of all tagged animals did not coincide in time and space with the Navy training event SCC at PMRF. Analyses of MFAS exposure will therefore be deferred until after the next tagging survey scheduled at PMRF for the FY18 field season.

2.2.1.7 MONITORING QUESTION: WHAT IS THE SEASONAL OCCURRENCE AND ABUNDANCE/DENSITY OF CETACEANS WITHIN THE NAVY'S SOUTHERN CALIFORNIA RANGE COMPLEX? [PROJECTS S1, S4]; AND,

WHAT, IF ANY, ARE THE SPATIAL PATTERNS IN FIN WHALE POPULATION STRUCTURES WITHIN THE NAVY'S SOUTHERN CALIFORNIA RANGE COMPLEX? [PROJECT S1]

PAM was conducted in the U.S. Navy's SOCAL from April 2016 to July 2017 to detect marine mammal and anthropogenic sounds (Rice et al. 2018a). HARPs recorded sounds between 10 Hz and 100 kHz at three locations: Site H, Site N, and Site P (**Figure 19**). A typical southern California marine mammal assemblage is consistently detected in these recordings (Hildebrand et al. 2012); however, only a select sub-set of species including blue, fin, and beaked whales were analyzed. Site H and N data were analyzed from July 2016 through June 2017 and Site P, from April to October 2016 and February through May 2017.

Blue whale B and D calls and fin whale 20-Hz calls were detected. 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 summer through late winter with a peak in November at Sites H and N. The fall peak in Northeast Pacific B calls is consistent with earlier recordings at these sites (Kerosky et al. 2013; Debich et al. 2015a; Debich et al. 2015b). There was no discernible diel pattern for the Northeast Pacific B calls. Blue whale D calls occurred during spring and winter and were most prevalent during the summer months at all sites; however, detections were lowest at Site P. A spring/summer peak occurred for blue whale D calls and is consistent with earlier recordings at these sites (Debich et al. 2015b; Rice et al. 2017). No discernible diel pattern occurred for the blue whale D calls.

Fin whales were detected at all sites; however, the highest values of the fin whale acoustic index (representative of 20-Hz calls) were measured at Site N. A peak in the fin whale acoustic index occurred in December 2016 at Site N. The peak in the fin whale acoustic index is consistent with earlier recordings at these sites (Debich et al. 2015a; Debich et al. 2015b; Širović et al. 2016; Rice et al. 2017).

Cuvier's beaked whales were detected throughout the deployment period and were the most commonly detected beaked whale. FM echolocation pulses from Cuvier's beaked whales were detected regularly at Site H and less commonly at Site N, with no detections at Site P. Detections were highest from March and April 2017 at Site H and January and February 2017 at Site N. The results at these sites were similar to those in previous monitoring periods (Kerosky et al. 2013; Debich et al. 2015a; Debich et al. 2015b; Širović et al. 2016; Rice et al. 2017). 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 only 10 times on 5 days between July 2016 and June 2017. Detections only occurred at Site N during late fall and winter months. There were no detections at Site H as there were in the last two monitoring periods (Širović et al. 2016; Rice et al. 2017); however, the overall results are consistent with previous reports (Kerosky et al. 2013; Debich et al. 2015a; Debich et al. 2015b). There was no discernible diel pattern for BW43 detections.

There is speculation that both resident and “transient” (pan-Pacific) populations of fin whales occur in the SCB. The common fin whale song type in the SCB is the doublet song, which is made of pulses repeated at two alternating IPIs of different lengths (i.e., short and long) (Širović et al. 2017b). A variant of the doublet, a singlet song, also occurs and has a single IPI that corresponds to one of the distinct IPI of the doublet song. The preliminary analyses conducted thus far by Širović et al. (2018) indicated that the fin whale songs recorded between 2009 and 2010 across all four HARP sites had the same doublet IPIs (**Figures 19 and 41**). Overall, the northernmost site (Site C) had the highest variability; this also was the site where there was the most variability in the doublet song IPIs during the winter and early summer. Singlet variants of the doublet songs were detected at all sites, but most often during the fall. During summer, the HARP at Site C was the only one to detect singlet songs. The “long doublet” or “seasonally variable” song that has also been termed the pan-Pacific song was detected at HARP Sites C and H. This song only appeared in its singlet version and was more common from 2005-2007, but it was also detected intermittently later in 2008, 2010, and 2011. The results presented here are preliminary and efforts to evaluate fin song patterns recorded in the SCB will continue in the coming months.

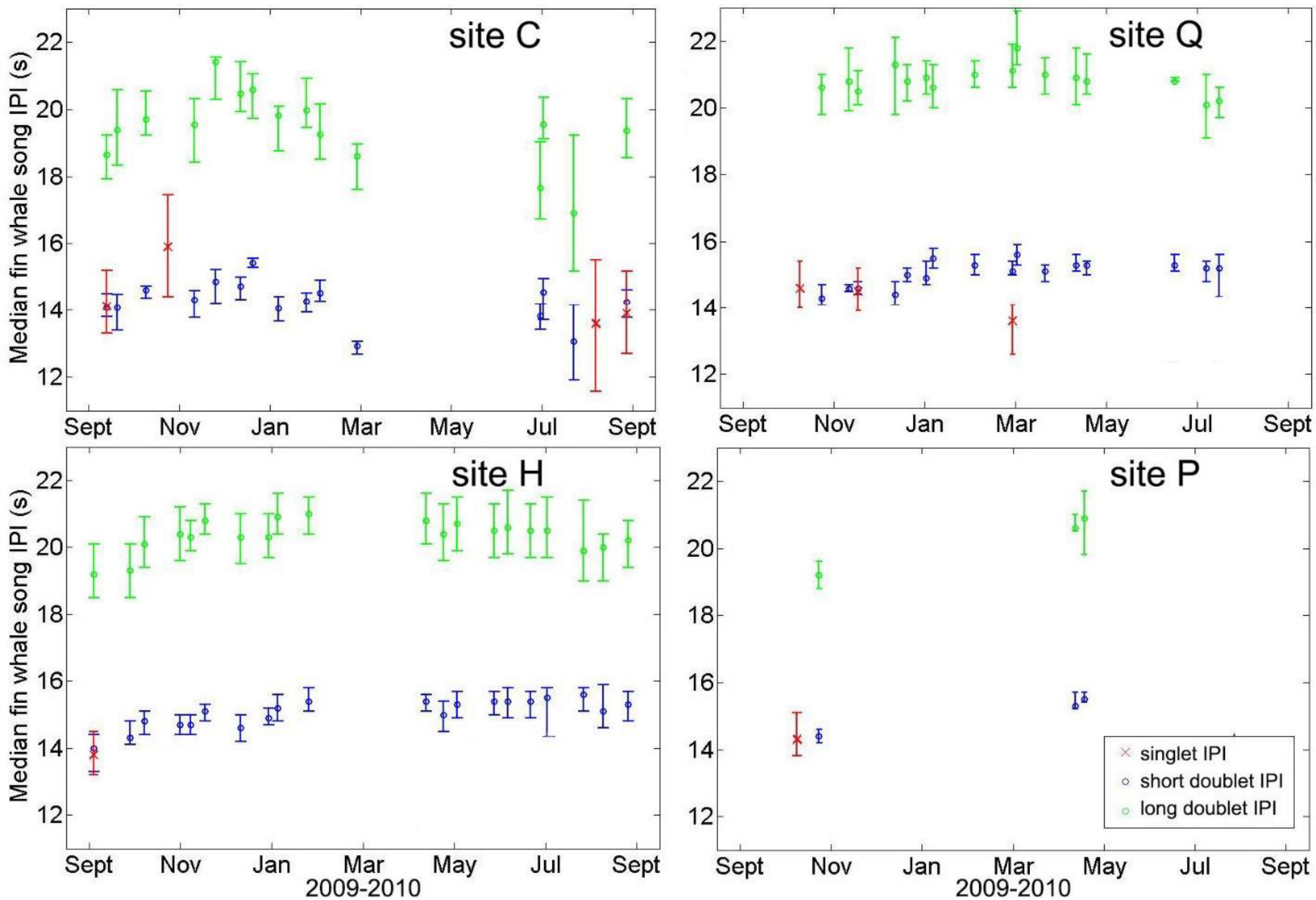


Figure 41. Interpulse intervals (IPIs) of fin whale short doublet songs recorded at four sites, C, Q, H, and P, in the Southern California Bight between September 2009 and September 2010. Doublet song median IPIs are represented with a circle and short IPI of doublet songs are marked with blue and long IPIs with green. Singlets are marked in red with median marked with x. Whiskers represent the first and third quartiles of those medians. From: Širović et al. 2018 [Project S1]

Also focused on the first monitoring question regarding seasonal occurrence and density, three CalCOFI cruises were conducted in 2017: a winter survey (January), a spring survey (April), and a summer survey (August) (Hildebrand et al. 2018). During these surveys, four species of mysticete whales were sighted, as well as 9 taxa of odontocetes. Species encountered in 2017 were roughly similar to those observed in previous years (2012–2016) (Campbell et al. 2014; Debich et al. 2017), with several exceptions. Killer whales were detected in April and August for the first time since January 2015. One group of striped dolphins was detected in August 2017, and this species had not been detected since January 2013. Northern right whale dolphins were not detected in 2016, but were during the April 2017 cruise. No Risso's dolphins or short-finned pilot whales were detected during the three cruises in 2017. Sightings from the 2017 cruises encompassed long-beaked and short-beaked common dolphins, northern right whale dolphins, Pacific white-sided dolphins, killer whales, Dall's porpoises, sperm whales, striped dolphins, and bottlenose dolphins) and four baleen whale species (blue, fin, gray, and humpback whales). Blue and fin whales were detected in January and August 2017, but not during the April 2017 cruise. Humpback whales were detected during all three 2017 cruises.

Data from 2014–2017 indicate that marine mammal species diversity varied by season (**Figures 44 and 45**). During 2014-2017 winter and spring cruises, most mysticete whale sightings occurred within 370 km of the shoreline. A particular nearshore shift of humpback whales was seen during the 2016 and 2017 spring cruises (**Figure 44**). During summer, there were more mysticete whale sightings along the continental slope and in offshore waters. Mysticete whale sightings were concentrated in the Channel Islands region during the 2015 and 2016 fall cruises (**Figure 44**). For odontocetes, short-beaked common dolphins (*Delphinus delphis*) were detected offshore more frequently than inshore, and during the summer and fall 2016 cruises, and they returned to offshore areas where they were absent during 2015 (**Figure 45**).

No new cetacean density estimates were derived as part of this year's work.

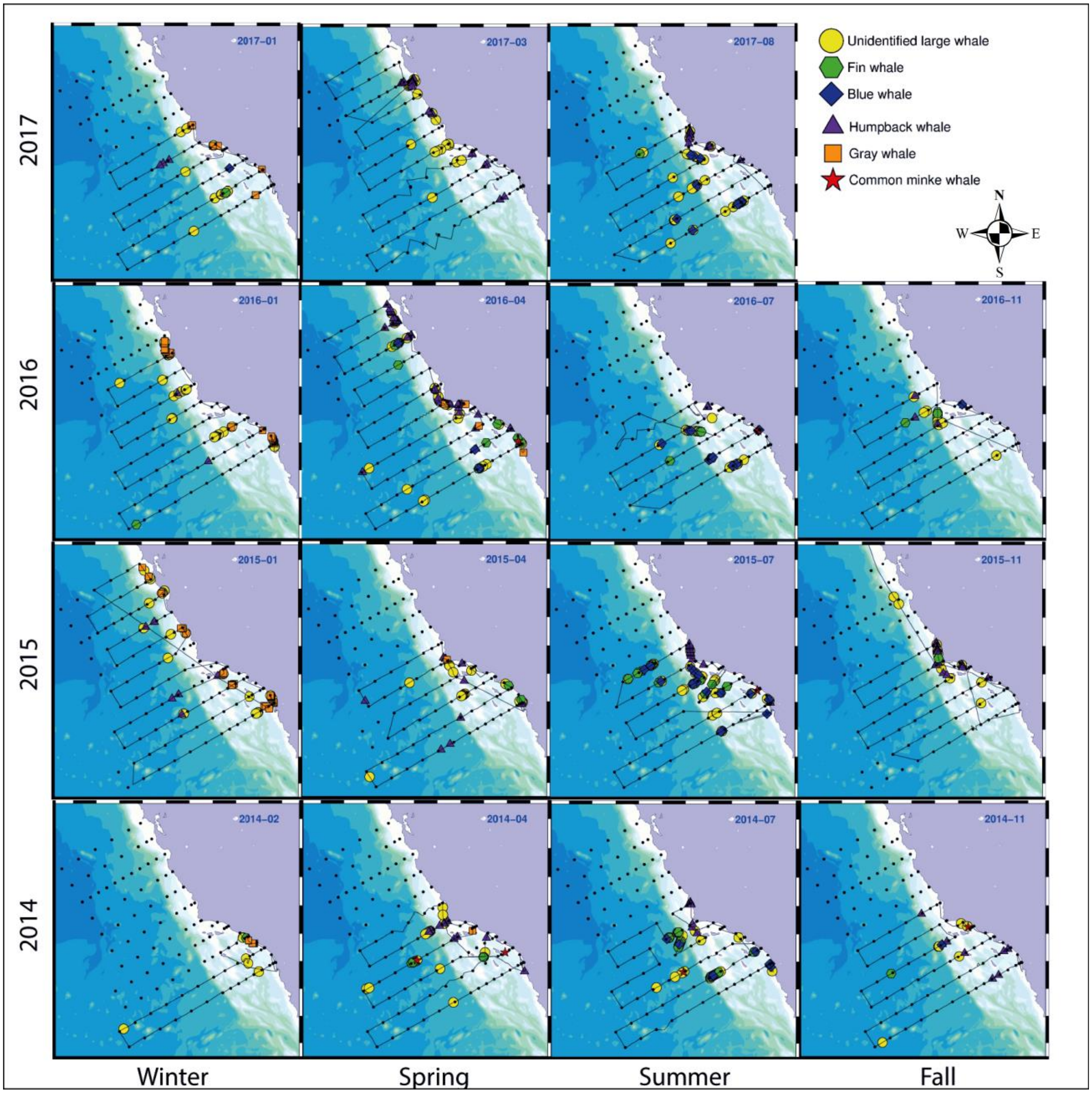


Figure 42. On-effort baleen whale sightings during CalCOFI cruises 2014-2017. CalCOFI stations are represented by black dots and the ship's trackline is represented as a solid black line between stations. Symbol shapes and colors denote different species, as per legend. From: Hildebrand et al. 2018 [Project S4]

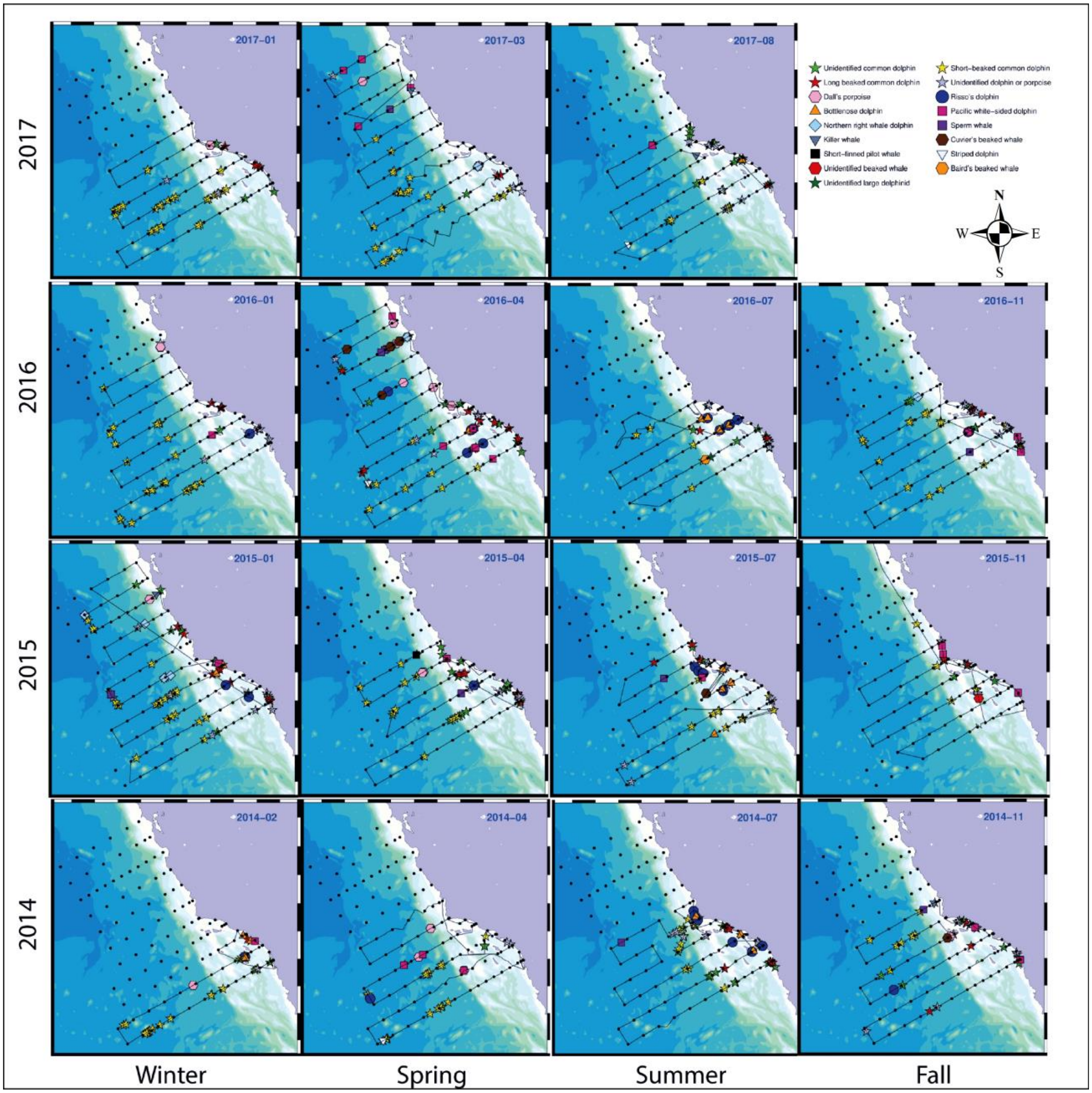


Figure 43. On-effort odontocete sightings during CalCOFI cruises 2014-2017. CalCOFI stations are represented by black dots and the ship's trackline is represented as a solid black line between stations. Symbol shapes and colors denote different species, as per legend. From: Hildebrand et al. 2018 [Project S4]

2.2.1.8 MONITORING QUESTION: WHAT ARE THE BASELINE POPULATION DEMOGRAPHICS, VITAL RATES, AND MOVEMENT PATTERNS FOR DESIGNATED KEY SPECIES IN THE SOUTHERN CALIFORNIA RANGE COMPLEX? [PROJECT S3]

As part of an ongoing study of the distribution and demographics of marine mammal species within SOCAL, specifically focusing on the Southern California Anti-submarine Warfare Range

(SOAR), 185 marine mammal sightings (14 cetacean species) were recorded, along with six sightings of juvenile loggerhead turtles from January 2016 to July 2017 (Schorr et al. 2017, 2018). The primary goal of these surveys was sighting and photographing marine mammals, and collecting biopsy samples from Cuvier's beaked whales and fin whales. During 16 d of survey effort performed in April and July 2017 at SOAR, observers encountered 8 groups (24 individuals) of Cuvier's beaked whales and 5 groups (8 individuals) of fin whales, with the majority of sightings occurring in July 2017 (Schorr et al. 2018) (**Figure 42**). During 2016 efforts, 12 groups (32 individuals) of Cuvier's beaked whales and 11 groups (12 individuals) of fin whales were recorded (**Figure 42**).

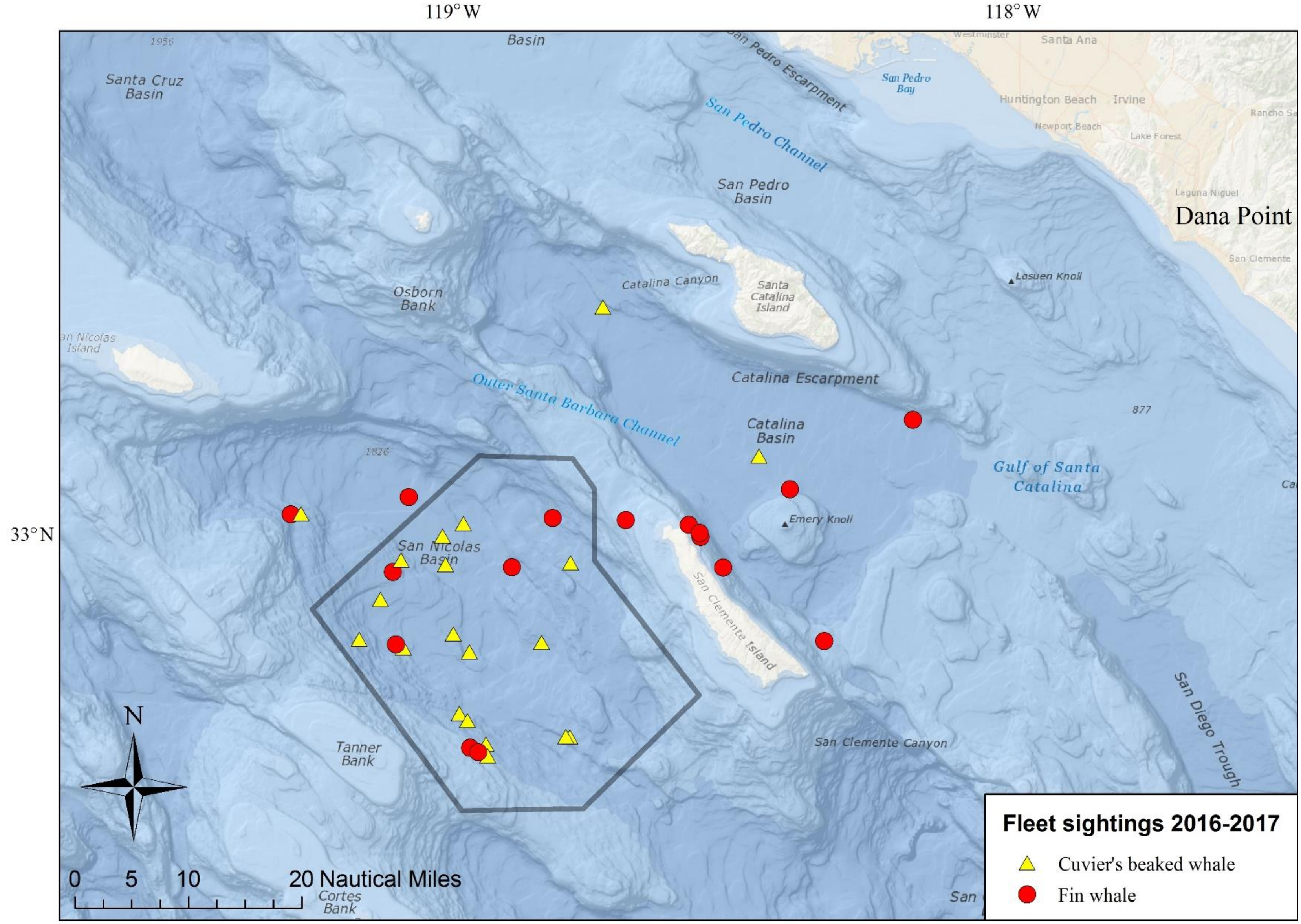
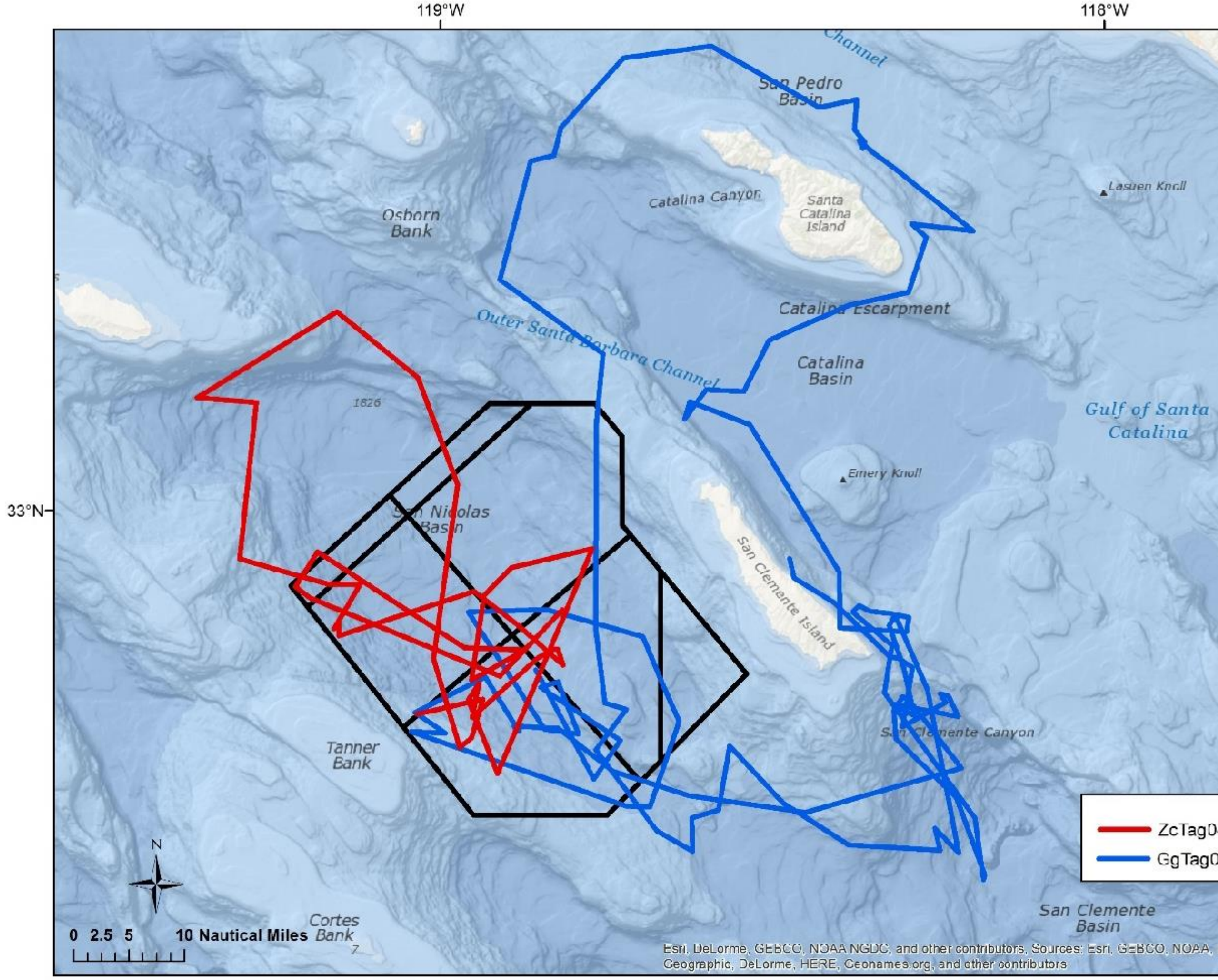


Figure 44. Sighting locations for Cuvier's beaked whales and fin whales during field efforts associated with this project during 2016 and 2017. The black lines indicate SOAR. From: Schorr et al. 2018 [Project S3]

Four satellite tags were deployed during Fleet-funded surveys in 2016 and 2017: one each on a Cuvier's beaked whale and fin whale, and two on Risso's dolphins. Transmission durations ranged from 12 to 40 d. In 2016, a tag on a Cuvier's beaked whale transmitted for more than 39 d and a Risso's dolphin tagged in 2017 was tracked for over 18 d (**Figure 43**). Tags deployed in 2016 and 2017 are being analyzed with tag data from additional projects (e.g., Schorr et al. 2014; Falcone et al. 2017; Scales et al. 2017); therefore, only basic summary information is provided here.

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, 2018). 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). Fin whales appeared to range broadly along the U.S. West Coast with no population substructure (**Figure 43**). Identification photos were collected from 68 of the estimated 81 individual Cuvier's beaked whales encountered in 2016-2017, representing 48 unique individuals (eight of these whales sighted on two different days, and another three on three different days) during the study period. Nineteen of these whales had been sighted during previous years. During 2016 and 2017, fin whale sightings were noticeably low during dedicated Fleet-funded surveys; however, opportunistic contributions of sighting data (photographs by other researchers, and whale-watch organizations) produced 294 sightings (244 identifications) of fin whales. Photo-ID analyses are ongoing.



Filtered tracklines of a satellite tagged Cuvier's beaked whale (red) and two Risso's dolphins (blue, green) during the 2016 and 2017 monitoring effort. From: Schorr et al. 2017 [Project S3]

2.2.1.9 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 S5/N4]

Since the start of this project in 2014, 93 blue whales, 32 fin whales, two humpback whales, one Bryde's whale and one blue/fin hybrid whale have been instrumented with a combination of LO, ADB and DM tags (see **Appendix A** for tag descriptions) in the waters off southern California and the Pacific Northwest.

In 2017, researchers deployed 28 tags on blue whales (**Figures 46 and 47**) and one tag on a fin whale off southern and central California (**Figure 48**) (Mate et al. 2017a). Seven of the 27 blue whale tags (26 percent) transmitted data for over 100 d. Detailed analyses for the 2017 OSU tagging effort are ongoing and will be available later in a final report. From 2014 through 2016, blue whales were located in SOCAL, PT MUGU, and NWTT, but only occurred in W237 of the NWTRC in 2014 (**Figure 49**). For the three years of analysis, PT MUGU was the most heavily-used Navy training range by blue whales in terms of individuals with locations there (50 of 63 tracked whales), residence time (overall mean of 26.2 d), and overlapping HRs and CAs (**Figures 50 and 51**). SOCAL was also used by a large number of tagged blue whales (37 of 63 tracked whales) and was the most heavily used range in terms of whale numbers in 2014 (**Figure 49**). The NWTT was used by a small number of blue whales (9 of 63) with an average of 23.2 d in the area, resulting in more extensive overlap of HRs and CAs with this range than with SOCAL (**Figures 50 and 51**). An equal proportion (17 percent) of tracked blue whales were located in NWTT in both 2014 and 2016. Only one of 63 tracked blue whales had locations in area W237 of the NWTT, spending 19.5 d in the area in 2014. Seasonality in the Navy training ranges was very similar between tagging years, with locations occurring predominantly in the summer and fall (July through November in SOCAL and PT MUGU, August through November in NWTT, September through November in W237).

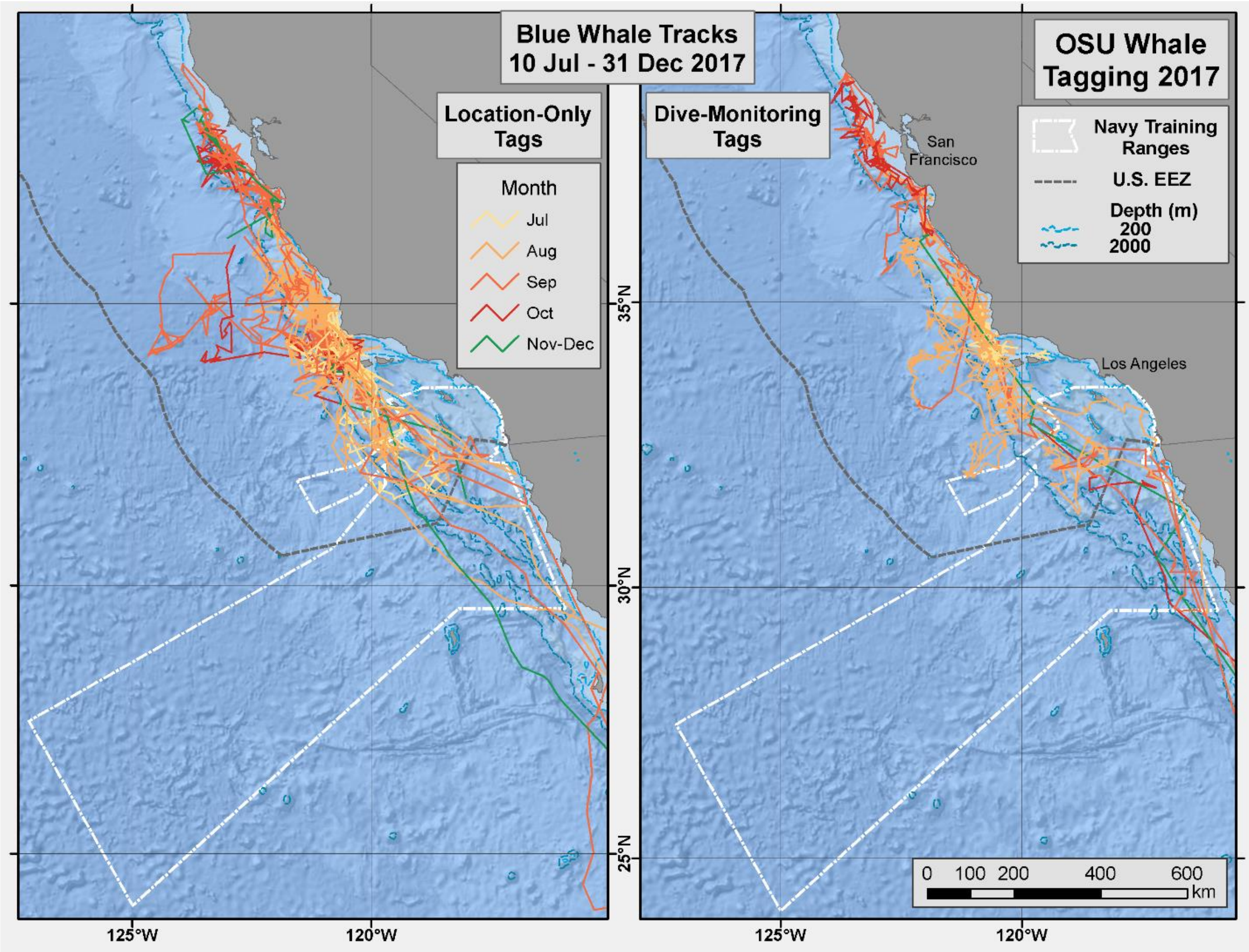


Figure 45. Satellite-monitored radio tracks in SOCAL for blue whales tagged off southern and central California 10 July through 31 December 2017 (13 LO tags, 15 DM tags). From: Mate et al. in prep. [Project S5]

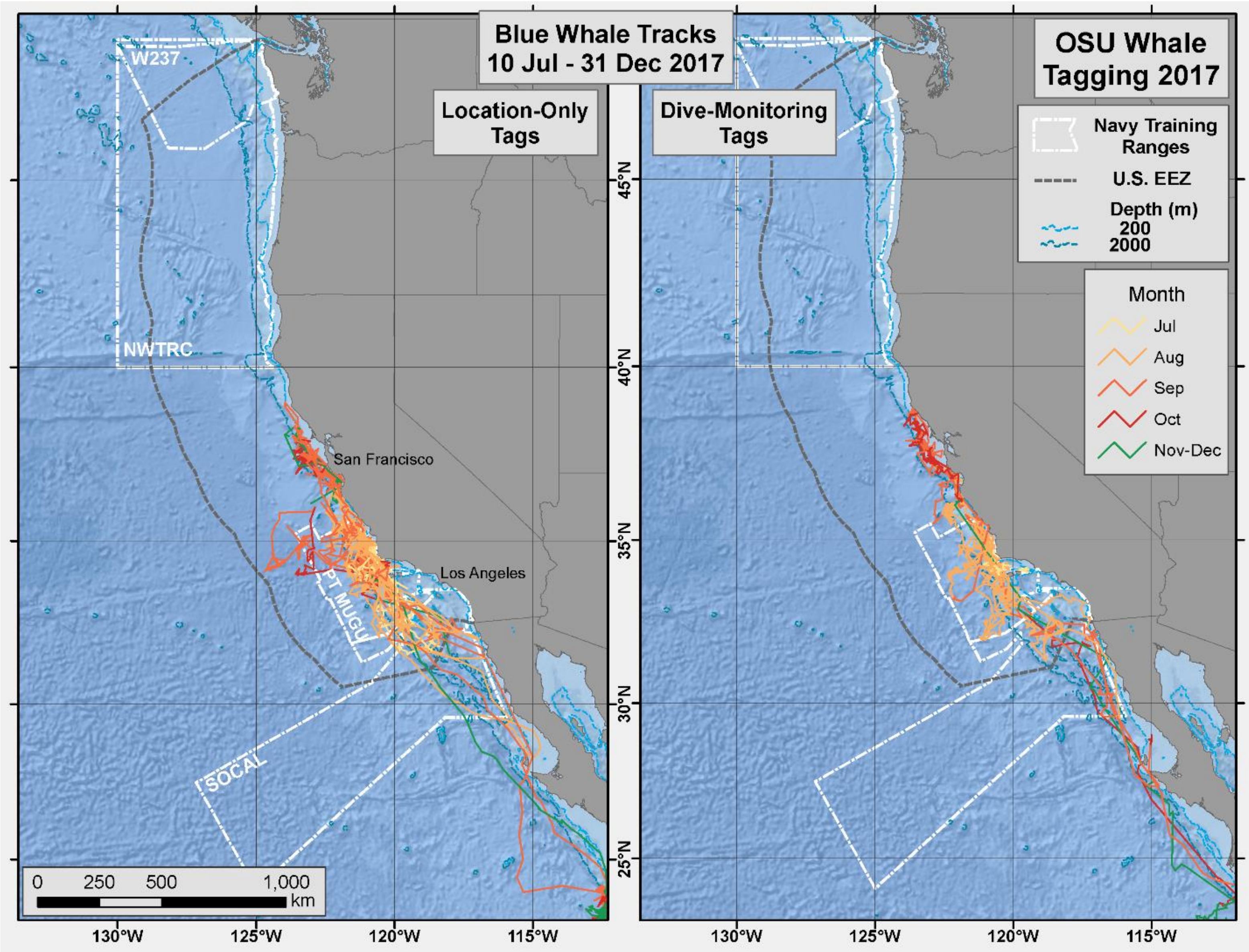


Figure 46. Satellite-monitored radio tracks in PT MUGU for blue whales tagged off southern and central California July through December 2017 (13 location-only tags, 15 DM tags). From: Mate et al. in prep. [Project S5]

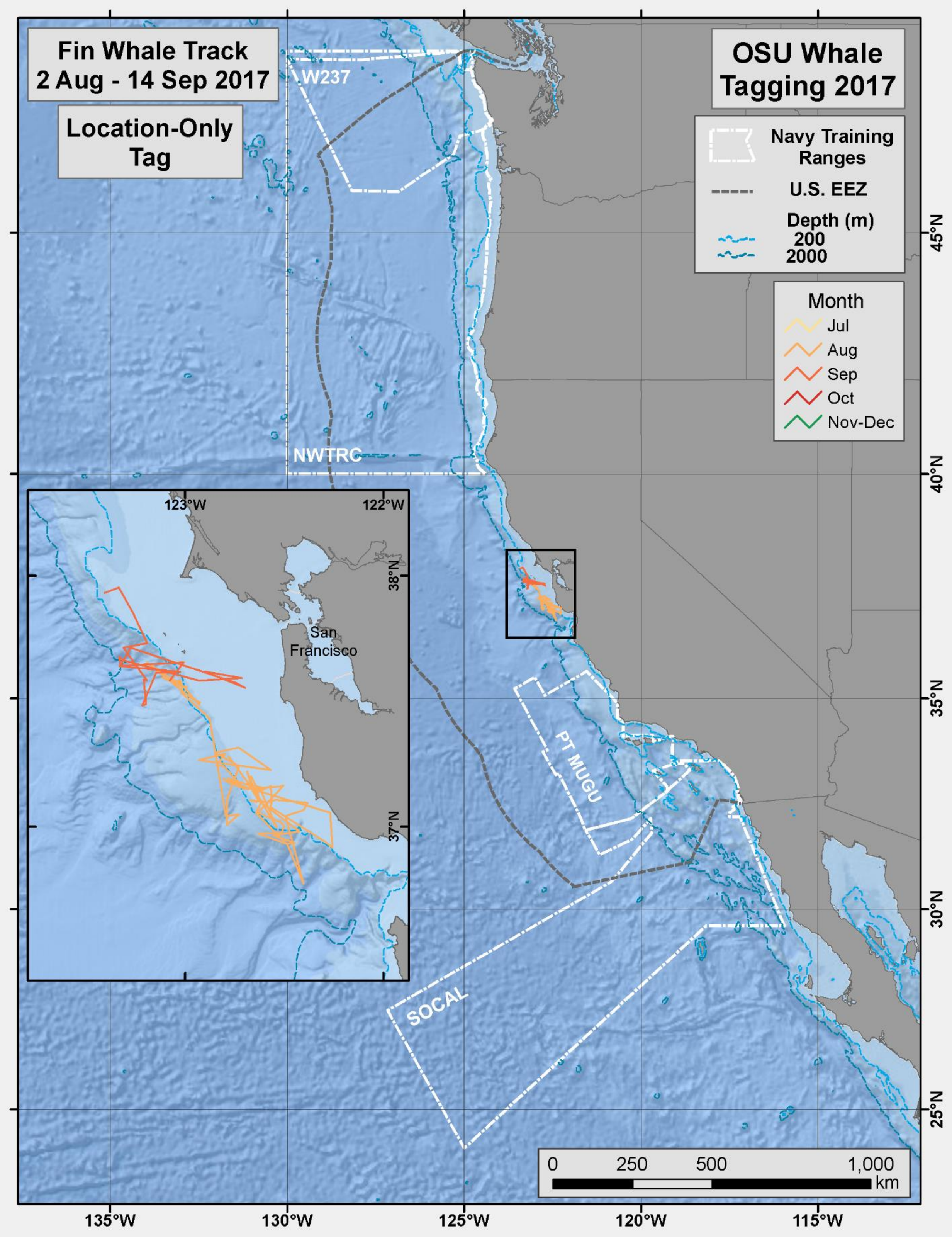


Figure 47. Satellite-monitored radio tracks for fin whales tagged off central California in 2 August through 14 September 2017 (1 LO tag). From: Mate et al. in prep. [Project S5]

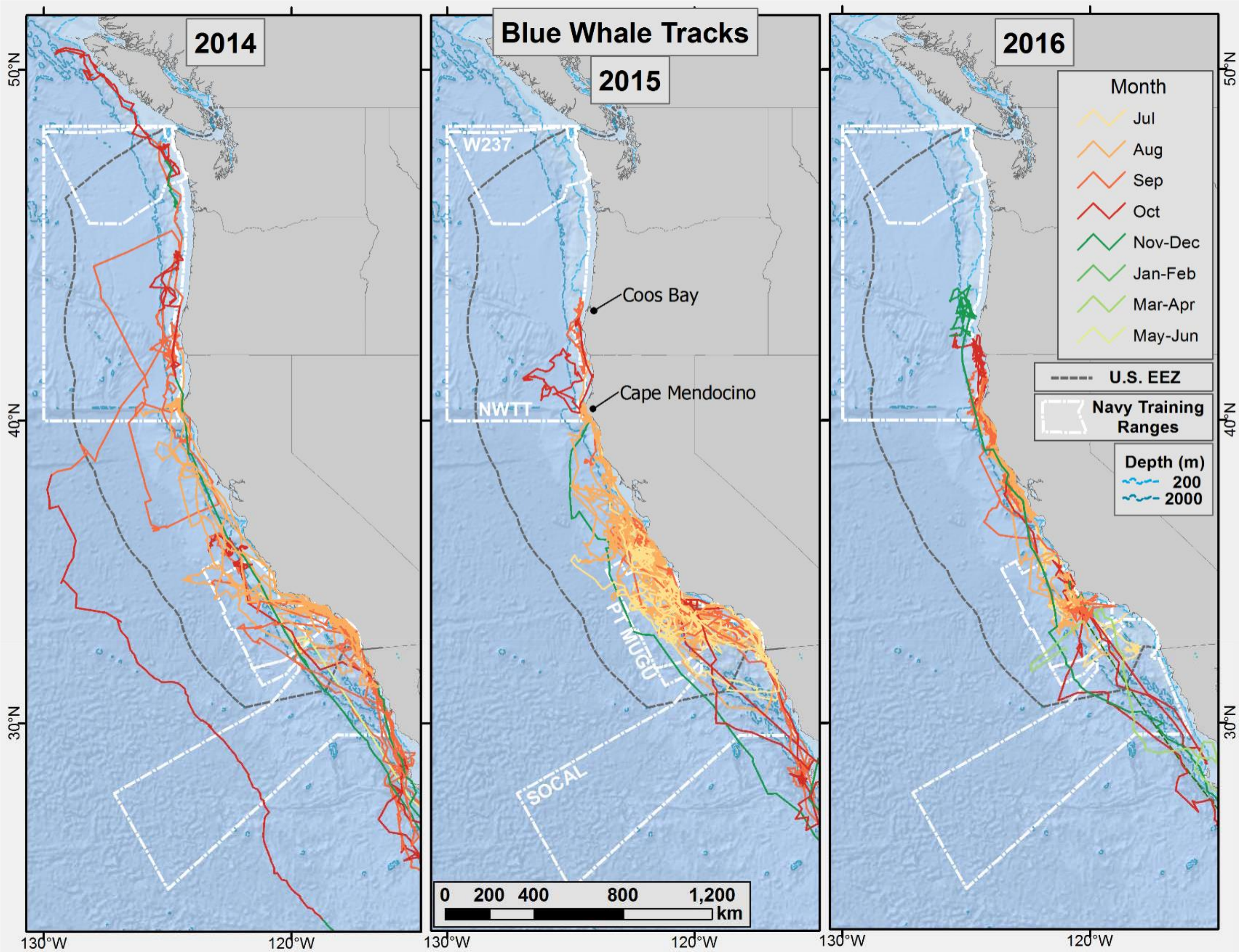


Figure 48. Satellite-monitored radio tracks for blue whales tagged off southern and central California in July and/or August, 2014 to 2016, zoomed-in to highlight feeding season movements rather than winter migratory destination. From: Mate et al. 2017a [Project S5]

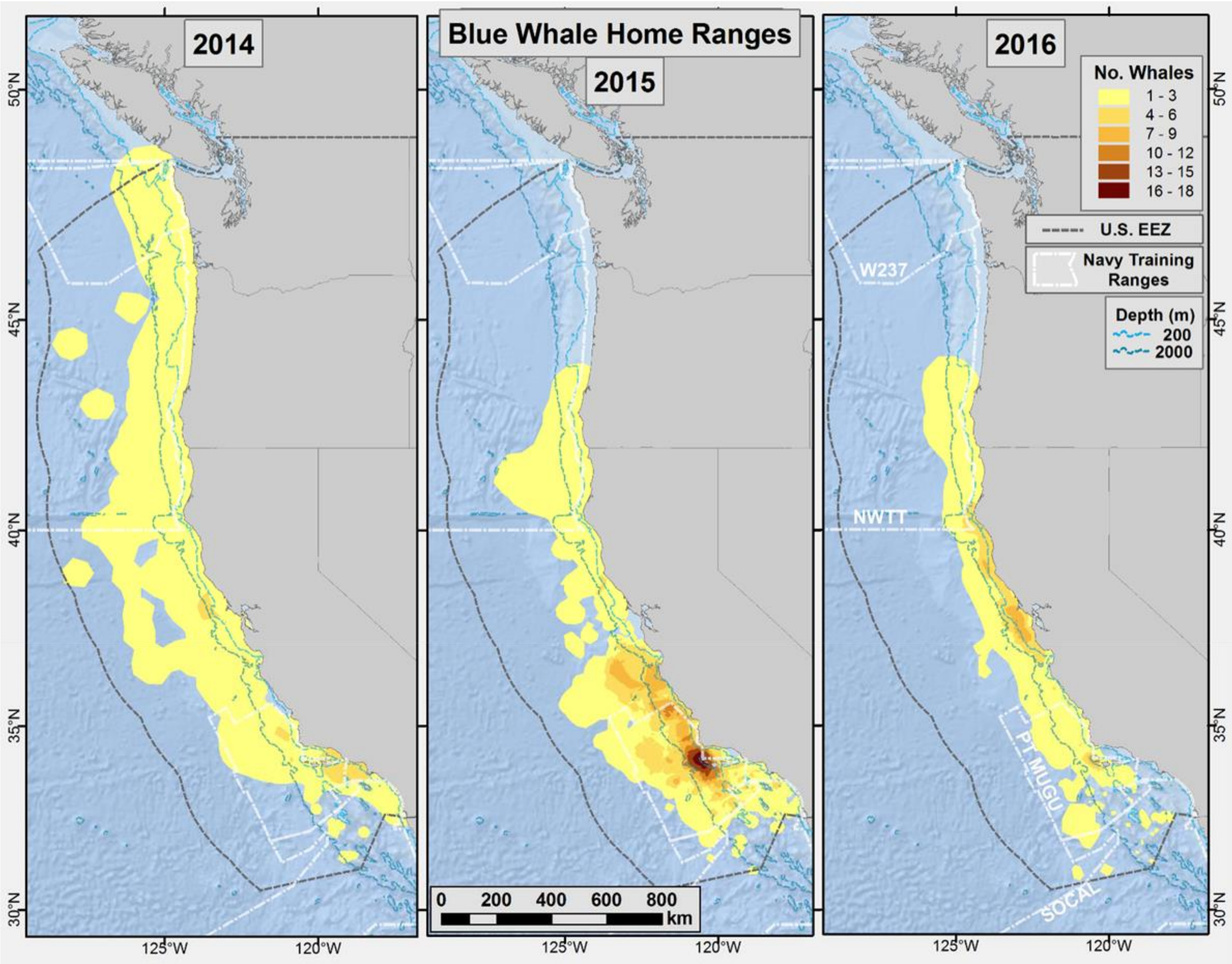


Figure 49. Home ranges (HR) in the U.S. Exclusive Economic Zone (EEZ) for blue whales tagged off southern California in 2014 (5 whales), off southern California in 2015 (17 whales), and off southern and central California in 2016 (14 whales). Shading represents the number of individual whales with overlapping HRs. From: Mate et al. 2017a [Project S5]

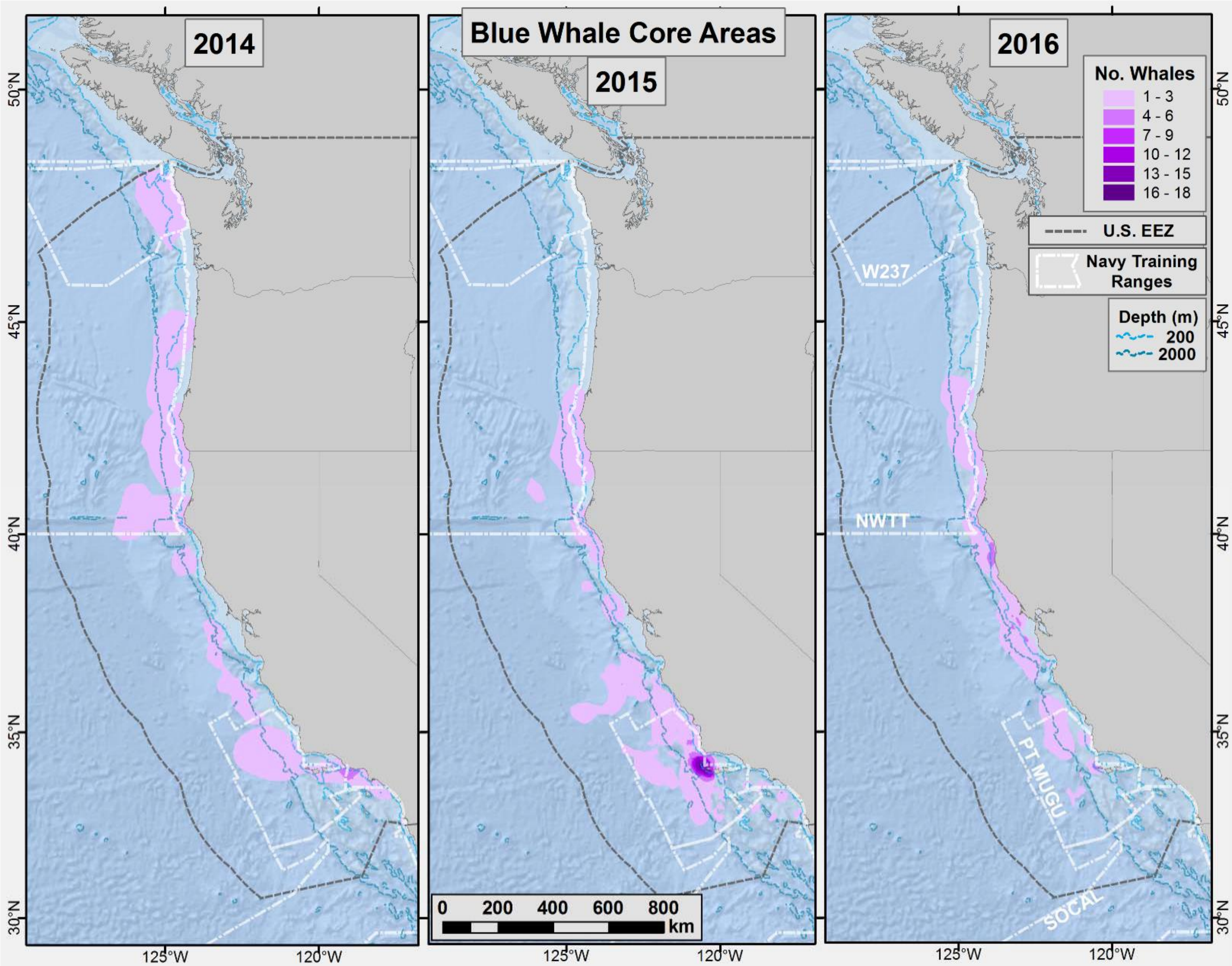


Figure 50. Core areas (CA) of use in the U.S. EEZ for blue whales tagged off southern California in 2014 (5 whales), off southern California in 2015 (17 whales), and off southern and central California in 2016 (14 whales). Shading represents the number of individual whales with overlapping CAs. From: Mate et al. 2017a [Project S5]

Fin whales had locations in the PT MUGU and NWTRC ranges in all three years, but locations in SOCAL occurred only in 2014 and 2015, and in area W237 in 2015 and 2016 only (**Figure 52**). PT MUGU was the most heavily used Navy training range for fin whales, in terms of number of whales having locations there, as well as HRs and CAs occurring there (**Figures 53 and 54**). SOCAL was the second most-heavily used training range in terms of number of fin whales, as well as HR and CA overlap in 2014, but the NWTT area was the second most-heavily used range in 2015 (**Figures 53 and 54**). No fin whales tagged in 2016 had locations in SOCAL, and only one fin whale crossed through the NWTT in 2016 (**Figure 52**). Two whales had locations in area W237 of the NWTT in 2015, and one in 2016, but the latter only passed through the area briefly on its way further north (**Figure 52**). Fin whale use of NWTT and W237 occurred primarily in late summer and fall, whereas fin whales could be found in PT MUGU in summer, fall, and winter, and in SOCAL in all seasons.

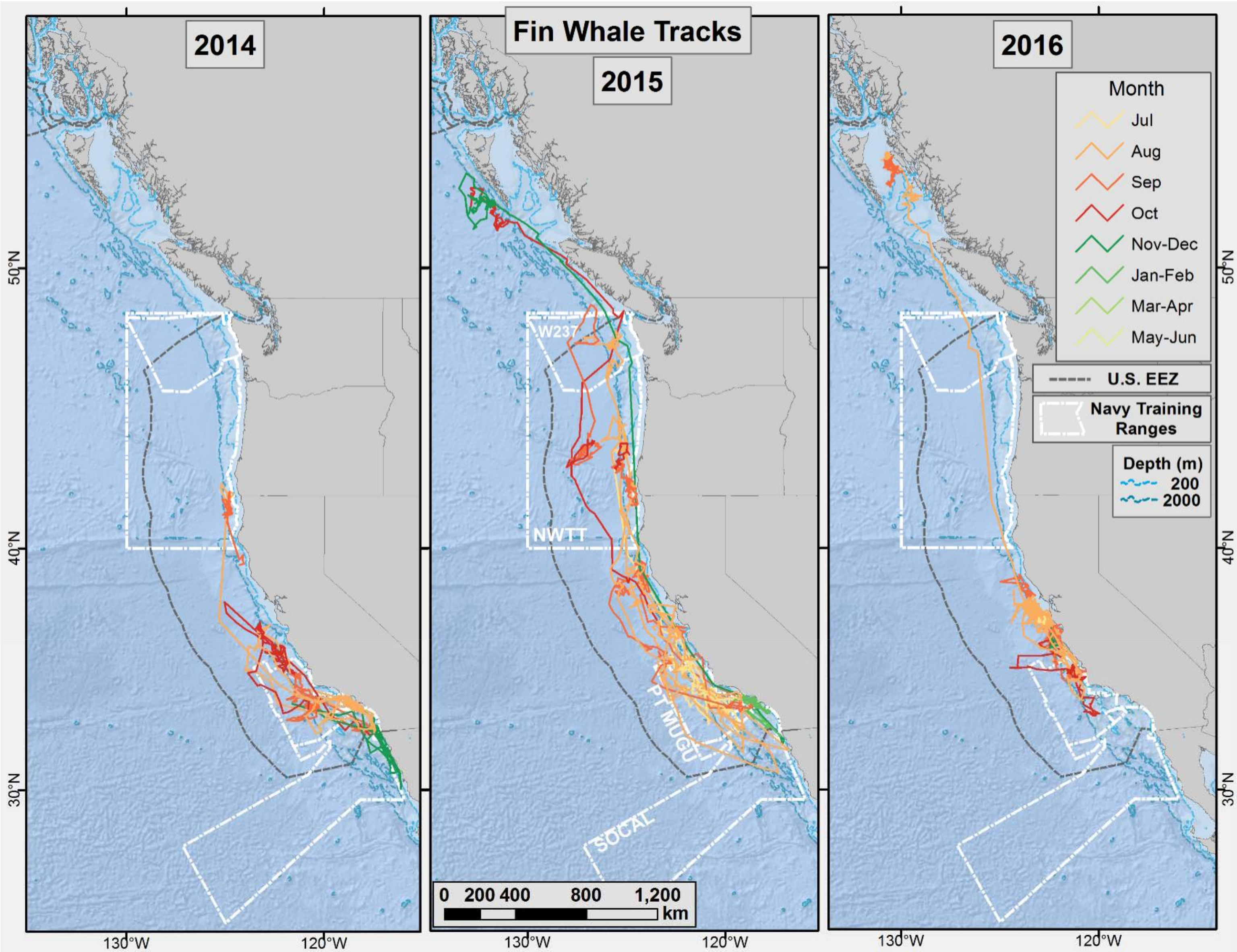


Figure 51. Satellite-monitored radio tracks for fin whales tagged off southern and central California during July and/or August 2014 to 2016. From: Mate et al. 2017a [Project S5]

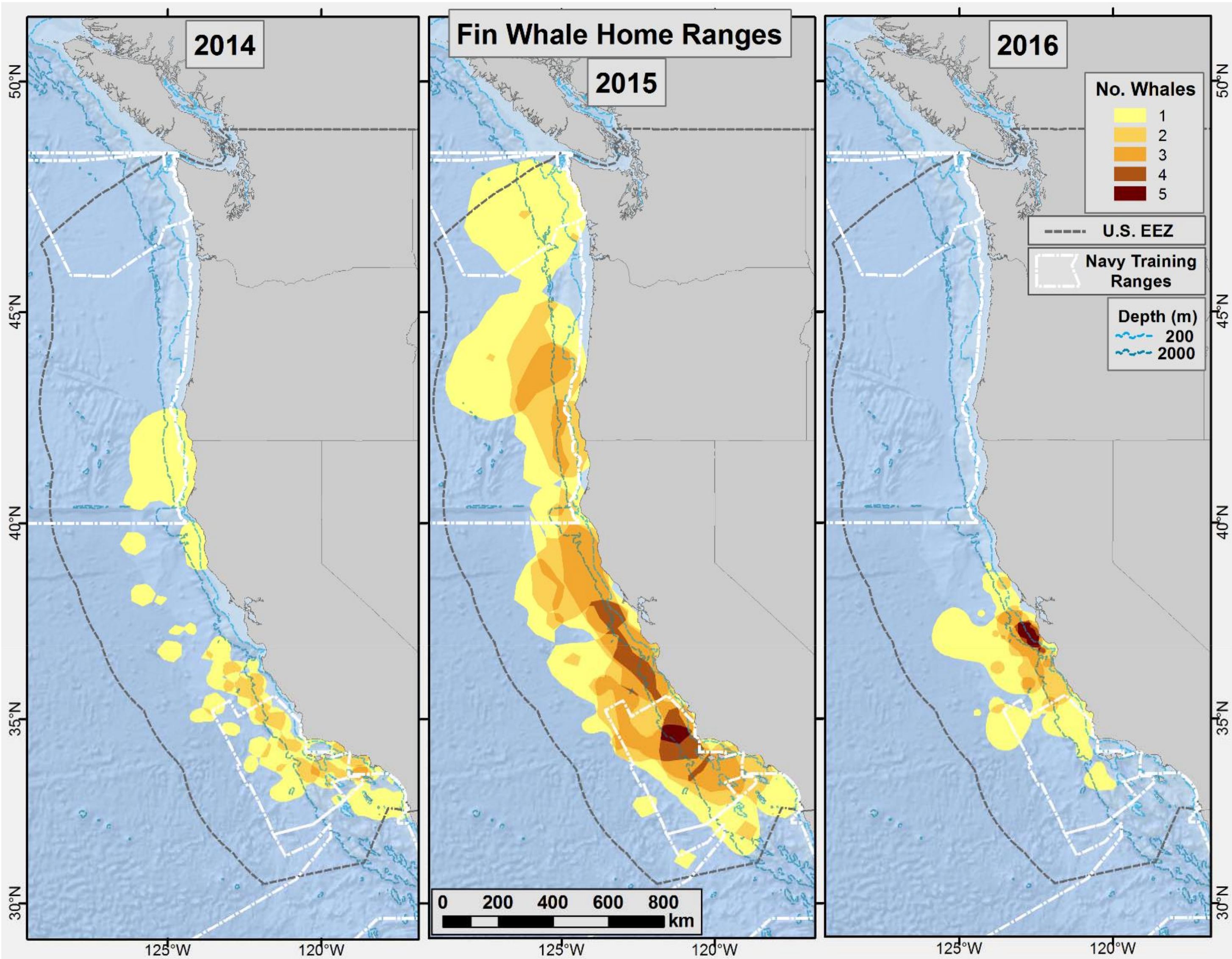


Figure 52. Home ranges (HR) in the U.S. EEZ for fin whales tagged off southern California in 2014 (3 whales), off southern California in 2015 (5 whales) and off central California in 2016 (5 whales). Shading represents the number of individual whales with overlapping HRs. From: Mate et al. 2017a [Project S5]

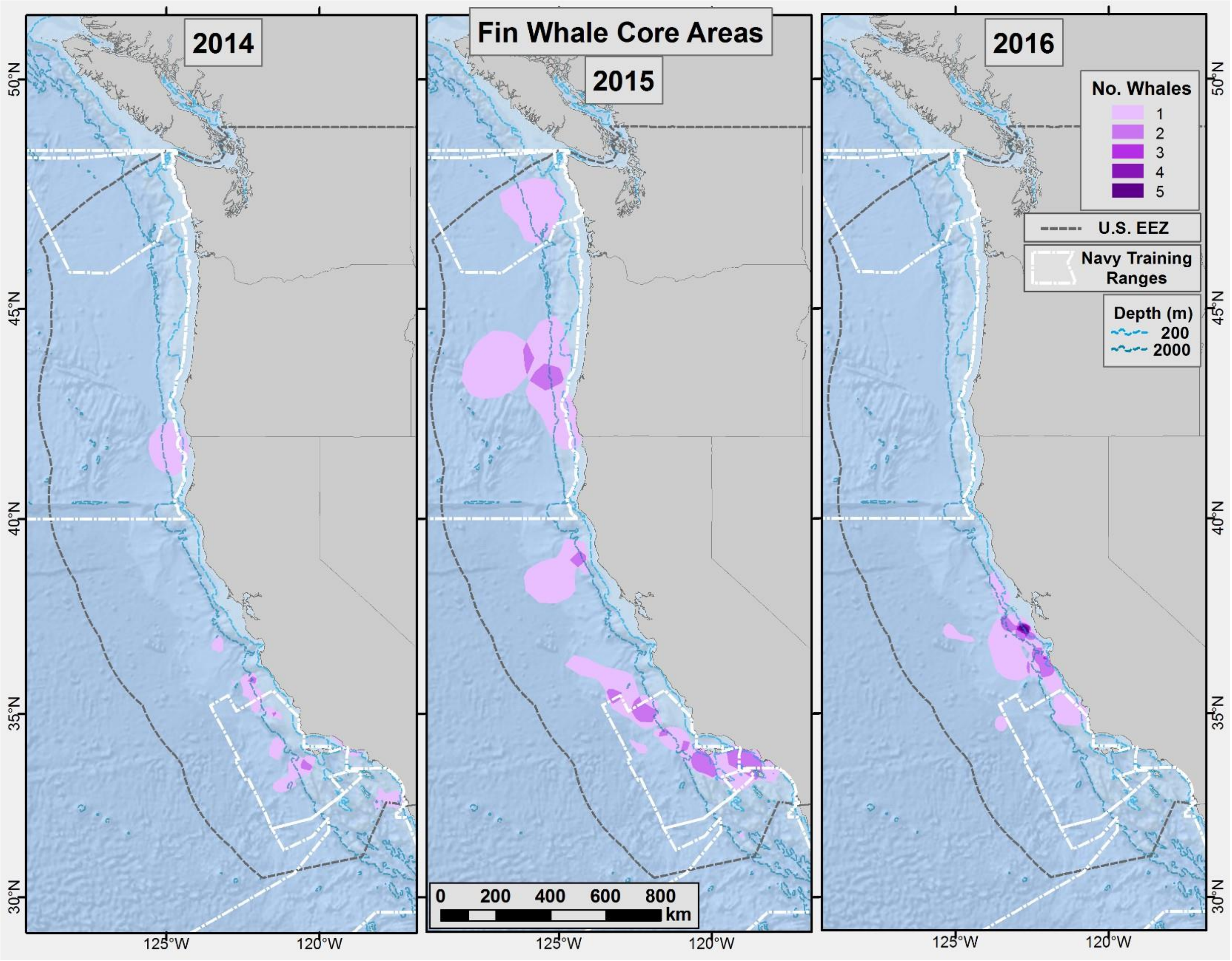


Figure 53. Core areas (CA) of use in the U.S. EEZ for fin whales tagged off southern California in 2014 (three whales), off southern California in 2015 (5 whales), and off central California in 2016 (5 whales). Shading represents the number of individual whales with overlapping CAs. From: Mate et al. 2017a [Project S5]

2.2.1.10 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 S5/N4]

Analysis of 2017 blue whale tag data in relation to NMFS-designated BIAs (Calambokidis et al. 2015; Ferguson et al. 2015) is still underway. Data from 2014-2016 indicate that, of the six blue whale BIAs that overlap Navy training ranges, the Santa Barbara Channel and San Miguel Island BIA is the most important area to blue whales, in terms of number of whales using the area, time spent there, and number of overlapping CAs within the BIA (**Figure 55**) (Mate et al. 2017a). There were interannual differences in BIA use: the San Diego and the Santa Monica Bay to Long Beach BIAs were the most-heavily used in 2014; the Santa Barbara Channel and San Miguel Island and the Point Conception/Arguello BIAs were the most-heavily used areas in 2015 and 2016. The remaining two BIAs, San Nicolas Island and Tanner/Cortez Banks, were used only minimally by blue whales in all three years, with residencies ranging from <0.1 to 1.7 d for Tanner/Cortez Bank, and 0.1 to 0.3 d for San Nicolas Island. In all three study years, blue whale occurrence in BIAs took place in summer and fall (July to November).

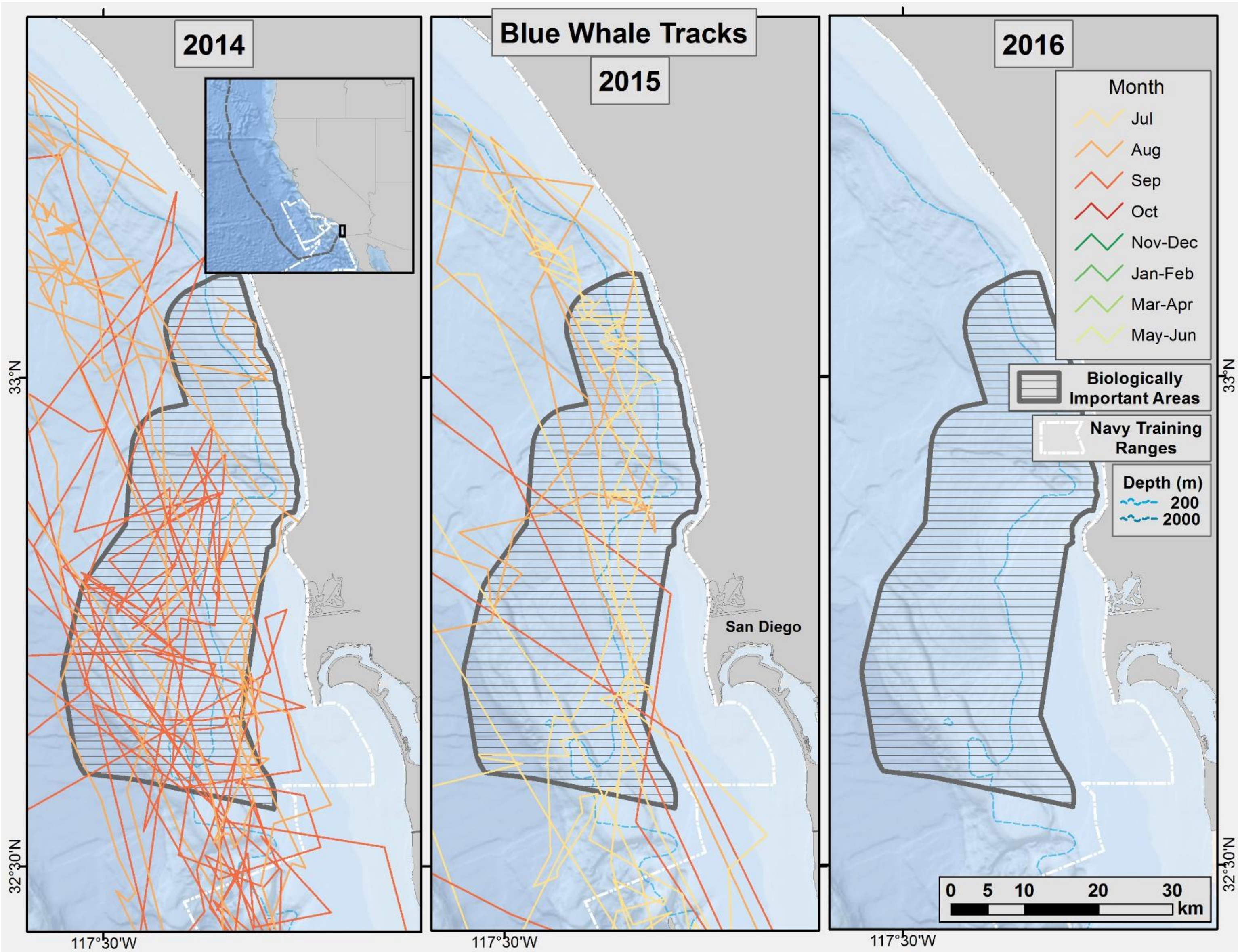


Figure 54. Satellite-monitored radio tracks of blue whales using the San Diego BIA (located in the SOCAL range), by tagging year (2014–2016). No blue whales tagged in 2016 were tracked in the San Diego BIA. From: Mate et al. 2017a [Project S5]

The amount of time spent in BIAs during 2016 by tagged blue whales ranged from less than 1 up to 100 percent of their total tracking periods (Mate et al. 2017a). 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 56 and 57**). 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 56 and 57**). 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.

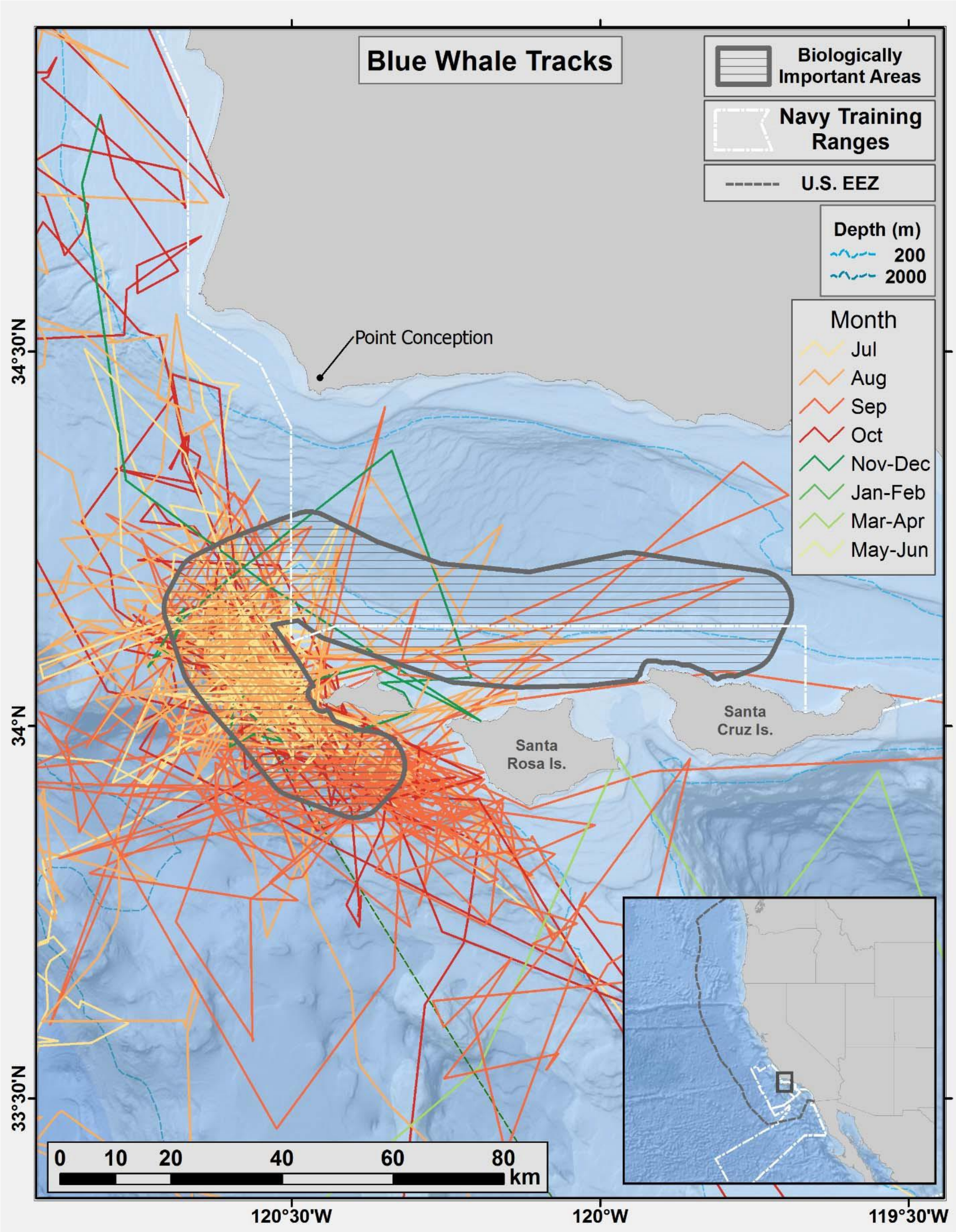


Figure 55. Satellite-monitored radio tracks in the Santa Barbara Channel and San Miguel BIA for blue whales tagged off southern and central California in July and August 2016 (5 LO tags, 5 DM tags). From: Mate et al. 2017a [Project S5]

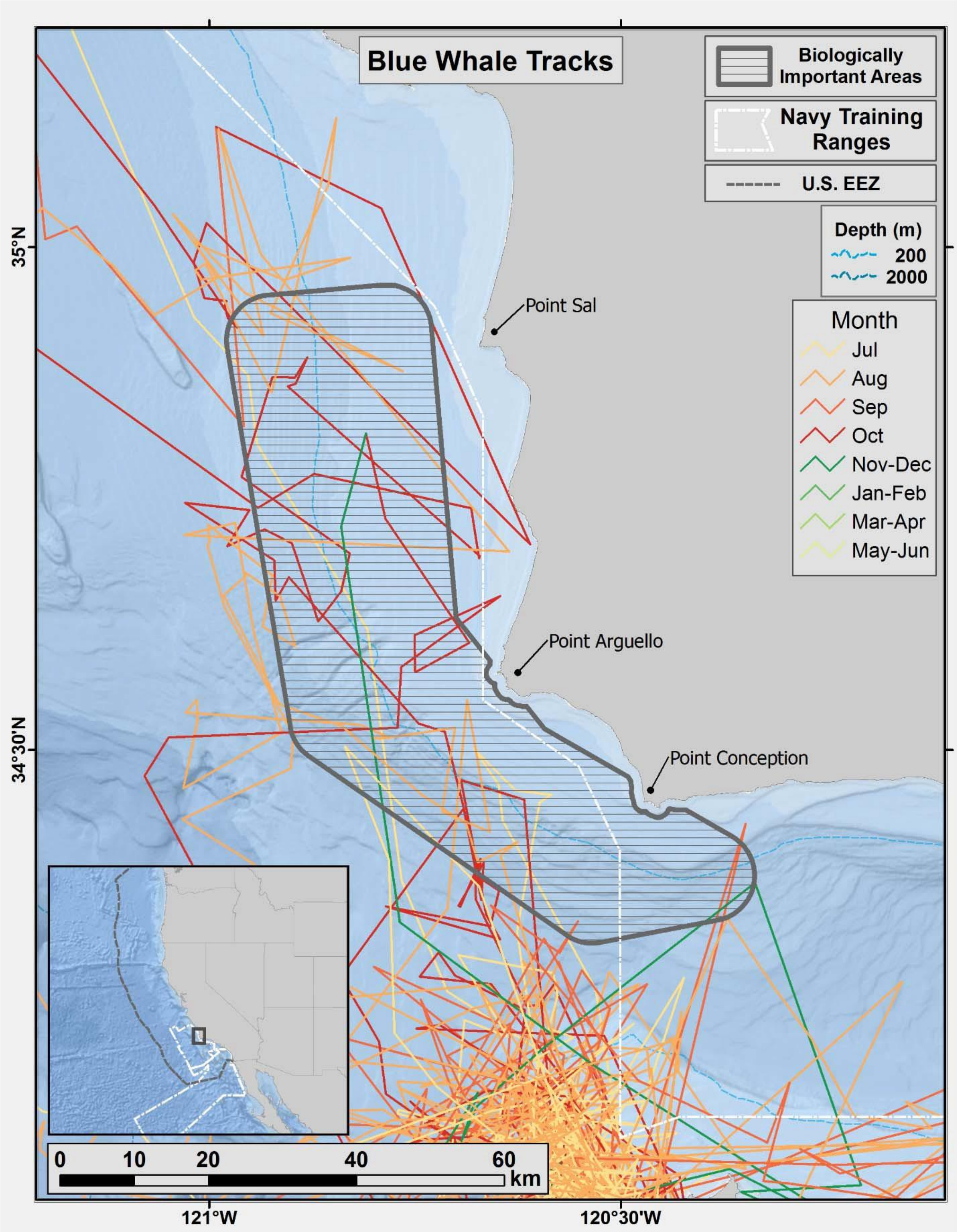


Figure 56. Satellite-monitored radio tracks in the Point Conception/Arguello BIA for blue whales tagged off southern and central California in July and August 2016 (4 location-only tags, 3 DM tags). From: Mate et al. 2017a [Project S5]

2.2.1.11 MONITORING QUESTION: 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)? [PROJECT N1]

Location data were received from all but one of the 19 deployed tags. Tag duration for DUR tags was 27.0 to 84.7 d (mean = 52.2 d, standard deviation [SD] = 22.4 d, n = 11), while for DM tags, the time was shorter, from 0.3 to 51.6 d (mean = 12.9 d, SD = 17.9 d, n = 7).

Whales tagged in July/August off California had locations ranging from the Santa Barbara Channel in southern California to Pacific City on the central Oregon coast (**Figures 58 and 59**). The individual with the widest movement range (Tag #10822) was tracked for 85 d for a distance of more than 900 km, moving between Pigeon Point, central California, and Pacific City, Oregon.

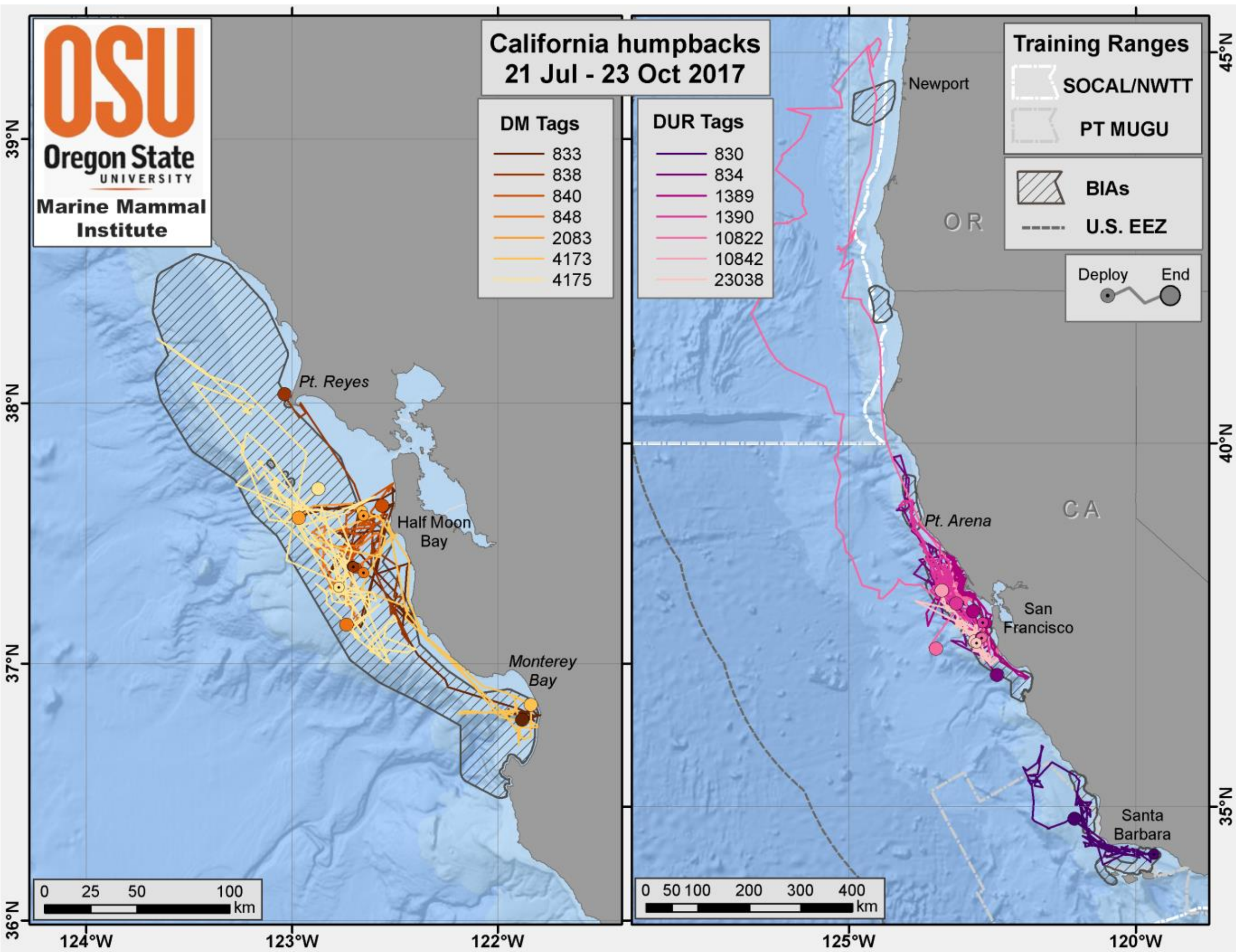


Figure 57. Tracks of humpback whales tagged off central and southern California during July-August 2017 with DM tags (left panel) and DUR tags (right panel). The last transmission was on 23 October 2017. From: Mate et al. 2017b [Project N1]

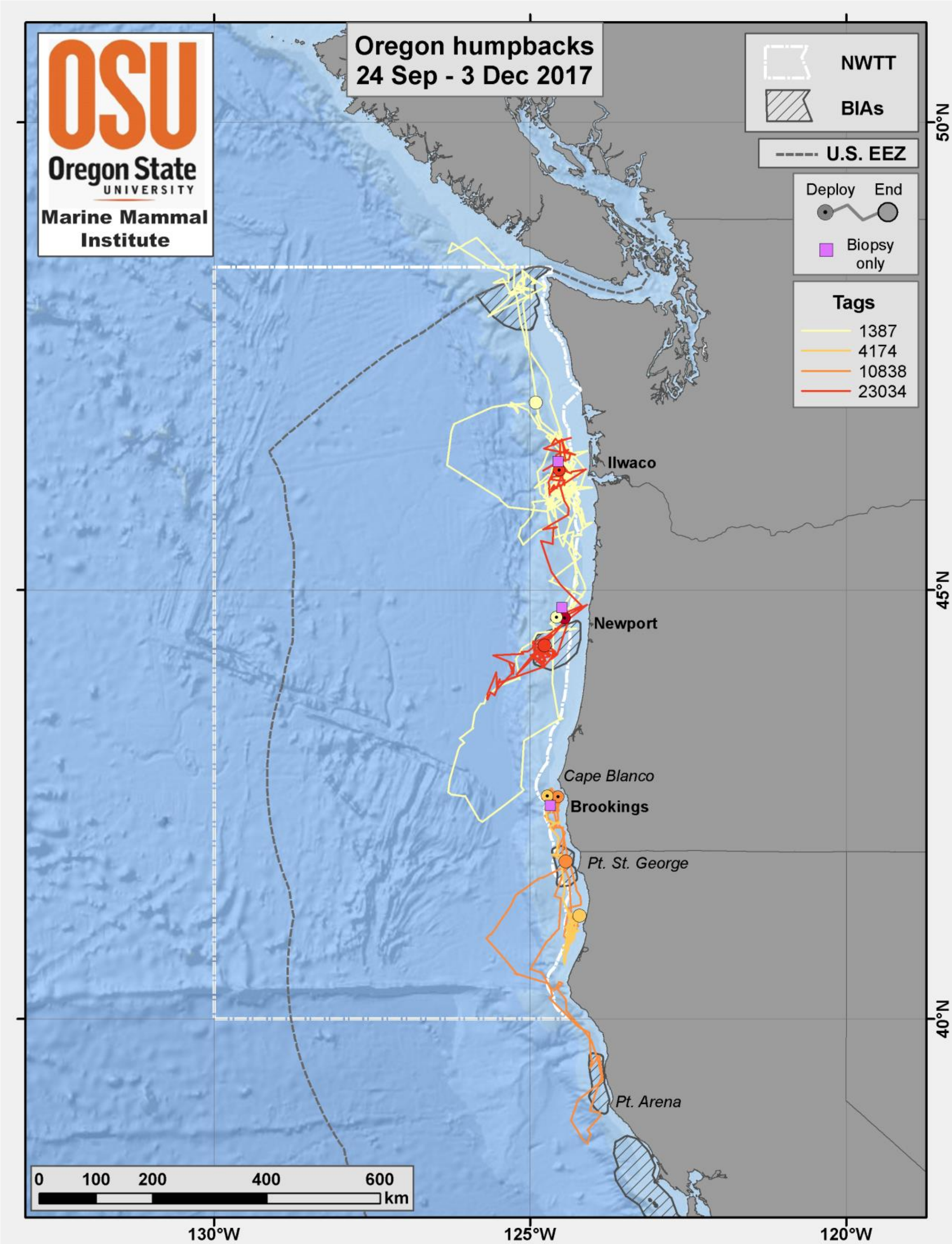


Figure 58. Tracks of humpback whales tagged with DUR tags off Oregon and Washington during September-October 2017. Tag # 1387 was still transmitting as of 3 December 2017. From: Mate et al. 2017b [Project N1]

A solitary individual (Tag #830) tagged in the Santa Barbara Channel off southern California transited the eastern Santa Barbara Channel to near Big Sur, California, where it spent most of its time in waters over the continental shelf break and continental slope. Most locations for humpbacks tagged off central California were in waters over the continental shelf along the central California coast, between Año Nuevo and Bodega Bay. one individual swam north using an offshore route to central Oregon, over the continental slope and abyssal plain (as far as 200 km from shore), and a more inshore route on the way south back to California, mainly over continental slope and continental rise waters.

Humpback whales tagged in Oregon and Washington had tracking data ranging from just south of Point Arena, northern California, to Vancouver Island, British Columbia. The individual that traveled the furthest (Tag #1387) moved between Cape Blanco, southern Oregon, and Barkley Sound, Vancouver Island, for a distance of more than 715 km (**Figure 59**). One of the tags deployed off Newport, Oregon (Tag #23043), generated three transmissions but provided no locations. One other tag (Tag #1387) was still transmitting on 3 December. The area off the mouth of the Columbia River (northern Oregon and southern Washington) was heavily used by two whales (Tag #23034, tagged near there, and Tag #1387, tagged off Newport). Most Argos tag locations in this area were in waters near the continental shelf break or over the continental slope. The two whales tagged near Cape Blanco, in southern Oregon, (Tags #4174 and #10838) spent most of their time in continental shelf waters with extended periods of time off Trinidad Head and Eureka, northern California. Two tagged whales moved offshore into deep waters over the abyssal plain, with one whale traveling over 170 km offshore (Tag #1387) and the other over 120 km offshore (Tag #10838).

As noted earlier, analyses for the 2017 tagging effort by Oceanwide Science Institute (OSI) are ongoing and will be available later in a final report. During 2016, two humpback whales were tagged with DM tags off Newport, Oregon (Mate et al. 2017a). Tagging duration was short at 7.3 and 18.9 days. These individuals were tagged 27.5 km from shore in waters with a depth of 143.2 m. One of the individuals was tracked from Oregon to Northern California. Three humpback whales (two tagged and one tag miss) were biopsy sampled; two were determined to be males and one was a female. The mitochondrial (mtDNA) haplotypes were qualitatively compared, and more closely match genetics for the stock of humpback whales feeding from Oregon to southeastern Alaska than to those from central and southern California.

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

Detection rates of SRKW were higher in 2012 (0.75) and 2014 (0.67) than the other years of effort. SRKW were found to have low rates of vocalization in the winter (44 percent of the time), in contrast to summer months. Hanson et al. (2018) speculated that these lower vocalization rates are likely due to the whales spending less time during the winter foraging and socializing, which are typically activities with much vocal activity.

Over one-third of the monitoring days were detected from sites within NWTRC W237. Ecological Acoustic Recorders deployed in W237 included areas where tagged SRKWs occurred infrequently in winter (e.g., mid-shelf) or not all (e.g., base of the continental slope). This deployment pattern was implemented to determine if SRKWs used these areas in other seasons when satellite-linked tags were not deployed. SRKWs were detected at only four of these nine sites located in W237, representing only about 25 percent of the total detections. Area W237 had an overall rate of 0.43 detections per month for SRKW. Westport Inshore (1.75 detections per month) had the highest average rate, followed by Columbia River North (1.57 detections per month), and La Push (1.27 detections per month).

SRKWs were detected acoustically offshore to 62 km west of the northern Washington coast (Cape Flattery Offshore). No detections occurred at either of the sites located off the continental shelf (Quinault Deep, Westport Deep). Two of the sites had no detections (Cape Flattery Inshore, Cape Flattery Mid Shelf). One site had a recorder failure in one year and was not recovered in another (Cape Flattery Deep), while at one site the recorder was not recovered in either year (Quinault Mid Shelf).

The model-generated predictive maps for SRKW occurrence from the acoustic recorder data in the winters of 2007 to 2011 (**Figure 60**) show a similar pattern to the distribution of satellite-tagged SRKW in 2012 to 2016 reported last year by Hanson et al. (2017). This pattern shows SRKW concentrated near the mouth of the Columbia River and Westport. Other areas with high occurrence were off the northern coasts of Washington and California.

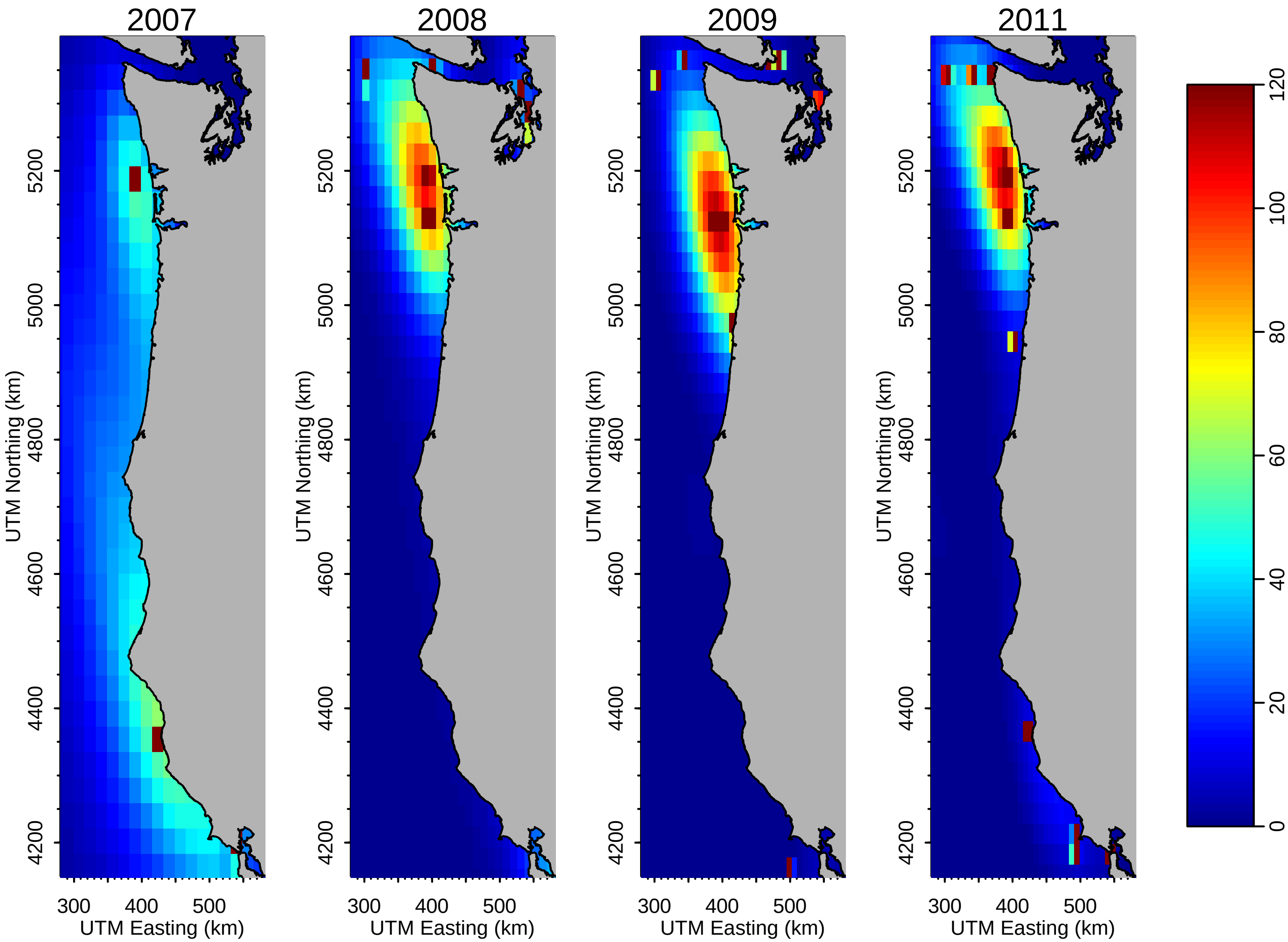


Figure 59. Spatial predictions of Southern Resident killer whale distribution based on acoustic recorder detections and visual sightings, without satellite-tagged whales. All maps represent predictions for February, and are shown on the same color scale relative to a uniform distribution (e.g., dark red values indicate 120x higher than expected by chance). From: Hanson et al. 2018 [Project N2]

2.2.1.13 MONITORING QUESTION: 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)? [PROJECT N3]

Chinook salmon originate from rivers along the coast of central California to Alaska. Results of the state-space model constructed by Shelton et al. (in review) revealed that Chinook salmon ocean distribution depends on where the salmon originate and seasonal timing (**Figure 61**). Survival showed regionally varying temporal patterns (Shelton et al. in review).

Salmon originating in the northern region (i.e., Alaska) almost exclusively were found in Alaska and Canada, while those fish coming from California and southern Oregon remained south of the British Columbia border, in U.S. waters. Fish originating from the Columbia River basin were the most widely distributed, with many individuals present in areas ranging from California to Alaska. The model also revealed that most salmon (>80 percent) present in the Salish Sea were from there, suggesting that few Chinook salmon are migrating into the Salish Sea from the outer coast. Shelton et al. (in review) also reported a “signature” of seasonal distributions in fish. Fish were distributed more northerly in summer as compared with the winter-spring period. Salmon often were located near their region of origin during the fall, due to spawning migrations. The distribution of Chinook salmon in the ocean tended to be spatially less concentrated in the winter-spring period. This in part may reflect the disparity in length of seasons in the model as winter-spring spanned seven months (November–May) while summer spanned only two months (June–July).

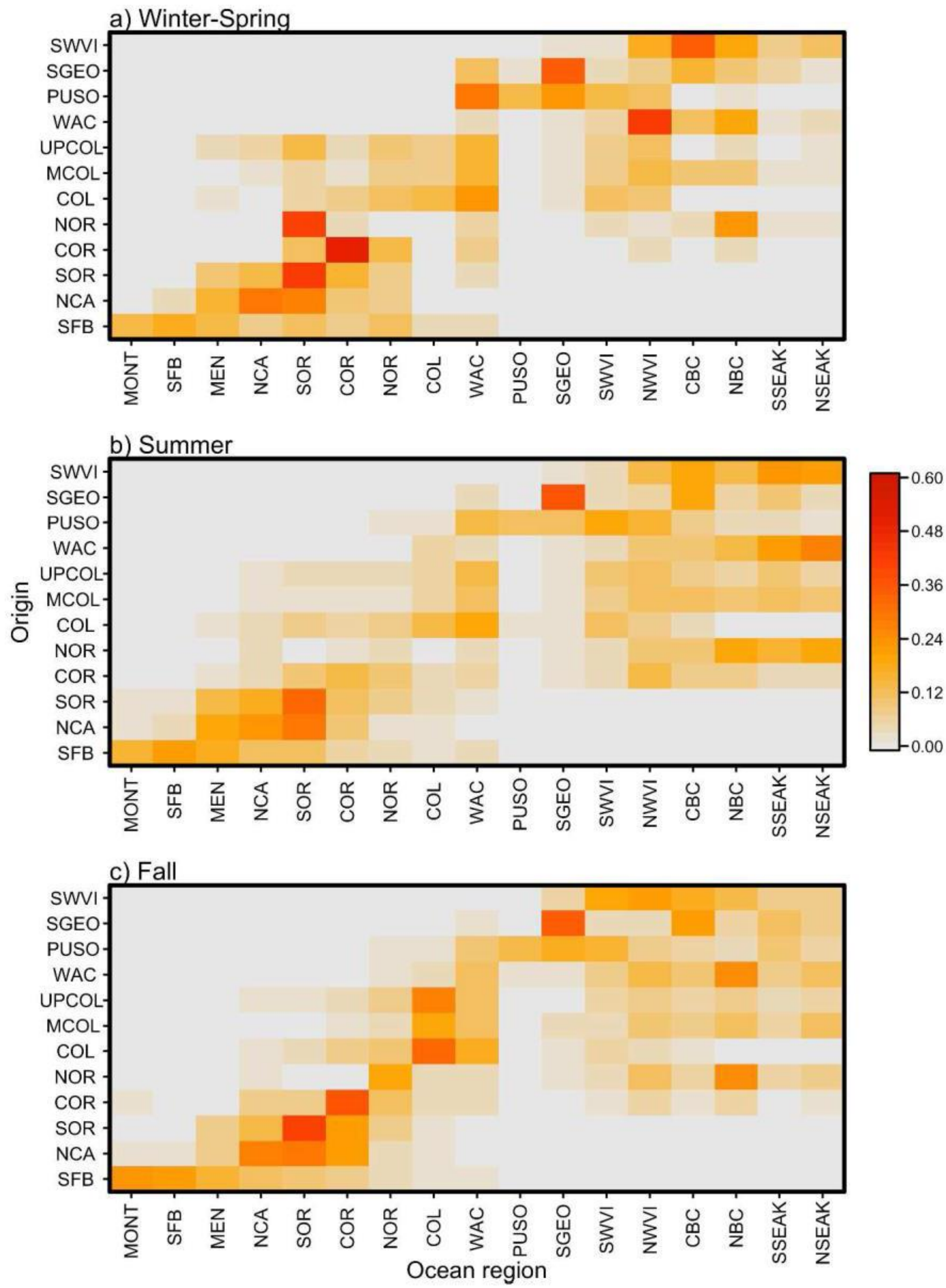


Figure 60. Estimated proportional spatial distribution by season of fall Chinook salmon originating from 11 different regions. Each row represents the proportion of fish from a region present in each ocean region (rows sum to one). Posterior means are shown. From: Shelton et al. in review [Project N3]

2.2.1.14 MONITORING QUESTION: WHAT IS THE ABUNDANCE OF CALIFORNIA SEA LIONS IN PACIFIC NORTHWEST USING NAVY FACILITIES (AND THE SURROUNDING AREAS)?; AND

WHAT IS PROPORTION OF TIME THAT CALIFORNIA SEA LIONS HAULED OUT WHEN IN THE PROXIMITY OF A NAVY FACILITY? [PROJECT N5]

Between 2014 and June 2016, researchers at Alaska Fisheries Science Center/National Marine Mammal Laboratory tagged a total of 30 adult and subadult male California sea lions at Bremerton and Manchester naval facilities in Puget Sound, Washington (**Figure 9**) (DeLong et al. 2017). Twenty-two animals were tagged in 2014-2015, and eight animals were tagged in 2016. The 30 individuals were instrumented with Mk10 Satellite-linked Depth Recorders (see **Appendix A**), which transmitted at-sea and from haul-out locations. Ten of the tagged individuals remained in the waters where the tag was deployed for up to four months; however, two individuals travelled to Hood Canal and used the Bangor facility to haul out and the adjacent waters to feed.

Eleven individuals moved out of Puget Sound to the Columbia River, passing through the Olympic Coast National Marine Sanctuary (OCNMS), while others hauled out on traditional haul-out sites within the OCNMS. Nineteen individuals used the outer coast regions producing 7,398 hourly estimated locations (79 percent occurred between the coast and the eastern edge of the NWTT and 21 percent occurred within the NWTT) (**Figure 62**). A total of 90 percent of the sea lion locations within the NWTT occurred outside of W237A and W237B. Maximum distances from the coast ranged from 44 to 144 km offshore. The kernel density analysis of hourly satellite tag locations indicates the high-usage of waters of inland Puget Sound adjacent to naval facilities at Bremerton and Manchester (shown in red, **Figure 63**).

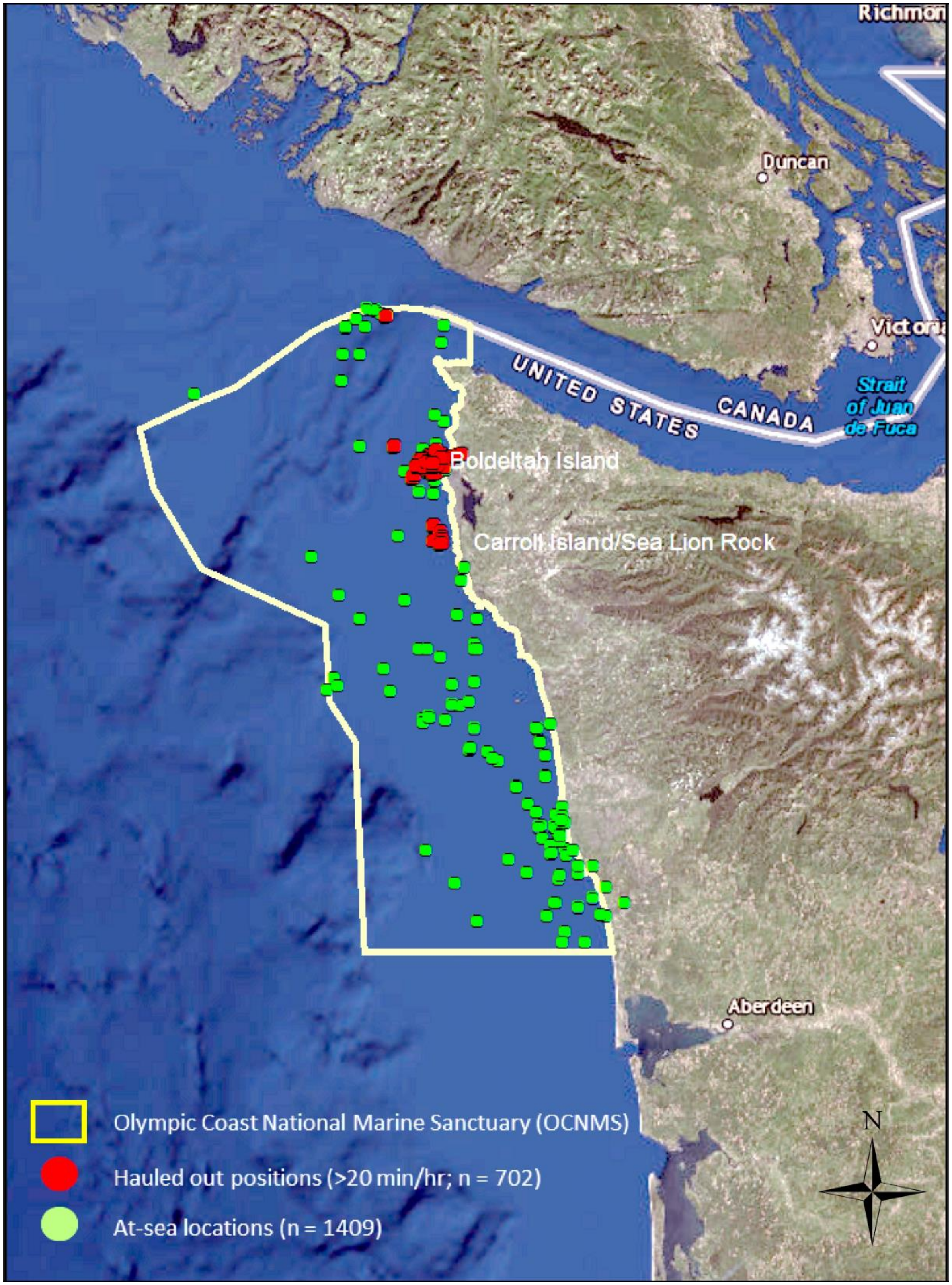


Figure 61. Estimated hourly haulout and at-sea locations for adult male California sea lions using the Olympic National Marine Sanctuary. From: DeLong et al. 2017 [Project N5]

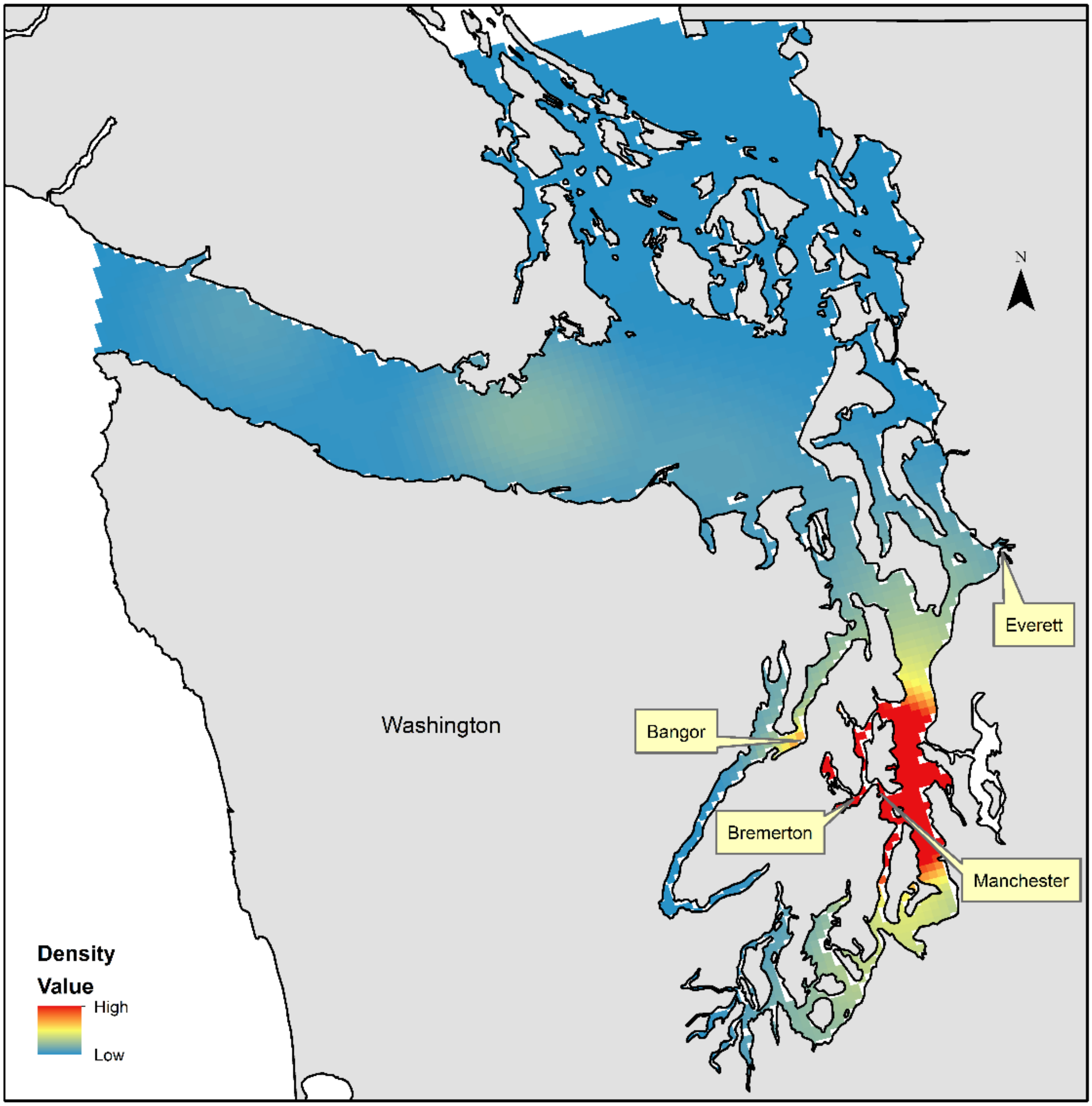


Figure 62. Kernel density analysis of estimated hourly locations of adult male California sea lions using the Washington Inland Waters region. Red indicates highest density of points and blue is lowest density of points. From: DeLong et al. 2017 [Project N5]

Weekly censuses of individuals hauled out on the port security barriers at the four naval facilities illustrated distinct patterns of California sea lion seasonal abundance that are common to all U.S. Navy facilities in Puget Sound. Sea lion abundance appeared to increase in August, with peak abundance occurring in October and November and decreasing in December and January (**Figure 64**). February and March tended to be a third of the November abundance from the previous year, with increasing abundance in March and April before the animals depart in May, with abundance near zero in June and July (**Figure 64**). The abundance estimate of California sea lions using Navy facilities in the inland waters of Washington during winter was 788 (99 percent CI: 534-1,186). The upper 99 percent confidence interval of 1,186 individuals provides a risk-averse estimate of California sea lions that potentially are affected by Navy activities at the facilities in the inland waters of Washington.

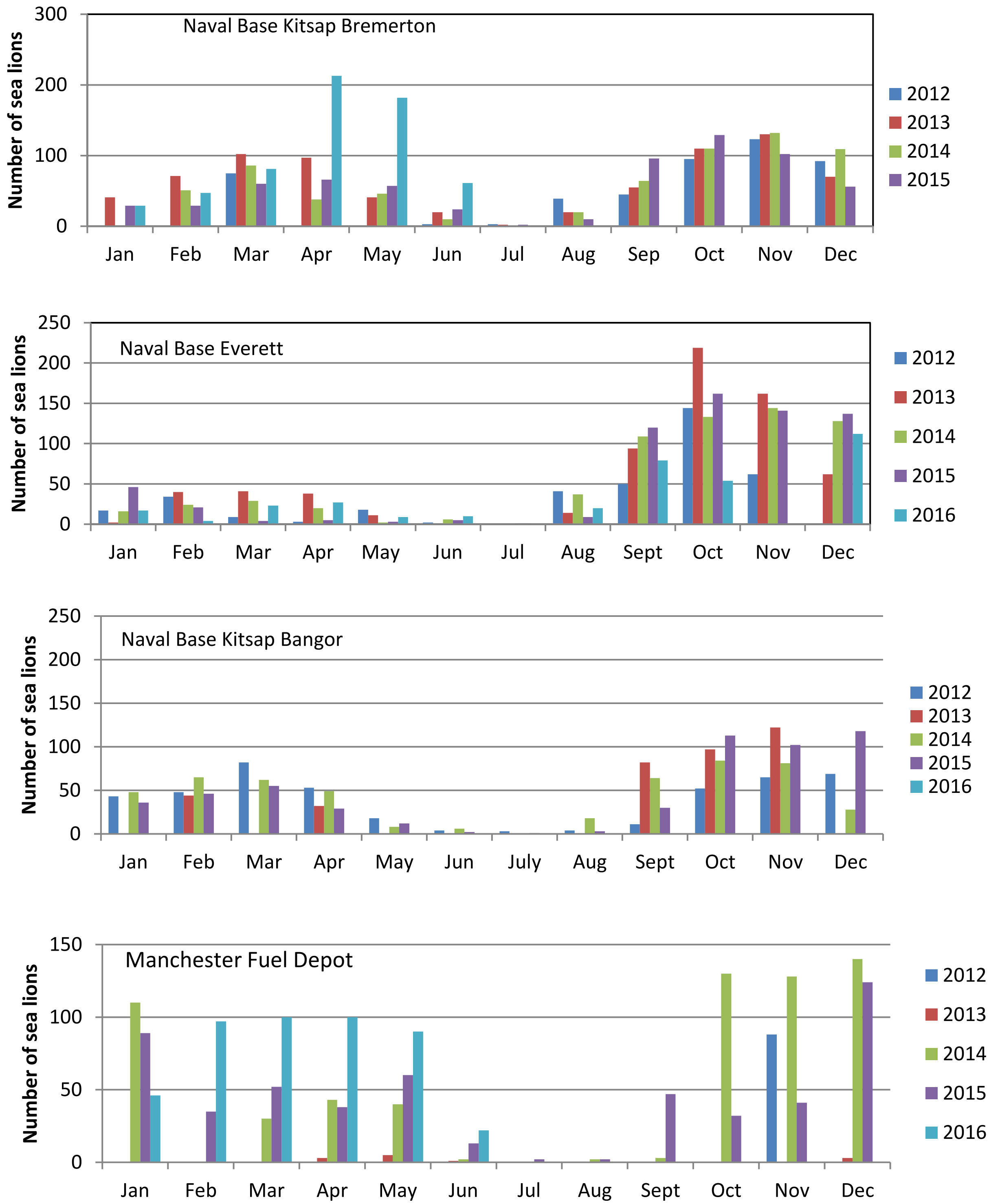


Figure 63. Highest single monthly counts of California sea lions at Naval Base Kitsap Bremerton, Naval Base Everett, Naval Base Kitsap-Bangor, and the Manchester Fuel Depot, Washington 2010 – 2015. From: DeLong et al. 2017 [Project N5]

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

In-water density and abundance was estimated for harbor seals in six sub-regions of Hood Canal, Washington (**Figure 25**), in order to evaluate impacts and estimate exposures from U.S. Navy activities that may cause acoustic disturbance. Navy-funded line-transect aerial survey data collected from 2013 to 2016 (Smultea et al. 2017) from Hood Canal were analyzed to estimate the density and abundance of harbor seals in the water. Using dive and surface time data from seal tagging studies (Wilson et al. 2014), a correction factor [trackline detection probability– *g*(0)] was estimated and used to correct for seals that were missed on the trackline during aerial-based surveys. Conventional and multiple covariate line-transect approaches were conducted and the best estimate of harbor seal densities expected to be in-water in the study region was 5.80 seals/km^2, with an estimated in-water abundance of 2,009 seals (coefficient of variation not including *g*(0) variance = 6.9 percent; including *g*(0) variance = 118.6 percent); breakouts of density by the pre-defined subregions of Hood Canal were also presented by Jefferson et al. (2017). Seasonal estimates of density and abundance were also produced for these six sub-regions of Hood Canal (see Jefferson et al. 2017).

2.2.1.16 MONITORING QUESTION: WHAT IS THE OCCURRENCE OF MARINE MAMMALS AND ANTHROPOGENIC NOISE IN THE GULF OF ALASKA? [PROJECT G1]

Acoustic data collected by HARPs deployed in the GOA TMAA in 2015 was analyzed for 40-Hz fin whale calls (Wiggins et al. 2017; Wiggins and Hildebrand 2018). During last year's reporting period, the ambient noise soundscape (i.e., whale sounds, ships, sonar, etc.) for the area was described. During 2017, further analyses were conducted on two fin whales that were moving and concurrently calling. These two individuals produced calls of 51.1 ±4.8 Hz (Whale A) and 40.2 ±3.4 Hz (Whale B) and source levels of 186.0 ±2.5 dB re 1 µPa @ 1 m (RMS) (Whale A) and 175.1 ±4.0 dB re 1 µPa @ 1 m (RMS) (Whale B). Possible causes for the wide range of source levels and frequencies may include: (1) animals choosing different call frequencies; (2) total lung volume being different for the two whales; or (3) varying depth in the water column of the calling whale. Prior to this research effort, there were no source level estimates for 40-Hz fin whale calls. Estimating source levels of vocalizing animals is an important variable for detection probability from PAM in order to estimate population densities using distance sampling methodology. Additionally, the ability to track vocalizing whales can provide details on an individual's swimming behaviors and habitat usage.

Acoustic data collected during the April-September 2017 were analyzed for describing ambient sound as well as detections of anthropogenic sound and the vocalizations of beaked whales and ESA-listed baleen whales (Rice et al. 2018b). As expected due to fewer MFAS sources in 2017 compared to the previous Northern Edge training exercise in 2015, there were insufficient detections of MFAS to perform the type of analysis investigating vocalization behavioral response of the form of Širović et al. (2017a) and Baumann-Pickering et al. (2018).

2.2.2 Conceptual Framework Category 2. Exposure

The following sections summarize progress made this monitoring year to address the issue of *exposure* of protected marine species to anthropogenic noise generated by U.S. Navy training activities. Only projects conducted in HSTT, SOCAL, and MITT address this topic. In HRC, the monitoring program invested in the installation of a second Wildlife Computers “Mote” satellite tag data receiver station with coverage over the waters at and adjacent to PMRF, in order to benefit multiple monitoring projects. This unit was installed in August 2017 on Niihau, joining the other station previously installed February 2016 at Makaha Ridge on Kauai. The current projects that can potentially benefit from the improved tag data collection capability these stations provide are: **[H2], [H5], [H6]**, and the Hawaii-portion of **[N1].**

A number of monitoring projects in 2017 addressed questions of marine mammal *exposure* to sound—specifically species that may be exposed to U.S. Navy sonar and UNDETs. This work included 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 areas typically used for training and testing activities. One new project addressed the potential exposure of corals to physical impacts from training ordnance.

2.2.2.1 MONITORING QUESTION: WHAT IS THE EXPOSURE OF SEA TURTLES TO EXPLOSIVES AND/OR SONAR IN THE MITT STUDY AREA? [PROJECT M2]

Between 2013 and 2017 for **Project [M2]**, 17 sea turtles were outfitted with satellite tags inside and near Apra Harbor (including capture sites at Orote Point, Dadi Beach, and Piti Bomb Holes (Martin and Jones 2018), and one tag was still transmitting as of January 2018. Tagging data reveal consistent patterns of movement and habitat use by turtles near UNDET areas (e.g., Martin and Jones 2017). While turtles are spending significant amounts of time in and moving through areas within 1–2 km of Agat Bay Mine Neutralization Site, Piti Point Mine Neutralization Site, and Outer Apra Harbor Underwater Detonation Site (**Figure 31**), there continues to be no direct overlap of the turtles with those UNDET areas. The low frequency of GPS locations obtained from these tags (often a maximum of one per day) could result in the lack of direct overlap between these sites and turtle locations.

2.2.2.2 MONITORING QUESTION: WHAT IN-WATER IMPACTS TO CORALS FROM ORDNANCE ARE OBSERVABLE AT FDM? [PROJECT M3]

Between 1997 and 2003, no significant impacts from bombing activities were reported in marine habitats around FDM. In 2004, significant damage (e.g., branch breakage) was observed. This damage may have been related to increased bombing activities, but probably more significantly resulted from storm damage from typhoon TingTing passing over the island. In 2007 and 2008, disturbances of 9 m^2 and 1 m^2 patches were observed from bomb detonations. In other years, bombing impacts were even less significant. Overall, prior surveys have concluded that naval range activities have had little discernible impact on the surrounding marine communities at FDM.

The 2017 survey found little evidence that U.S. Navy training had affected coral communities at FDM and was the first survey in which none of the divers sighted a single fresh rocket, bomb or fragment. No fresh bombs, blast pits, craters, or significant areas of coral breakage were observed. With the exception of a single 50 caliber brass cartridge case, the ordnance observed during the survey was almost exclusively old, was encrusted in marine life, with no discernable impact to surrounding communities.

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]

Martin et al. (2018) presents preliminary results of the FY17 disturbance analysis for the 31 minke whales tracked immediately before and during the portion of the February 2017 SCC training event that utilized surface ship hull-mounted MFAS.

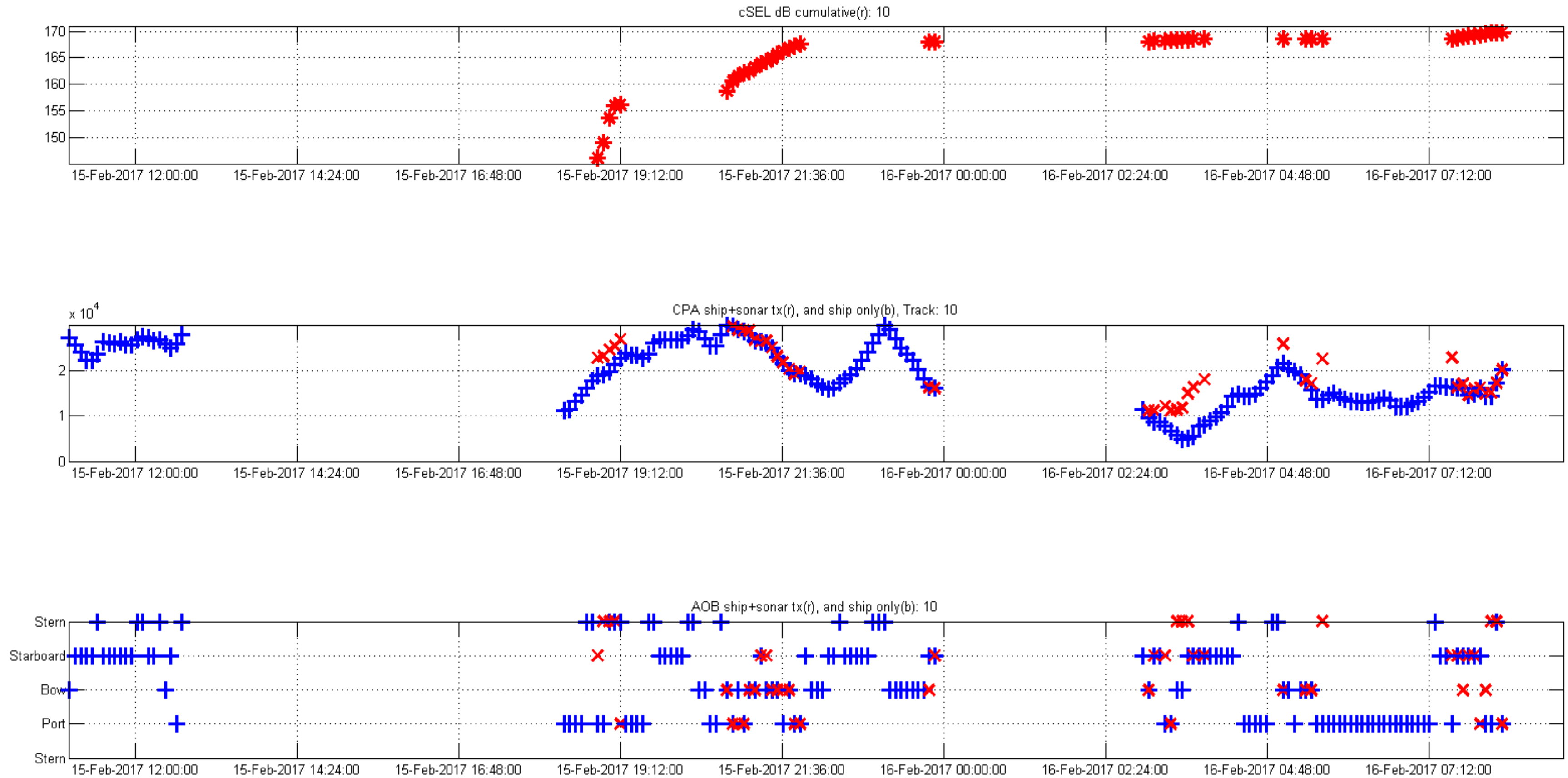


Figure 64. Overview of ship-whale geometries and cumulative received levels for minke whale track 10 during the February 2017 SCC on a 5 min binned basis. Minke whale track 10 had the highest cumulative received level and the minimum closest point of approach to a ship not transmitting hull mounted MFAS out of 31 minke whales tracked during this time. From: Martin et al. 2018 [Project H2]

Disturbance analysis plots are included here only for the minke whale associated with track 10 (minke whale track 10) (refer to **Figure 65**). The top plot shows the cumulative sound exposure level that this individual received over the duration of the track. Received sound exposure level was not accumulated between bouts of MFAS transmissions.

Minke whale track 10 is shown in **Figure 66** relative to tracks of multiple ships transmitting MFAS (gray shaded regions reflect generalized tracks, since actual ship positions are sensitive naval data). Minke whale track 10 had its minimum closest point of approach at 4.8 km to a ship that was not transmitting hull-mounted MFAS. The yellow star indicates the closest point of approach of a ship transmitting MFAS to minke whale track 10, which was 11.0 km, with a maximum estimated received level of 148.7 dB SPL re: 1µPa and a CSEL of 168.3 dB cSEL re: 1µPa^{2}s at that time. At the end of its track, minke whale track 10 had the highest CSEL (169.8 dB cSEL re: 1µPa^{2}s) of the tracked minke whales (**Figure 66**).

During the previous reporting period, results were presented of a “test case” analysis of three minke whales tracked during MFAS during the SCC training event in February 2016 (Martin et al. 2017). The CSEL began at the same level as the sound exposure level (SEL) of 137.3 decibels re 1 microPascal-squared-second (dB re µPa^{2}s) at the onset of sonar activity. 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^{2}s 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^{2}s.

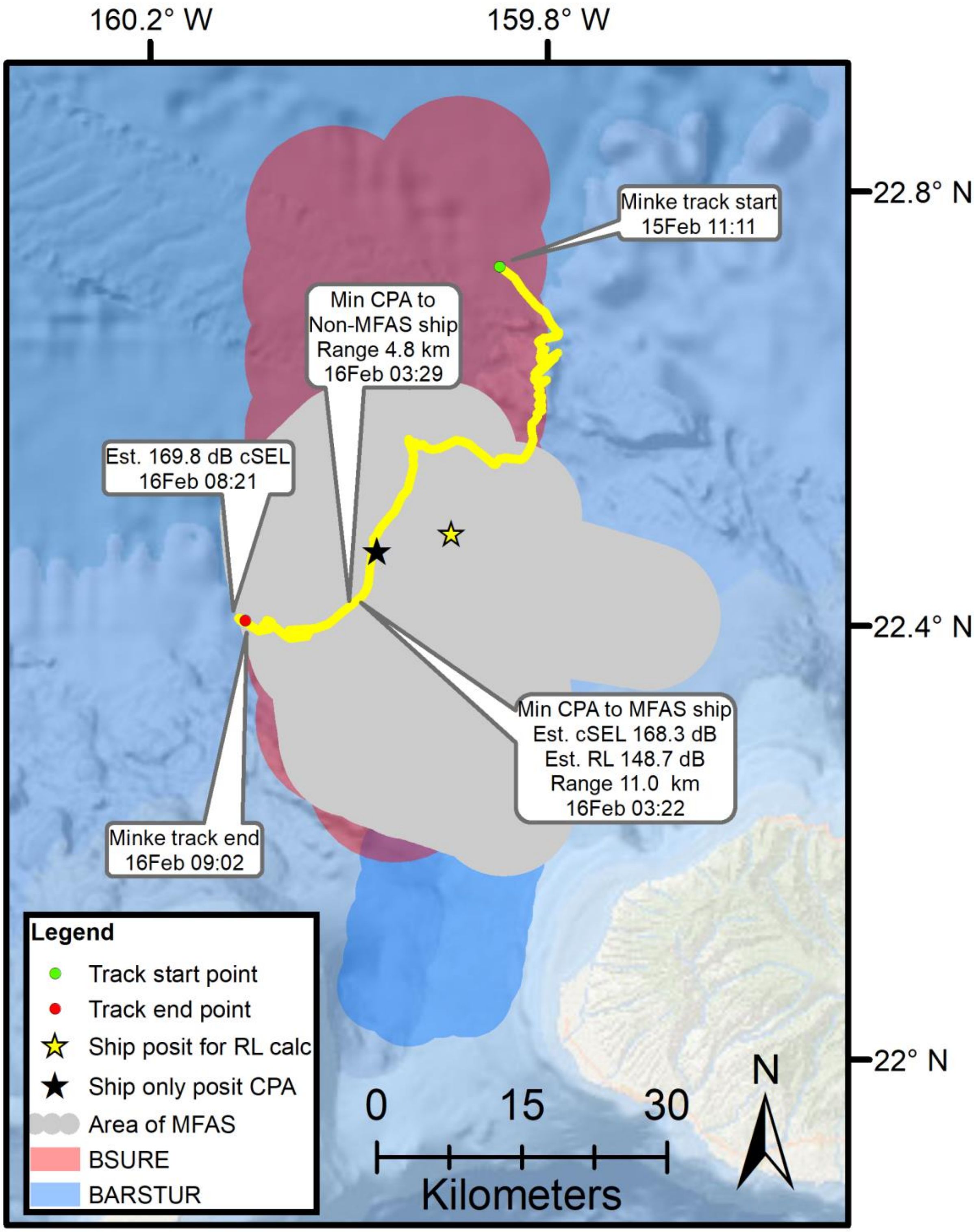


Figure 65. Situational plot for minke whale track 10. The callout labels along the minke whale track (yellow line) indicate the animal's localized position that corresponds to when the track starts (green dot), ends (red dot), when the maximum cumulative sound exposure level occurred, the closest point of approach to a ship not transmitting MFAS (black star), and the closest point of approach and estimated received level from a ship transmitting MFAS (yellow star). From: Martin et al. 2018 [Project H2]

2.2.2.4 MONITORING QUESTION: WHAT IS THE EFFECTIVENESS OF NAVY LOOKOUTS ON NAVY SURFACE SHIPS AND WHAT SPECIES ARE SIGHTED DURING SONAR TRAINING EVENTS? [PROJECT H4]

Although scheduled and mobilized in February 2017, the intended embark did not occur due to emergent mechanical difficulties of the ship; therefore, no additional results are available to present this year.

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). Humpback whales 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. Lookout effectiveness (LOE) studies since 2014, all in Hawaii for the Pacific ranges, have also 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 with sea turtle sightings.

2.2.2.5 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 H6]

In an effort to continue assessing the exposure levels of marine mammals to MFAS, data are being 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. 2017a). 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.

Analyses are ongoing and the final report is expected during the FY18 reporting period, therefore, no additional results are available to present this year. Also note that the nimals tagged during the 2017 field season left the area of PMRF before the SCC event commenced, so that analysis of exposure beyond the above project, as well that for behavioral response, will be deferred until collection of data from the 2018 tagging field season at PMRF.

2.2.3 Conceptual Framework Category 3. Response

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

Monitoring projects conducted in HRC and SOCAL addressed potential *responses* of protected marine species to anthropogenic sound, including call cessation and changes in dive behavior.

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) decreased echolocation clicks, and 3) movement such as relocation to areas outside of where MFAS was used.

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. (2018) performed an estimation of marine mammal exposures to MFAS and possible subsequent behavioral reactions by analyzing data collected before, during, and after the February 2017 SCC training event held at PMRF. Minke whales during the February 2017 SCC training event were analyzed, and are in progress for humpback whales. No fin/sei/Bryde's whales were observed to have tracks overlapping with the February 2017 SCC.

Martin et al. (2018) gives an example of an application of semi-automated determination of ship disturbances on marine mammals from both proximity of ships and MFAS exposures. There was a total of 53 h of MFAS training activities during the February 2017 SCC event. Of the 31 minke whale tracks, 23 whale tracks overlapped temporally with ship positions; minke whale positions were analyzed for disturbances both from ships' proximities and MFAS exposures from hull-mounted sonars. While disturbance analysis plots (such as **Figure 65**) were only included for minke whale track 10 (the animal closest to the activity), plots were generated for all animal tracks that overlapped with ship or hull-mounted sonar activity. Martin et al. (2018) pointed out that the minke whale reflected in track 10 continued to call at the nominal call rate for 41 min, emitting seven calls, after receiving the highest cSEL (169.8 dB cSEL re: 1µPa2s) of all animals tracked when surface ship hull-mounted MFAS were employed during the February 2017 SCC training event. This particular observation contrasts with previously reported results for February 2011, 2012, and 2013 when minke whales reduced their calling in response to MFAS used during naval training (Martin et al. 2016a, 2017). During February 2011, 2012, and 2013, calling whales in the same latitudinal area as the MFAS activities appeared to reduce calling, or move outside the area where MFAS was used (Martin et al. 2017). Whales began calling soon after sonar stopped, suggesting that some minke whales remain in the area after cessation of calling and resume calling rather than departing the area when sonar activity begins (Martin et al. 2017).

Analyses of August 2017 SCC training event recordings will be conducted in early FY18, and therefore, are not yet available.

2.2.3.2 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]

In 2016, researchers completed processing/preparation of 19 years of archived acoustic data recorded at four strategic sites in SOCAL (**Figure 19**). In 2017, these data were analyzed using GEE models to assess behavioral response (e.g., vocal activity) of blue and Cuvier's beaked whales to MFAS and explosions (**Figure 67**). The covariate *sonarlag* (sonar lag) was influential in the probability of detecting both blue whale calls and beaked whale clicks (i.e., detections increased when intervals of sonar increased); however, Baumann-Pickering et al. (2018) cautioned that the models require reevaluation due to outliers. The authors did note that the model suggested beaked whales have a negative behavioral response (i.e., decrease echolocation clicks) to larger variations in sonar sound exposure levels occurring over the preceding hour. Work will continue during 2018 to develop GEE models for the three other SOCAL sites of interest, which will allow for evaluation of the results of the selected models at different locations. Blue whale B calls will be added to the D calls for analysis, and researchers will assess the applicability of a multispatial convergent cross mapping approach to address behavioral responses by blue and beaked whales to MFAS.

Figure 66. Finalized analysis for MFAS, explosions, 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. From: Baumann-Pickering et al. 2018 [Project S2]

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 S3]

An initial risk function was completed for Cuvier's beaked whales (Moretti 2017) and in 2017, work was completed to estimate the probability of foraging dive disruption as a function of MFAS sound pressure level (SPL) exposure level (DiMarzio et al. 2018). Based on preliminary analysis, the presence of active sonar operations at SCORE decreases the probability of observing a group vocal period (GVP) start during the same time window. Assuming that the GVP starts are associated with the initiation of foraging dives by beaked whale groups, it may be inferred from this result that sonar operations influence beaked whale behavior. Once the results of the sonar localization and propagation modeling analyses are available and have been used to estimate a risk function, the relationship between the sonar exposure intensity and beaked whale behavior will be better known. The automated sonar localization algorithm will also offer the potential to process and include an increased quantity of data, which will result in a more precise estimate for the risk function. Preliminary analysis estimated a risk function for Cuvier's beaked whales and ongoing analyses are in progress to refine the estimates for sonar exposure levels.

2.2.4 Conceptual Framework Category 4. Consequences

The following section summarizes progress made this monitoring year to address potential marine species population *consequences* caused by anthropogenic noise generated by U.S. Navy training activities. The Navy research and development efforts funded by the Office of Naval Research is the primary avenue for exploring the population consequences of disturbance, due to high technical risk and expected long-term project timescales. However two compliance monitoring projects conducted in HSTT did investigate multi-year trends of abundance, which is relevant to population consequences. As part of these projects, the abundance and density of two beaked whale species were estimated over 3-year and 8-year periods, and no population-level changes were detected for the time periods 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 EXPLOSIVES IMPACT THE LONG-TERM FITNESS AND SURVIVAL OF INDIVIDUALS OR THE POPULATION, SPECIES, OR STOCK (WITH INITIAL FOCUS ON CUVIER'S BEAKED WHALES)? [PROJECT S3]

Beaked whale abundance and density at SCORE and PMRF were estimated using a dive-counting passive acoustic method (Moretti 2017; DiMarzio et al. 2018). 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 August 2010 through September 2017. The mean monthly Cuvier's beaked whale abundance showed a drop in September from a peak in January, followed closely in May, with a smaller dip in abundance in February (**Figure 68**).

Annual abundance estimates of beaked whales at SCORE showed no decline in the Cuvier's beaked whale population over the 8-year period from 2010 through 2017.

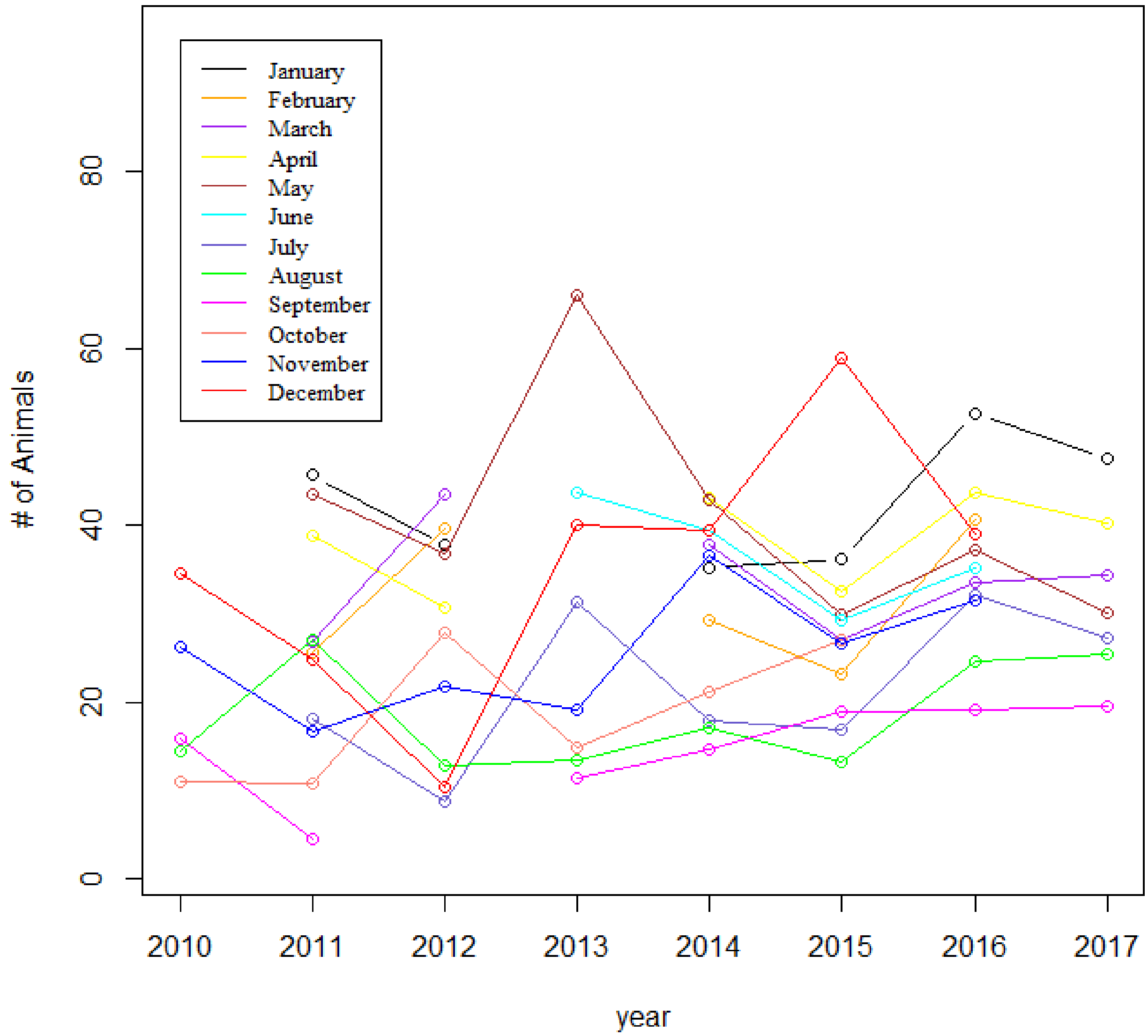


Figure 67. Corrected composite estimate of monthly abundance of Cuvier's beaked whales at SCORE from year 2010-2017. From: DiMarzio et al. 2018 [Project H3]

Likewise, initial abundance values for Blainville's beaked whales were derived for PMRF, using M3R data archives from 2015 to 2017. In 2017, the first extended archive of six months of continuous data was obtained and analyzed for Blainville's beaked whale abundance and added to the previous estimates. The mean monthly Blainville's beaked whale abundance peaked in June, with the lowest numbers in February and October (**Figure 69**). There was no indication of a change in the population trend line for Blainville's beaked whales over the 3-year project period.

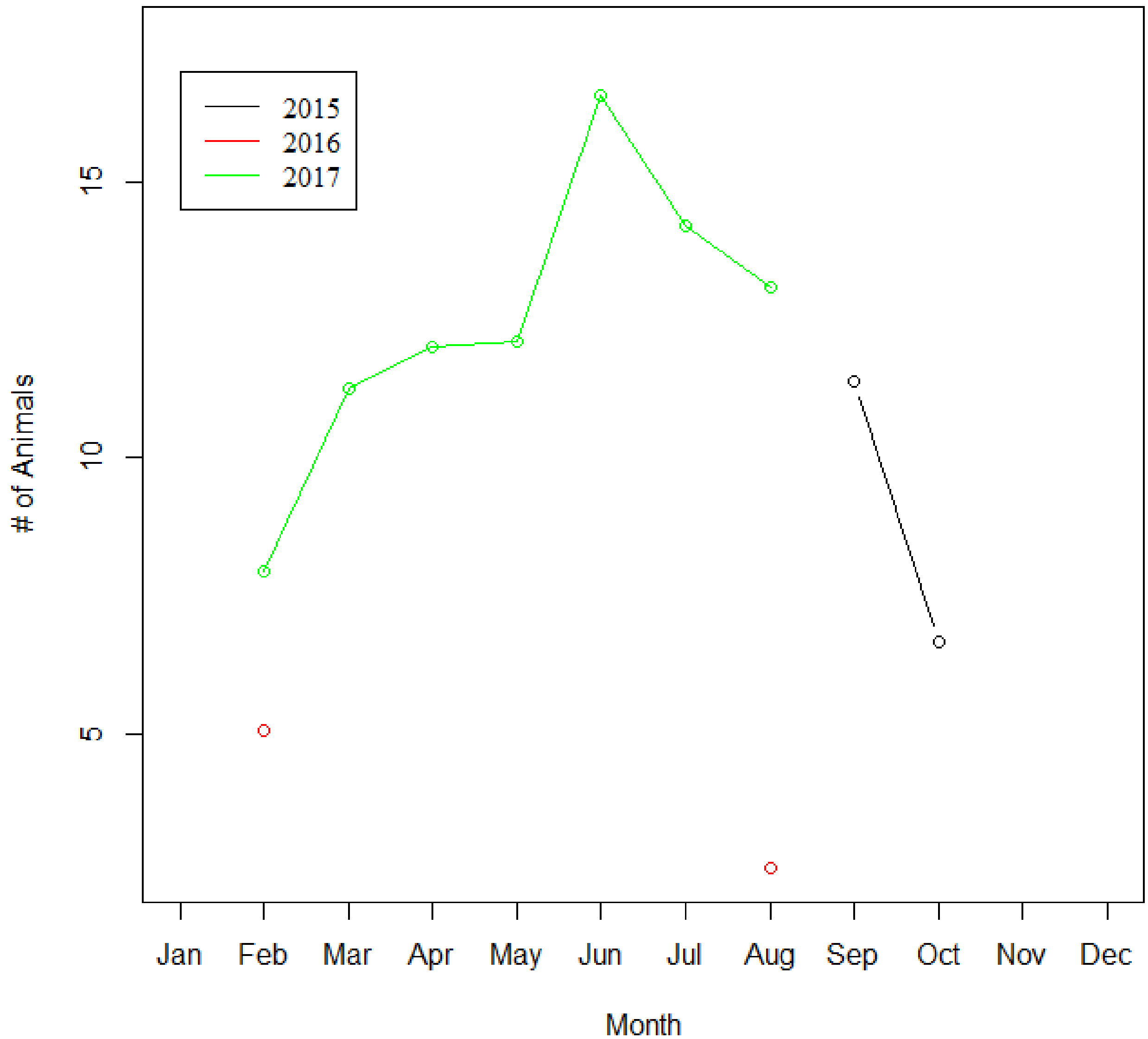


Figure 68. Mean monthly abundance estimates for 2015 – 2017 for Blainville's beaked whales at PMRF. From: DiMarzio et al. 2018 [Project H3]

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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 2018 are listed in **Table 2** and are also listed on the U.S. Navy's Marine Species Monitoring website:

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

Table 2. 2018 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 12)	Continuing or Proposed New Start
Location: Hawaii Range Complex (HRC)			
Title: Long-term Trends in Abundance of Marine Mammals at PMRF **Methods:** Analysis of archived PMRF hydrophone recordings **Performer:** SSC Pacific and 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[1]. #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[1].	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[1]. #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[1].	Continuing from FY15

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 12)	Continuing or Proposed New Start
Location: Hawaii Range Complex (HRC) (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:** SSC Pacific 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[1]. #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 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[1].	Continuing from FY15

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 12)	Continuing or Proposed New Start
Location: Hawaii Range Complex (HRC) (continued)			
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
Title: Humpback Whale Tagging at PMRF **Methods:** (pinger/satellite tagging/PAM) **Performer:** SSC Pacific	• 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.	Continuing from 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.

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 12)	Continuing or Proposed New Start
Location: Southern California Range Complex (SOCAL)			
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 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 and 2019.
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 U.S. Navy's SOCAL 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 12)	Continuing or Proposed New Start
Location: Southern California Range Complex (SOCAL) (continued)			
Title: Cuvier's Beaked Whale Impact Assessment at 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[1]. #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[1].	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 12)	Continuing or Proposed New Start
Location: Southern California Range Complex (SOCAL) (continued)			
Title: Passive acoustic monitoring in SOCAL **Methods:** PAM **Performer:** Scripps Institution of Oceanography, University of California San Diego	• What is the seasonal occurrence and abundance of cetaceans within the Navy's Southern California Range Complex? • What, if any, are the spatial patterns in fin whale population structures 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. #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 #6: Establish the regional baseline vocalization behavior, including seasonality and acoustic characteristics of marine mammals where Navy training and testing activities occur.	Continuing from 2015
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)	#7: Determine what behaviors can most effectively be assessed for potential response to Navy training and testing activities. #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. #13: Assess existing data sets which could be utilized to address the current objectives[1].	Continuing from 2015
Title: Guadalupe Fur Seal Population Census and Satellite Tracking Across Multiple Navy Ranges **Methods:** Tagging, visual survey (land census) **Performer:** The Marine Mammal Center, Sausalito, CA	• What is the habitat use (by age-sex class) of Guadalupe fur seals of the SOCAL and NWTT study areas, as well as other areas including epipelagic waters.	#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	New start spring 2018

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 12)	Continuing or Proposed New Start
Location: Mariana Islands Training and Testing (MITT)			
Title: Visual Surveys **Methods:** Visual surveys (nearshore small vessel winter and summer season), photo-ID (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, Some effort may be on a large vessel (NOAA ship) on an opportunistic basis, instead of a small vessel.
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.	Continuing from FY12 Project will conclude in FY18.

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 12)	Continuing or Proposed New Start
Location: Mariana Islands Training and Testing (MITT) (continued)			
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
Title: FDM Coral Survey **Methods:** Georeferenced diver survey **Performer:** SSC Pacific	• What is the occurrence of ESA-listed corals around FDM? • What is the composition of coral around FDM? • What in-water impacts to coralsfrom ordnance are observable at FDM?	#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 ESA-listed species 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.	Continuing from FY17. Project will conclude in FY18 with completion of final species ID and final report.

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 12)	Continuing or Proposed New Start
Location: Northwest Training and Testing (NWTT)			
Title: Modeling the Offshore Distribution of Southern Resident Killer Whales **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?	#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.
Title: : Characterizing the Distribution of Salmonids in the Pacific Northwest with Pop-up Satellite Tags **Methods:** tagging **Performer**: National Marine Fisheries Service-Northwest Fisheries Science Center and The University of Washington, School of Aquatic and Fisheries Sciences	• What is the seasonal distribution and variability of salmonid species that may be important prey for the Southern Resident Killer Whale?	#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 ESA-listed species 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 ESA-lisetd species where Navy training and testing activities occur.	New Start 2018[2]

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 12)	Continuing or Proposed New Start
Location: Northwest Training and Testing (NWTT) (continued)			
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 DPSs 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.	Continuing from 2017
Location: Gulf of Alaska Temporary Maritime Activities Area (GOA TMAA)			
(No projects in FY18)[3]			

[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.

[2] Though labeled as a new start due to an update in methodology (from modeling of data to new field tagging), this project is conceptually a refinement and continuation of Project [N3], "Modeling the Offshore Distribution of Chinook Salmon in the Pacific Northwest." The updated project retains substantially the same monitoring question, with NWFSC now collaborating with the University of Washington.

[3] The training exercise Northern Edge is not scheduled to occur during FY18.

Key: BIA = Biologically Important Area; CalCOFI = California Cooperative Oceanic Fisheries Investigations; DDG = guided missile destroyer; ESA = Endangered Species Act; FY = Fiscal Year; GOA = Gulf of Mexico; GPS = Global Positioning System; HRC = Hawaii Range Complex; LIMPET = Low Impact Minimally Percutaneous Electronic Transmitter; MFAS = Mid-frequency active sonar; MITT = Mariana Islands Training and Testing; NMFS = National Marine Fisheries Service; NWTT = Northwest Testing and Training; PAM = Passive Acoustic Monitoring; PCoD = Population Consequences of Disturbance; photo-ID = photo identification; PMRF = Pacific Missile Range Facility; SOAR = Southern California Offshore Antisubmarine Warfare Range; SOCAL = Southern California; SSC = Space and Naval Warfare Systems Center; TMAA = Temporary Maritime Activities Area;

Concluding Projects

Several monitoring projects concluded their final year of effort in 2017, and will not continue in 2018:

- **SOCAL: SOCAL Soundscape-** This project was a component of the larger "PAM in SOCAL" project. This soundscape portion of the project, funded at the end of FY17 has completed analysis and final reporting this monitoring year.

- **SOCAL/NWTT Blue and Fin whale satellite tagging-** This project completed its last planned field work this monitoring year and concludes blue and fin whale tagging for the near future. Analysis and 2017 reporting will be completed by July 2018. Some small additional FY18 funding is anticipated for a last consolidated report summarizing key observations, overall occurrence and residency patterns, and lessons learned over the entire 2014-2017 tagging period and to support future scientific publications. The consolidated report is anticipated by April 2019.

- **MITT – FDM coral survey-** this survey will be conducted every five years in accordance with the MITT Biological Opinion (NMFS 2017d). This project is listed here because five years beyond the survey date of (Fall 2022) is beyond the 2020 expiration of this Biological Opinion.

- **NWTT: Tagging and Behavioral Monitoring of Sea Lions in the Pacific Northwest in Proximity to Navy Facilities-** This project has completed analysis and final reporting this monitoring year.

- **NWTT: Harbor Seal Density Estimation-** This project has completed analysis and final reporting this monitoring year

- **GOA TMAA: PAM of Marine Mammals in the Gulf of Alaska Temporary Maritime Activities Area using Bottom-Mounted Devices-** By the finalization of this annual report, this project is expected to have completed analysis and reporting for field effort in association with the 2017 Northern Edge training exercise. Adaptive management with NMFS will determine monitoring in GOA during next scheduled Northern Edge exercise in 2019.

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A

Animal Telemetry Tag Types

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Table A-1. Table Summary of Animal Tracking Tag Types Used on Navy-Funded Monitoring Projects

Tag Name	Acronym	Project #	Use[1]
Advanced dive behavior	ABD	S5, N4	Provides short-term, fine-scale dive profile information and Global Positioning System-quality locations.
Coded-wire tags	CWT	N3	Provides information on stock-of-origin, time of release, and other details about a hatchery release group or wild fish collection event. Contains a numeric identifier unique to each batch of fish.
Dive monitoring	DM	S5, N1, N4	Provides intermediate duration Argos tracking and data on dive behavior (duration, depth, number of feeding lunges per dive).
Dive duration monitoring	DUR	S5, N1	Provides data on longer-term movements and dive durations.
Flipper	-	M2	The most common tag used on sea turtles. Made from metal or plastic and attached by piercing through the skin of flipper. The tags usually have a unique number on one side, and a return address on the other (in case someone finds the turtle far away from where the turtle was tagged). This tag does not transmit data
Location-only	LO	M1, M2, H1, H6, S3, S5, N2, N4	Provides long-term tracking information via the Argos satellite system such as derived location, depth, temperature, light level, and wet/dry sensor. **SPLASH and SPOT are specific types of location-only tags (see below)**.
Smart position and temperature	SPOT	S5, N2, N4	Provides data on a variety of measurements, such as temperature, salinity, and depth.
SPLASH	SPLASH	M2, H1, S3	Provides horizontal movement and additional information such as vertical behavior (depth). The SPLASH10 tag includes sensors to measure depth, temperature, light level, and wet/dry periods (to determine surfacing). During the deployment, depth and temperature data are collected, analyzed, summarized, and compressed for transmission through the Argos satellites. The SPLASH10 tag is configured with 1 GB of non-volatile memory available for the archived data. The SPLASH10 tag must be recovered in order to retrieve the entire raw archived data set. The Low Impact Minimally Percutaneous Electronic Transmitter (LIMPET) configuration is sometimes mentioned in reference to SPLASH tag. The tag's small size allows for deployment high on the dorsal fin to enable frequent transmissions to Argos satellites.
Mk10 satellite-linked depth recorder	SDR	N5	Records temperature and depth.
Passive integrated transponder	PIT	M2	Tracks individual organisms (in this report, sea turtles) using electromagnetically-coded glass-encased microchips (i.e., reliable lifetime 'barcode' for an individual animal). Animal has to be caught and scanned; data is not transmitted.

[1]References: Hill et al. 2018; Martin and Jones 2018; Mate et al. 2017a, b; Shelton et al. in review; https://wildlifecomputers.com/

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