2021 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), Brittany A. Bartlett (Naval Facilities Engineering Systems Command, Pacific), Jessica Chen (Naval Facilities Engineering Systems Command, Pacific), Benjamin R. Colbert (Naval Sea Systems Command), Mark Deakos (HDR, Inc.), Chip Johnson (U.S. Pacific Fleet), and Julie A. Rivers (U.S. Pacific Fleet).

List of Contributors (Technical Reports) (Alphabetized by Organization):

Robin W. Baird, Colin J. Cornforth, Annette E. Harnish, Michaela A. Kratofil, Shannon E. Vasquez, and Kimberly A. Wood (Cascadia Research Collective); Len Thomas and Cornelia Oedekoven (Centre for Research into Ecological and Environmental Modelling); Gustavo Cardenas-Hinojosa and Rodrigo Huerta Patino (CONANP); Shannon N. Coates, Erin A. Falcone, Erin L. Keene, Brenda K. Rone, Gregory S. Schorr, and David A. Sweeney (Marine Ecology and Telemetry Research); Gabriela C. Alongi, Regina A. Guazzo, Tyler A. Helble, E. Elizabeth Henderson, Roanne A. Manzano-Roth, Cameron R. Martin, and Brian M. Matsuyama (Naval Information Warfare Center Pacific); Stephen W. Martin (National Marine Mammal Foundation); Alexandra Carroll, Nancy A. DiMarzio, Karen Dolan, Susan Jarvis, Ron Morrissey, Alexander Muniz, Steven Vaccarro, and Stephanie Watwood (Naval Undersea Warfare Center Division Newport); Robyn P. Angliss, Jessica L. Crance, and Kim T. Goetz (NOAA Fisheries-AFSC); Marc O. Lammers (NOAA Hawaiian Islands Humpback Whale National Marine Sanctuary); Candice K. Emmons, M. Bradley Hanson, Marla Holt, David D. Huff, and Joseph M. Smith (NOAA Fisheries-NWFSC); Alexander R. Gaos, Summer L. Martin, Jennifer L.K. McCullough, and Erin M. Oleson (NOAA Fisheries-PIFSC); Marie C. Hill and Kymberly M. Yano (NOAA Fisheries-PIFSC and University of Hawaii); Jay Barlow and Annette E. Henry (NOAA Fisheries-SWFSC); Robert Pitman (Oregon State University); Simone Baumann-Pickering, Kaitlin E. Frasier, Ashlyn Giddings, John A. Hildebrand, Macey A. Rafter, Ally C. Rice, Jennifer S. Trickey, and Sean M. Wiggins (Scripps Institution of Oceanography); Dawn Breese and Todd Pusser (Unaffiliated); Michael B. Courtney and Andrew C. Seitz (University of Alaska, Fairbanks); Cody Clifton, Nicholas Hofmann, Connor Humann, Kyra Jacobson, Jana Phipps, Ilse Silva-Krott, and Kristi L. West (University of Hawaiʻi at Manoa); and Laura B. Heironimus, Shaffryn M. Schade, and Matthew T. Sturza (Washington Department of Fish and Wildlife).

Cover Photograph Credit:

Blainville’s beaked whales (*Mesoplodon densirostris*) photographed by Kimberly A. Wood/Cascadia Research Collective under NMFS Permit #20605 to Robin Baird.

Executive Summary

The United States (U.S.) Navy conducts training and testing activities in the Pacific study areas described in Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) documents for Hawaii-Southern California Training and Testing (HSTT) (Department of the Navy [DoN] 2018a), Mariana Islands Training and Testing (MITT) (DoN 2020b), Northwest Training and Testing (NWTT) (DoN 2020c), and the Gulf of Alaska (GOA) Navy Training Activities (DoN 2016a, 2020a). The U.S. Navy training and testing ranges covered by these documents include the Hawaii Range Complex (HRC) and Southern California Range Complex (SOCAL), which are part of the HSTT Study Area; the Mariana Islands Range Complex (MIRC), which is part of the MITT Study Area; the Northwest Training Range Complex (NWTRC), including the Naval Sea Systems Command's Naval Undersea Warfare Center Keyport Range Complex (Keyport Range Complex), which is part of the NWTT Study Area; and the GOA Temporary Maritime Activities Area (TMAA).

To authorize these actions, the National Marine Fisheries Service (NMFS) issued Final Rules and Letters of Authorization (LOA) under the Marine Mammal Protection Act (MMPA) to Commander, U.S. Pacific Fleet and Commander, Naval Sea Systems Command; and Biological Opinions under the Endangered Species Act (ESA) for each training and testing area.

This monitoring report was prepared in accordance with the annual monitoring reporting requirements for the 2021 calendar year, and presents results and progress made during the period of 1 January 2021 to 31 December 2021. The marine species monitoring described was conducted in accordance with objectives listed on the U.S. Navy's Marine Species Monitoring Program website:

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

In this report, monitoring goals for the HSTT, MITT, NWTT, and GOA TMAA study areas are framed in terms of progress made on question-based scientific objectives and programmatic Intermediate Scientific Objectives (as discussed in Section 1). The following list provides brief summaries of key results during 2021 with additional details in Section 2 and **Appendix A**. Section 3 lists the 2022 Monitoring Goals.

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

- Several projects in the HSTT and NWTT Study Areas resulted in peer-reviewed publications in 2021, including: Odontocete Studies on Pacific Missile Range Facility (PMRF), Cuvier's Beaked Whale (BW) Impact Assessment at Southern California Anti-Submarine Warfare Range (SOAR), Marine Mammal Monitoring on PMRF, and Beaked Whale Cruise off Baja California, Mexico (see **Appendix B**).

- With regard to the conceptual framework categories, several projects in calendar year 2021 demonstrated progress beyond the category for *occurrence* and estimated the *exposure* of animals to mid-frequency active sonar (MFAS) and explosives, assessed animals' *responses* to underwater noise generated by U.S. Navy training and testing activities, and continued to make strides toward assessing any population *consequences* resulting from these activities by investigating population trends.

U.S. Navy range-specific progress highlights include the following:

MITT

- Concluded a field study, initiated in 2013, of marine turtle abundance and spatial-temporal ecology in the nearshore waters of Saipan, Tinian, and Guam; all satellite tags (n = 111) have ceased transmitting and final tag data processing and analysis are underway.

- The U.S. Navy provided funding for the University of Hawaii Health and Stranding Lab to conduct comprehensive stranding response, necropsy, and cause of death investigations for 24 stranding events that occurred in calendar year 2021, spanning a wide geographical range that includes Guam, American Samoa, and the unincorporated U.S. territory of Wake Island. Funding also supports detailed analysis of diseases such morbillivirus and circovirus, as well as ingestion of marine debris.

- As part of a partnership among federal agencies, the U.S. Navy provided funding for the Mariana Archipelago Cetacean Survey (MACS), a shipboard survey conducted from 3 to 31 May 2021 and 15 June to 14 July 2021 in order to characterize the abundance and distribution, population structure, and habitat preferences of cetaceans and seabirds that occur in the U.S. waters around the Mariana Archipelago.

HSTT HRC

- More than 3,200 hours of recordings collected from 62 bottom-mounted PMRF hydrophones between September 2020 and August 2021 were used to estimate the abundance of baleen, beaked, sperm, and killer whales on the range and to examine responses of three species of BW to MFAS transmission.

- An in-depth noise analysis was conducted on Fiscal Year 2020 data collected at PMRF to investigate the effects of the coronavirus disease 2019 (COVID-19) anthropause, but no clear quieting was found during periods of reduced anthropogenic activity.

- Analysis of Marine Mammal Monitoring on U.S. Navy Ranges (M3R) acoustic data on PMRF collected from 2011 to 2021 indicate Blainville's BW numbers appear to be relatively consistent across years, with seasonal peaks occurring in early May and December; both Blainville's and Cuvier's BWs were detected on the PMRF range year-round, with at least twice as many Blainville's BW group vocal periods (GVPs) detected as Cuvier's BW.

- Fourteen satellite tags were deployed on six odontocete species, including Blainville's BW, at PMRF prior to a Submarine Command Course (SCC) training event in August 2021; data from all tagged individuals overlapped temporally with Phase A of the SCC, and 11 of them overlapped temporally with Phase B of the SCC; some of the tagged individuals remained on or close to PMRF during sonar events.

- Data was synthesized from 27 lookout effectiveness embarks conducted primarily on destroyer-class vessels between 2010 and 2019, generating 716 sighting "trials" of marine mammals for analysis; a new analytical method was developed to estimate the probability of animals approaching the vessel undetected (PrU) by lookouts and to compare results from U.S. Navy lookouts against trained marine mammal observers (MMOs).

HSTT SOCAL

- Data recorded by High-frequency Acoustic Recording Packages (HARPs) deployed at four sites in the Southern California Bight (SCB) from April 2020 to April 2021 were analyzed to characterize the seasonal occurrence and relative abundance of BWs; frequency modulated (FM) echolocation pulses from Cuvier's BWs were regularly detected at all sites; Hubbs' BW and BW43 (thought to be Perrin's BW) FM pulses were also detected intermittently.

- The M3R program conducted an assessment of seasonal and interannual trends in distribution and abundance of Cuvier's BWs at SOAR from 2010 through 2021, and of Blainville's and Cuvier's BWs at PMRF from 2011 through 2021, using the GVPs method.

- As part of an ongoing study of the distribution and demographics of BWs and fin whales within SOCAL, small vessel surveys were conducted in SOAR from 3 September 2021 to 15 November 2021; genetic samples were collected from five Cuvier's BWs and five fin whales; 30 unique Cuvier's BWs were identified from photographs, including two females that were sighted with their first calves in the study. Identification photos of fin whales from directed and opportunistic data collection in 2020, as well as opportunistic collections from earlier years that had not been previously submitted to our catalog, were processed in 2021. This collection brings a US West Coast fin whale catalog to 1,250 individuals, of which 760 have sighting histories in Southern California. Ten genetic samples were collected in 2021, five each from Cuvier's BWs and fin whales.

- Seasonal and interannual variation in the distribution, density, and abundance of cetaceans in SCB was assessed from visual survey data collected during quarterly California Cooperative Oceanic Fisheries Investigations (CalCOFI) cruises from 2004 to 2021; abundance and density estimates were developed for blue, fin, humpback, and gray whales; bottlenose, Risso's, Pacific white-sided, and common dolphins; and Dall's porpoise.

- An expedition was conducted to relocate the unknown species of BWs encountered in 2020 and identify the species that produces BW43 calls; although these target species were not located, an apparent BW hotspot was discovered in nearshore waters off Baja California, Mexico during the search.

NWTT

- As part of an ongoing study investigating the ocean distribution of salmonids in the NWTT, genetic samples from Chinook salmon tagged along the coast of Washington State between 2019 and 2021 were analyzed to determine stock identification; acoustic tags (n = 86) and pop-up satellite archival tags (PSATs) (n = 14) were also deployed on female steelhead kelts in Willapa Bay, Washington, in February 2021 and resulting acoustic detections were analyzed to characterize their spatial distribution.

- In order to characterize the distribution of two distinct populations of green sturgeon in and near the NWTT, 110 acoustically tagged green sturgeon from a collaborative agency effort were tracked in 2020 and 2021 on over 100 acoustic receivers in the coastal waters of Washington and British Columbia. Genetic samples were analyzed from 188 green sturgeon fin clips in order to assign individuals to the Northern or Southern (ESA-listed) Distinct Population Segments (DPS).

- Five autonomous acoustic recorders deployed in and near the NWTT were successfully recovered and redeployed in 2021; acoustic data from previous deployments (2019–2020) were analyzed for SRKW detections. An increase in detections from the Juan de Fuca recording site suggests a shift in seasonal distribution.

GOA TMAA

- PSATs were deployed on Chinook salmon in the GOA to characterize their horizontal and vertical distribution, habitat use, natural mortality of tagged individuals, and occupancy in the TMAA; tissue samples were also collected for genetic analysis to determine stock-of-origin for each tagged fish.

- As part of a partnership among federal agencies to conduct Multispecies Cetacean and Ecosystem Assessment Surveys (MCEAS), the U.S. Navy provided funding for the Pacific Marine Assessment Program for Protected Species (PacMAPPS) survey, conducted in GOA from 1 to 26 August 2021; survey goals included estimation of cetacean abundance and population trends, delineation of stock structure, and development of habitat density models in a changing environment. North Pacific right whales were detected two times.

- As part of an ongoing study of ESA-listed salmonid distribution in and near GOA TMAA, 68 Chinook salmon were implanted with acoustic tags near Yakutat, Alaska (n = 32), in March 2021 and near Chignik, Alaska (n = 36), in August 2021.

Chinook salmon tagged and released with a pop-up satellite archival tag near Chignik Bay, Alaska. Research activities were conducted under the University of Alaska Fairbanks Institutional Animal Care and Use Committee assurance 495247 and State of Alaska Aquatic Resource Permits CF-20-039, CF-21-027, and CF-21-085. Photo credit: Michael Courtney.

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Acronyms and Abbreviations

ADCP	Acoustic Doppler Current Profiler
Argos	Advanced Research and Global Observation Satellite
ATN	Animal Tracking Network
BO	Biological Opinion
BSS	Beaufort sea state
BW	beaked whale
BWB	BW Baja
BWCV	beaked whale circovirus
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CeMV	cetacean morbillivirus
CFC	Conceptual Framework Category
CI	confidence interval
cm	centimeter
COVD-19	Coronavirus disease 2019
CRC	Cascadia Research Collective
CREEM	Centre for Research into Ecological and Environmental Modelling
CSIA-AAs	Compound Specific Isotope Analysis of Amino Acids
CSM	Cross Seamount
CTD	Conductivity, Temperature, and Depth
CY	calendar year
d	day
dB re 1µPa	decibel(s) referenced to 1 microPascal
DDG	guided missile destroyer
DELTS	deformities, erosion, lesions, and tags
DEMVAL	Demonstration-Validation
DIFAR	Directional Fixing and Ranging
DNA	deoxyribonucleic acid
DoN	Department of the Navy
DPS	Distinct Population Segment
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FM	frequency-modulated
FY	fiscal year
GOA	Gulf of Alaska
GPS	Global Positioning System
GSI	Genetic stock identification
GVP	group vocal period
HARP	High-frequency Acoustic Recording Package
HMM	Hidden Markov Models
hr	hour(s)
HRC	Hawaii Range Complex
HSTT	Hawaii-Southern California Training and Testing
Hz	Hertz
ICMP	Integrated Comprehensive Monitoring Program
ISO	Intermediate Scientific Objective(s)
kHz	kilohertz
km	kilometer(s)
kt	knot(s)
LIMPET	Low Impact Minimally Percutaneous Electronic Transmitter
LO	location-only
LOA	Letters of Authorization
LT	lookout team
m	meter(s)
M3R	Marine Mammal Monitoring on U.S. Navy Ranges
MACS	Mariana Archipelago Cetacean Survey
MarEcoTel	Marine Ecology and Telemetry Research
MCEAS	Multispecies Cetacean and Ecosystem Assessment Surveys
MFAS	mid-frequency active sonar
MIRC	Mariana Islands Range Complex
MITT	Mariana Islands Training and Testing
MMO	marine mammal observer
MMPA	Marine Mammal Protection Act
MTBAP	Marine Turtle Biology and Assessment Program
NARWHAL	Navy Acoustic Range Whale Analysis
nm	nautical mile(s)
NMFS	National Marine Fisheries Service
NUWC	Naval Undersea Warfare Center
NWTRC	Northwest Training Range Complex
NWTT	Northwest Training and Testing
OEIS	Overseas Environmental Impact Statement
ONR	Office of Naval Research
PacMAPPS	Pacific Marine Assessment Program for Protected Species
PAM	passive acoustic monitoring
PARR	Public Access to Research Results
PCoD	Population Consequences of Disturbance
PCR	polymerase chain reactions
photo-ID	photo-identification
PIFSC	Pacific Islands Fisheries Science Center
PIT	Passive Integrated Transponders
PMRF	Pacific Missile Range Facility
PrU	probability of remaining undetected
PSAT	Pop-up Satellite Archival Tag
RHIB	rigid-hulled inflatable boat
RL	received level(s)
s	second(s)
SCB	Southern California Bight
SCC	Submarine Command Course
SDA	Speed-Distance-Angle
SIO	Scripps Institution of Oceanography
SNP	single nucleotide polymorphism
SOAR	Southern California Offshore Antisubmarine Warfare Range
SOCAL	Southern California Range Complex
SPOT	smart position and temperature
SRKW	Southern Resident Killer Whale
SSC Pacific	Space and Naval Warfare Systems Center Pacific (now NIWC Pacific)
TMAA	Temporary Maritime Activities Area
TP	Trophic Position
U.S.	United States
WARP	Whale Acoustic Reconnaissance Project
WDFW	Washington Department of Fish and Wildlife

1 Introduction

The United States (U.S.) Navy conducts training and testing activities in the Pacific study areas described in the following Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) documents: Hawaii-Southern California Training and Testing (HSTT) (Department of the Navy [DoN] 2018a), Mariana Islands Training and Testing (MITT) (DoN 2020b), Northwest Training and Testing (NWTT) (DoN 2020c), and the Gulf of Alaska (GOA) Navy Training Activities (DoN 2016a, 2020a).

The U.S. Navy training and testing ranges covered by these documents include the Hawaii Range Complex (HRC) and Southern California Range Complex (SOCAL), which are part of the HSTT Study Area; the Mariana Islands Range Complex (MIRC), which is part of the MITT Study Area; Northwest Training Range Complex (NWTRC), including the Naval Sea Systems Command's Naval Undersea Warfare Center Keyport Range Complex (Keyport Range Complex), which is part of the NWTT Study Area, and the GOA Temporary Maritime Activities Area (TMAA).

To authorize these actions, the National Marine Fisheries Service (NMFS) under the Marine Mammal Protection Act (MMPA) issued Final Rules for HSTT (NMFS 2018a, 2020j), MITT (NMFS 2020g), NWTT (NMFS 2020d), and GOA TMAA (NMFS 2017b); Letters of Authorization (LOA) under the MMPA to Commander, U.S. Pacific Fleet and Commander, Naval Sea Systems Command for HSTT (NMFS 2018c, 2018d, 2020h, 2020i), MITT (NMFS 2016, 2020f), NWTT (NMFS 2020b, 2020c), and GOA TMAA (NMFS 2017a); and Biological Opinions (BOs) under the Endangered Species Act (ESA) for HSTT (NMFS 2018b), MITT (NMFS 2017d, 2020e), NWTT (NMFS 2020a), and the GOA TMAA (NMFS 2017c).

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 Code of Federal Regulations § 218.75(d) (HSTT), § 218.95(d) (MITT), § 218.145(d) (NWTT), and § 218.155(f) (GOA TMAA). Monitoring results from all Pacific U.S. Navy ranges, (i.e., HRC, SOCAL, MIRC, NWTRC, 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 seventh such "Multi-Range"-Complex Annual Monitoring Report (see DoN 2016b, 2017, 2018b, 2019, 2020d, 2021). Monitoring at each range complex is coordinated under the U.S. Navy's Integrated Comprehensive Monitoring Program (ICMP)[1] (DoN 2010). Results from this report are intended to iteratively inform future cycles of the ICMP, Adaptive Management Review, and Strategic Planning Processes; and provide a comprehensive view of marine species monitoring in the Pacific Ocean

[1] The U.S. Navy's ICMP (DoN 2010) provides the overarching framework for coordination of the U.S. Navy's Marine Species Monitoring Program efforts and serves as a planning tool to focus U.S. Navy monitoring priorities pursuant to ESA and MMPA requirements. The purpose of the ICMP 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 ICMP does not identify specific fieldwork 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.

during this reporting period. Additional information about the ICMP and Strategic Planning Process is available on the U.S. Navy's Marine Species Monitoring Program website at:

https://www.navymarinespeciesmonitoring.us/reading-room/program-workshop/

Prior-year reports and associated publications are available on the U.S. Navy's Marine Species Monitoring Program website at:

https://www.navymarinespeciesmonitoring.us/reporting/pacific/

This monitoring report was prepared in accordance with the annual monitoring reporting requirements, and presents results and progress made during the period from 1 January 2021 to 31 December 2021, with some variation in reporting period.

Marine species monitoring was conducted in accordance with project objectives listed on the U.S. Navy's Marine Species Monitoring Program website at:

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

Section 2 of this report summarizes monitoring results with additional data and information in the bullets below:

- Detailed technical reports for the individual marine species monitoring projects are provided as supporting documents to this report (Baird et al. 2022; Crance et al. 2022; DiMarzio et al. 2022; Gaos and Martin 2022; Hanson et al. 2022; Heironimus et al. 2022; Henderson et al. 2022; Martin et al. 2022; Oedekoven and Thomas 2022; Rice et al. 2022; Schorr et al. 2022; Seitz and Courtney 2022; Smith and Huff 2022; West et al. 2022a, 2022b, 2022c; and Yano et al. 2022).

- Abstracts and executive summaries from the 2021 technical reports are in **Appendix A**.

- 2021 publications and conference presentations from U.S. Navy-funded monitoring are listed in **Appendix B** by author last name.

- Details of 2022 monitoring projects are in **Appendix C**.

- Animal telemetry tag types used in these projects are in **Appendix D**.

2 Marine Species Monitoring in the Pacific

2.1 2021 Monitoring Goals and Implementation

The U.S. Navy training and testing ranges in the Pacific are located in the HSTT Study Area, MITT Study Area, NWTT Study Area, and GOA TMAA. The ranges vary in terms of monitoring goals implemented for protected marine species, including marine mammals, sea turtles, and ESA-listed fish in support of each study area's MMPA and ESA requirements (NMFS 2016, 2017a, 2017b, 2017c, 2017d, 2018a, 2018b, 2018c, 2018d, 2020a, 2020b, 2020c, 2020d, 2020e, 2020f, 2020g, 2020h, 2020i, 2020j).

Figures 1 and **2** provide an overview of all marine species monitoring projects and goals across all the Pacific ranges. **Figure 1** shows the distribution of monitoring questions and study objectives with respect to monitoring projects and Conceptual Framework Categories (CFC) (i.e., *occurrence, exposure, response, consequences*) (DoN 2010), as well as illustrates which Intermediate Scientific Objectives (ISOs) are addressed by each monitoring project. **Figure 2** illustrates the relative number of monitoring questions associated with each CFC, and how this varies by U.S. Navy range.

Following advancements in methodology made through investments by the Office of Naval Research (ONR) and others, the compliance monitoring programs continue to invest in the CFC co*nsequences*. One monitoring question each for HRC and SOCAL projects was related to population trends of species at range complexes, shown in **Figure 2** under *consequences*.

Current monitoring goals are framed in terms of progress made on scientific monitoring questions and ISOs and are shown paired with cumulative accomplishments in **Table 1**. Project accomplishments are shown for the current year (2021) as well as one year prior (2020). Readers may refer to DoN (2021: **Table 1**) for additional project accomplishments from previous years.

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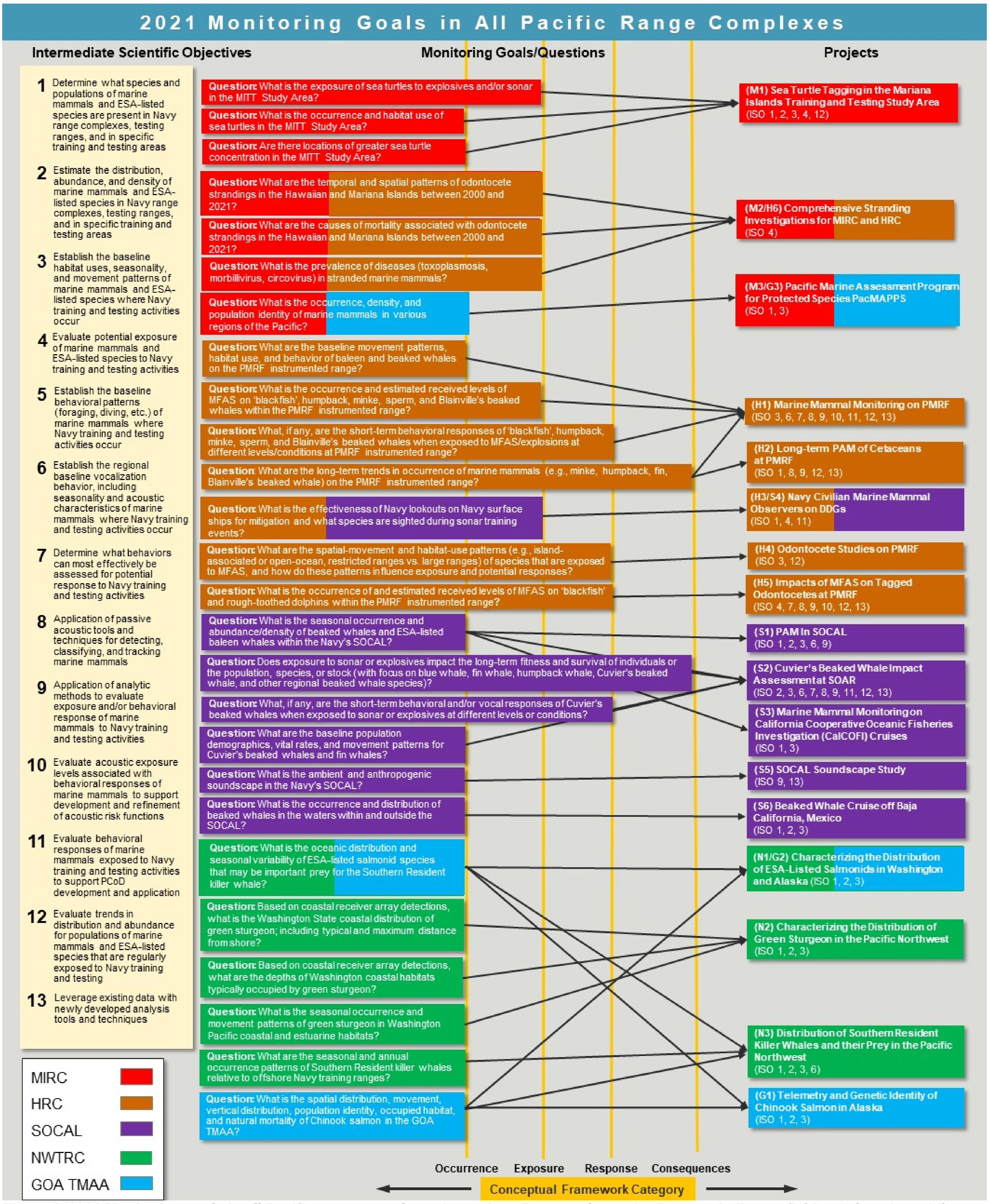

Figure 1. 2021 Monitoring goals in all Pacific range complexes by project. Range color under Projects indicates fieldwork location while under Monitoring Goals/Questions indicates where the questions are being addressed.

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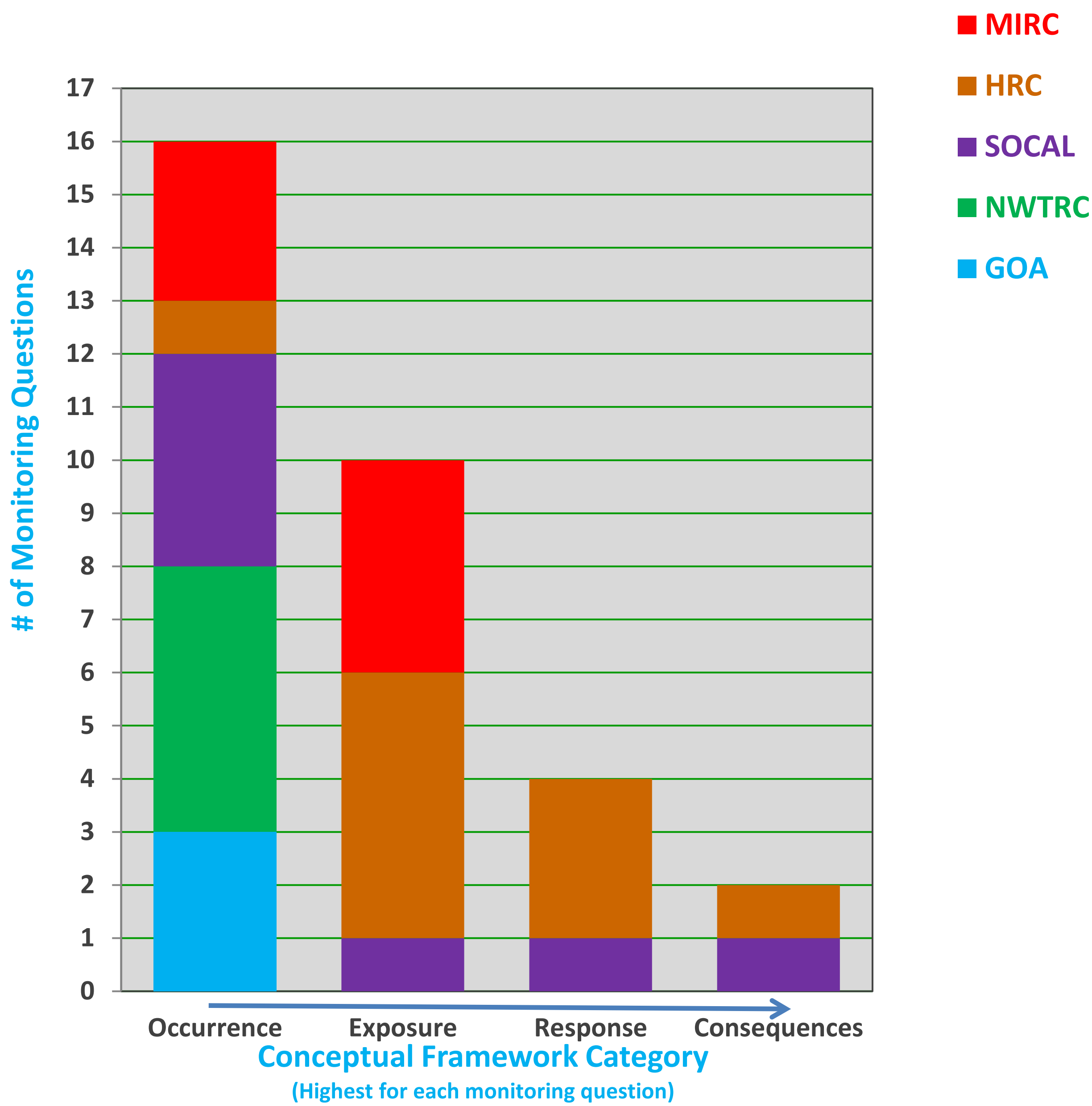

Figure 2. Number of monitoring questions and goals in all U.S. Navy Pacific range complexes that address the four progressive Conceptual Framework Categories for monitoring knowledge outlined by the Scientific Advisory Group. Additional U.S. Navy-funded effort under Response (not represented here) has been conducted in HRC and SOCAL under the Office of Naval Research Marine Mammal and Biology and Living Marine Resources programs.

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Table 1. Monitoring goals and accomplishments for U.S. Navy training study areas/ranges in 2020 and 2021.

Project (Technical Report for 2021)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 1)	Monitoring Questions	Accomplishments[1]
MITT				
[M1] Sea Turtle Tagging in the Mariana Islands Training and Testing Study Area (Gaos and Martin 2022)	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 ESA-listed species in Navy range complexes, testing ranges, and in specific training and testing areas. #3: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species where Navy training and testing activities occur. #4: Evaluate potential exposure of marine mammals and ESA-listed species 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.	• 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 sea turtle concentration in the MITT Study Area?	In 2021: • All satellite tags (n = 111) deployed as part of this study, which initiated in 2013, have ceased transmitting, and final tag data analysis is underway (Gaos and Martin 2022). • Analyzed data from dozens of turtles equipped with satellite tags just outside Apra Harbor and found core and home range areas did not overlap with U.S. Navy underwater detonation areas, although some turtles are spending significant amounts of time within 1−2 km of these sites. • Analyzed data from previous boat-based snorkel surveys and aerial surveys to identify areas of high sea turtle density in Guam, Saipan, and Tinian. • Effort is underway to facilitate the satellite tag data processing steps for efficiently assessing mapping migrations and home ranges, and evaluating dive parameters (i.e., time at depth, maximum dive depth, time at temperature, dive duration). In 2020: • The COVID-19 pandemic prevented fieldwork from occurring. Instead, effort was focused on creating a web project within the ATN and formatting existing archived data for upload, advancing the project toward fulfilling its PARR requirements.
[M2/H6] Comprehensive Stranding Investigations for MIRC and HRC (West et al. 2022a, 2022b, 2022c) This project is also a component of HRC [H6].	Exposure	#4: Evaluate potential exposure of marine mammals and ESA-listed species to Navy training and testing activities.	• What are the temporal and spatial patterns of odontocete strandings in the Hawaiian and Mariana Islands between 2009 and 2021? • What are the causes of mortality associated with odontocete strandings in the Hawaiian and Mariana Islands between 2009 and 2021? • What is the prevalence of diseases (toxoplasmosis, morbillivirus, circovirus) in stranded marine mammals?	In 2021: • Conducted stranding response, necropsy, and cause of death investigations for 24 stranding events that occurred in CY 2021, spanning a wide geographical range that includes four of the main Hawaiian Islands (Hawaii, Oahu, Maui, and Kauai), the northwestern Hawaiian Islands (Pearl and Hermes Atoll), the U.S. Island territories of Guam and American Samoa, and the unincorporated U.S. territory of Wake Island (West et al. 2022a). • Sample collections confirmed 10 different cetacean species and included newborn calves, juveniles, sexually mature males and females, and pregnant and lactating females (West et al. 2022a). • Calculated amino acid values from six stranded or bycaught false killer whales in the Hawaiian Islands between 2010 and 2019, revealing an average TP of 4.82, which is considered high and will further help assess dietary patterns and contaminant burdens (West et al. 2022a). • Removed significant masses of marine debris from the stomachs of three necropsied pilot whales that stranded between 2014 and 2017, with monofilament and multifilament line dominating (West et al. 2022a). • Genetic sequencing results revealed that 17 of 22 (77.3%) stranded *Kogia* specimens were confirmed as the same species originally identified morphologically, of which four (18.2%) were only identifiable as *Kogia* spp. • All 35 stranded marine mammal cases suspected of infectious disease that were tested showed negative results for *Taxoplasma gondii* (West et al. 2022b). • Examined a total of 90 tissue samples from 21 stranded marine mammals resulting in 13 (61.9%) testing positive for *Brucella* spp. (West et al. 2022b). • Tested archived tissues from individuals stranded between 2000 and 2021 (n = 20) by PCR for the presence of Beaked Whale Circovirus (BWCV) (West et al. 2022c). • BWCV represents an emergent disease with unknown population impacts; now includes dwarf sperm whale as a new host species and expands the geographic range to Saipan in the Western Pacific and American Samoa in the South Pacific based on stranded Cuvier's BWs (West et al. 2022c). • Determined the length of time following death of a marine mammal that could be successfully tested by PCR for *T. gondii* (the parasite responsible for fatal toxoplasmosis) to be 2 weeks, with no successful detection after 28 days of degradation (West et al. 2022c).

Project (Technical Report for 2021)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 1)	Monitoring Questions	Accomplishments[1]
MITT (continued)				
[M2/H6] (continued)	See above	See above	See above	In 2020: • Made progress in developing an operational in-house PCR laboratory to screen for known pathogens of concern and the development of tooth aging capabilities. • Conducted PCR screening on archived tissues representing 20 stranded individuals (six different species) for circovirus, an emerging disease in cetaceans, with 35% of suspected samples testing positive. • A DNA degradation tool to quantitatively estimate the actual day of death in stranded specimens that were not fresh dead at the time of stranding discovery was successfully doubled from 14 to 28 days postmortem with a significant linear relationship ($r^2 = 0.76$) in degradation rate. • Aged a stranded false killer whale using newly developed techniques and validated the result. • Responded to, conducted comprehensive investigations, and collected samples from strandings in Hawaii, Guam, Commonwealth of the Northern Mariana Islands, and other Pacific Islands. Earbone samples were sent for analysis of potential acoustic impacts.
[M3/G3] Pacific Marine Assessment Program for Protected Species (PacMAPPS) (Yano et al. 2022) PACMAPPS was also conducted in GOA TMAA [G3].	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: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species where Navy training and testing activities occur.	• What is the occurrence, density, and population identity of marine mammals in various regions of the Pacific?	In 2021: • Conducted two shipboard visual and PAM surveys for cetaceans and seabirds in U.S. waters around the Mariana Archipelago from 3 to 31 May 2021 and 15 June to 14 July 2021 (Yano et al. 2022). • Surveyed approximately 8,700 km of on-effort trackline during 57 of 59 days-at-sea with 77 cetacean sightings, including at least 16 species with sperm whales (n = 18), false killer whales (n = 10), and pantropical spotted dolphins (n = 8) being the most frequently sighted, and two tissue samples collected from the ship during two sightings of false killer whales (no small boat was launched). • Deployed a total of 15 sonobuoys during baleen whale sightings (to assist with visual species identification), and 22 DASBRs were recovered for further processing to determine species presence away from the boat. Acoustic detections were made on 245 separate cetacean groups (47 linked to visually sighted groups). Baleen whale detections included a single humpback whale and three Bryde's whales.

Project (Technical report for 2021)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 1)	Monitoring Questions	Accomplishments[1]
HRC				
[H1] Marine Mammal Monitoring on PMRF (Martin et al. 2022)	Occurrence, Exposure, Response, Consequences	#3: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species 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 is the occurrence and estimated received levels of MFAS on 'blackfish', humpback, minke, sperm, and Blainville's beaked whales within the PMRF instrumented range? • What, if any, are the short-term behavioral responses of 'blackfish,' humpback, minke, sperm, and Blainville's beaked whales when exposed to MFAS/explosions at different levels/conditions at PMRF instrumented range? • What are the baseline movement patterns, habitat use, and behavior of baleen and beaked whales on the PMRF instrumented range? • What are the long-term trends in occurrence of marine mammals (e.g., minke, humpback, fin, Bryde's, Blainville's) on the PMRF instrumented range?	In 2021: • An in-depth noise analysis was conducted on FY20 data to investigate the COVID-19 anthropause, but no clear quieting of anthropogenic noise was found during periods of reduced anthropogenic activity (Martin et al 2022). • Over 3,200 hr of new acoustic data were collected from 4 September 2020 through 26 August 2021, with a gap in data collection between March and June 2021 due to failure of the legacy recorder. • These data were used to generate cetacean abundance estimates for PMRF for the following species: humpback whales, Bryde's whales, fin whales, and blue whales, Blainville's BW, Cuvier's BWs, BWC, sperm whales, and killer whales. • A detailed investigation of individual tracks from previous minke whale abundance results determined that the probability that a rapid call rate would occur increased as the distance to the nearest minke whale decreased. • HMMs were developed to examine movement behavior during the different phases of the SCC training events using new statistical models developed by collaborators at the University of St. Andrews CREEM. • Conducted disturbance analyses on three species of BW (Blainville's, BWC, and Cuvier's) and all demonstrated reduced GVPs during the various SCC training phases with and without MFAS, and a return to foraging behavior after the training. • A collaboration with NUWC Division Newport led to the adaptation and application of the NARWHAL detection, classification, localization, tracking, and noise analysis algorithms on data from SOAR. • Published five and submitted two manuscripts based on these collected data (see Appendix B). In 2020: • Collected a total of 2,972.2 hr of recordings from 62 bottom-mounted PMRF hydrophones at sample rates of 96 and 6 kHz between September 2019 and September 2020, including a spring 2020 recording to capture any potential changes in acoustics related to the COVID-19 pandemic. • Abundance results for baleen whales, using the maximum number of individuals detected within 10-minute snapshot periods, revealed a maximum of four minke whales in February 2020, three humpback whales in March 2020, and three tracks from the LF baleen whales in January and February 2020. • Used spectral correlation call templates to attribute calls from acoustic tracks to fin, Bryde's, and a 40 Hz down sweep call type (potentially from fin and/or sei whales). • Estimated abundance results for odontocetes between September 2019 and September 2020 using a maximum number of dives per hr and included Blainville's (4.4; October 2019), CSM (0.45; May 2020), and Cuvier's BWs (0.19; May 2020). There was a maximum of four sperm whale tracks detected in a 10-minute snapshot period in April 2020. • Detected a Longman's BW in September 2019. • Performed a disturbance analysis for minke whales and Blainville's BWs during the February and August 2020 SCC training events within PMRF; Blainville's BWs demonstrated a reduction in the number of dives per hr before a phase of MFAS transmissions and an increase in dives per hr following the MFAS transmissions. • Investigated the Lombard effect in humpback whales and results were published by Guazzo et al. (2020). • Continued the E-BREVE modeling efforts, which revealed different suites of environmental parameters associated with the presence of each species (humpback, minke, and fin whale) that could potentially be used to predict future occurrence patterns in Hawaii. • Presented findings from this project at the Ocean Sciences Meeting. • Published three manuscripts in Frontiers in Marine Science, "Fin whale song patterns shift over time in the Central North Pacific" (Helble et al. 2020b), the Journal Of the Acoustical Society of America, "Lombard effect: minke whale boing call source levels vary with natural variations in ocean noise" (Helble et al. 2020a), and in Aquatic Mammals, "Changes in the spatial distribution of acoustically-derived minke whale (*Balaenoptera acutorostrata*) tracks in response to navy training" (Harris et al. 2020).

Project (Technical report for 2021)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 1)	Monitoring Questions	Accomplishments[1]
HRC (continued)				
[H2] Long-term Passive Acoustic Monitoring of Cetaceans at PMRF and SOAR (DiMarzio et al. 2022) This is a joint project with [H4] "Odontocete Studies on PMRF" and [S2] "Cuvier's Beaked Whale Impact Assessment at SOAR."	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 instrumented range?	In 2021: • Assessed seasonal and interannual trends in distribution and abundance of Cuvier's BWs at SOAR and Blainville's and Cuvier's BWs at PMRF using the GVPs method (DiMarzio et al 2022). • Results indicated a clear seasonal pattern of Cuvier's BW distribution at SOAR, peaking in May and December/January; preliminary results also indicated a slight decreasing trend from 2010 through 2021 for the number of Cuvier's BWs present at SOAR, although this has not yet been statistically verified. • Blainville's and Cuvier's BWs were found to be present on the PMRF range year-round, with at least twice as many Blainville's BW GVPs detected as Cuvier's BW. • Blainville's BW GVPs at PMRF have remained relatively stable from 2011 through 2021. • Conducted a field test in August 2021 with CRC. Logged 197 acoustic detections at PMRF, of which 22 were directed, and 14 were visually verified. • Identified steps that can be taken to improve M3R's real-time LF tracks. • Although M3R's LF localization routine can effectively localize calls from several baleen species, it was determined that better solutions exist for differentiating between calls from different species by adding dedicated detector-classifier capability for LF calls. • Validated the sprinkle analysis method as a relatively straightforward way for representing temporal and spatial variation in ambient noise levels on the ranges over time, which could provide useful information for environmental analysis, the development of detectors, and acoustic effects models. • Conducted two field tests in October 2020 and September 2021 on SOAR in coordination with MarEcoTel (see **Project [S2]**). • Logged a total of 146 acoustic detections, including 89 of Cuvier's BWs, 13 of fin whales, two of blue whales, one of common dolphins, 38 of unidentified dolphins, and three of unidentified baleen whales. Among 22 groups of Cuvier's BWs and nine groups of fin whales to which MarEcoTel was directed, they visually verified two and four, respectively. In 2020: • Results from PMRF appear to be relatively consistent over the past 6 years (2015–2020), with peaks in January, December, and June, and the lowest numbers detected in September. • Observed changes in vocalizations for Cuvier's and Blainvillle's BWs consistently with exposure to two sources of MFAS (hull-mounted and dipping sonar). • An evaluation of the Autogrouper algorithm determined that only about one-third of the Blainville's BW groups at PMRF are accurately detected; provided the detection statistics and correction factors are appropriately applied to the data, the correct abundance values should be recovered. A new version of Autogrouper is currently being developed. • M3R conducted one field test in conjunction with CRC in February 2020 at PMRF (see **Project [H4]**). Of the acoustic sightings, 25 were directed, and eight were visually verified.
[H3/S4] Navy Civilian Marine Mammal Observers on DDGs (Oedekoven and Thomas 2022) This project is also a component of SOCAL, [S4].	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. #4: Evaluate potential exposure of marine mammals and ESA-listed species 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.	• What is the effectiveness of Navy lookouts on Navy surface ships for mitigation and what species are sighted during sonar training events?	In 2021: • Developed a new analytical method that allows the estimation of the probability of animals approaching to within a specified mitigation range without being detected (PrU) and compared Navy lookouts trained to detect marine mammals against trained MMOs. • Conducted a total of 27 cruises between 2010 and 2019, mostly on destroyer class vessels, generating 716 sighting "trials" of marine mammals for analysis. (Oedoekoven and Thomas 2022) • Conducted final comprehensive analysis and prepared final project report (Oedoekoven and Thomas 2022). • The probability of cetaceans remaining undetected by the LT was higher than the MMO. • The probability of small cetaceans, particularly in small groups, remaining undetected was higher than for large cetaceans for both LT and MMO. In 2020: • Final analysis and results of the U.S. Navy-wide lookout effectiveness study is expected by the end of 2021.

Project (Technical report for 2021)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 1)	Monitoring Questions	Accomplishments[1]
HRC (continued)				
[H4] Odontocete Studies on PMRF (Baird et al. 2022) Tag telemetry data collected was also used in Project [H5]. This project is conducted in conjunction with Project [H2].	Occurrence, Exposure, Response	#3: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species 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 2021: • Encountered a group of approximately 24 Fraser's dolphins for the first time in more than 13 prior years of research (Baird et al. 2022). • Obtained four genetic samples from a Blainville's BW and a melon-headed whale, and two from false killer whales. • Deployed a total of 14 satellite tags on six different species, including 12 depth-transmitting SPLASH10-F (Fastloc®-GPS) tags, one LO SPOT6 tag, and one depth-transmitting SPLASH10 tag. • Published two manuscripts in Marine Mammal Science, "Diel and lunar variation in diving behavior of rough-toothed dolphins (*Steno bredanensis*) off Kaua'i, Hawai'i" (Shaff and Baird 2021), and "Site fidelity, spatial use, and behavior of dwarf sperm whales in Hawaiian waters: using small-boat surveys, photo-ID, and unmanned aerial systems to study a difficult-to-study species" (Baird et al. 2021b); and one to Biological Conservation, "Bringing the right fishermen to the table: indices of overlap between endangered false killer whales and nearshore fisheries in Hawai'i" (Baird et al. 2021a). In 2020: • Deployed a tag on a short-finned pilot whale that remained in deep water far offshore in the area where the SCC took place over the 16-day period of transmission, and two tags were deployed on bottlenose dolphins, known to be part of the Kauai and Niihau community, providing location and behavioral data for 13.9 and 20 days. • Encountered a group of pygmy killer whales adding 15 new individuals to the catalog. • Identified core areas (50% kernel densities) for the resident population of bottlenose dolphins and the western community of short-finned pilot whales; different proportions of the respective core areas overlapped with PMRF, suggesting exposure to MFAS is likely but the extent is dependent on species. • Published data collected during Navy funded surveys was used in Fisheries Research, "Using dolphins to catch tuna: assessment of associations between pantropical spotted dolphins and yellowfin tuna hook and line fisheries in Hawai'i" (Baird and Webster 2020), and Science of the Total Environment, "Life history and social structure as drivers of persistent organic pollutant levels and stable isotopes in Hawaiian false killer whales (*Pseudorca crassidens*)" (Kratofil et al. 2020).
[H5] Impacts of MFAS on Tagged Odontocetes at PMRF	Exposure, Response	#4: Evaluate potential exposure of marine mammals and ESA-listed species to Navy training and testing activities. #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 of and estimated received levels of MFAS on 'blackfish' and rough-toothed dolphins within the PMRF instrumented range?	In 2021: • Data analysis for this project is ongoing, although a report for CY 2021 is not available. In 2020: • Upgraded analytical methods were applied to previously analyzed and newly deployed satellite tags to quantify the movement and diving behavior of tagged odontocetes before, during, and after SCC training events at PMRF off Kauai, Hawaii, as well as their exposure and potential response to MFAS during these events. • Tagged nine pilot whales, four rough-toothed dolphins, and two bottlenose dolphins between February 2014 and February 2020. Eleven of these tags had previously been analyzed with a simpler two-dimensional model for RL and were re-analyzed with the new three-dimensional model with 95% confidence level error ellipses. • Examined movement and dive behavior of the tagged odontocetes relative to the before, during Phase A (ships but no MFAS), between phases, during Phase B (with MFAS), and after (when all of those periods were available). Movement and dive behavior were also examined in the context of normal patterns, including diel and lunar cycles, in order to put the context of any potential response into a framework of baseline variability. • While there were statistical differences in dive behavior of all three species across the periods of the SCC, there were no consistent patterns that appeared to indicate broad, sustained responses to MFAS (e.g., large-scale habitat abandonment). There were often inter-individual differences in how the dive behavior changed across periods, and in many cases the differences in dive behavior seemed more related to the lunar cycle than to training activity. • The highest median RLs in close exposure cases were approximately 175 dB re 1µPa, the median levels plus two standard deviations were around 195 dB re 1µPa, and maximum modeled levels exceeded 200 dB re 1µPa. The probability of reaching these maximum levels is quite low but indicate that in some cases odontocetes at PMRF may be exposed to high RLs.

Project (Technical report for 2021)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 1)	Monitoring Questions	Accomplishments[1]
HRC (continued)				
[H6/M2] Comprehensive Stranding Investigations for MIRC and HRC (West et al. 2022a, 2022b, 2002c) This project is also a component of MIRC [M2].	*See Project M2/H6 (above, in MIRC)*			
SOCAL				
[S1] Passive Acoustic Monitoring in SOCAL (Rice et al. 2022)	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 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. #6: Establish the regional baseline vocalization behavior, including seasonality and acoustic characteristics of marine mammals where Navy training and testing activities occur. #9: Application of analytic methods to evaluate exposure and/or behavioral response of marine mammals to Navy training and testing activities.	• What is the seasonal occurrence and abundance/density of beaked whales within the Navy's SOCAL?	In 2021: • Analyzed data recorded by HARPs deployed at sites E, H, N, and U (west and southwest of SCI) from April 2020 to April 2021 (Rice et al. 2022) to characterize the seasonal occurrence and relative abundance of BWs. • FM echolocation pulses from Cuvier's BWs were regularly detected at all sites, but were detected in higher numbers at sites E and H. • At Site E, Cuvier's BW detections were highest in December 2020, but at Site H they peaked in October and November 2020. • Hubbs' BW FM pulses (previously referred to as BW37V; Rice et al. 2021) were only detected at Site H in November 2020 and January 2021. • The FM pulse type, BW43, thought to be produced by Perrin's BW (Baumann-Pickering et al. 2014), was detected intermittently at sites H and N, and throughout the recording period at Site U. No other BW signal types were detected. In 2020: • Analyzed data recorded by HARPs deployed at sites E, H, N, and U from November 2018 to May 2020 (Rice et al. 2021) for seasonal occurrence and relative abundance of blue, fin, and BWs; MFAS; and underwater explosions. • Results were generally consistent with previous findings in the southern California region, although the 2020 analysis indicated higher numbers of Cuvier's BWs and BW37V FM pulses at Site H, and the presence of the BW37V signal at Site N. • Sites H and N also had fewer MFAS wave trains and packets normalized per year than in previous monitoring periods.

Project (Technical report for 2021)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 1)	Monitoring Questions	Accomplishments[1]
SOCAL (continued)				
[S2/H2] Cuvier's Beaked Whale Impact Assessment at SOAR (Schorr et al. 2022; DiMarzio et al. 2022) This is a joint project with [H2] "Long-term Passive Acoustic Monitoring of Cetaceans at PMRF".	Occurrence, Exposure, Response, Consequences	#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: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species 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 Cuvier's beaked whales and fin whales? • What, if any, are the short-term behavioral and/or vocal responses of Cuvier's beaked whales when exposed to sonar or explosives at different levels or conditions? • What is the seasonal occurrence and abundance/density of beaked whales and ESA-listed fin whales within the Navy's SOCAL? • Does exposure to sonar or explosives impact the long-term fitness and survival of individuals or the population, species, or stock (with focus fin whale, Cuvier's beaked whale, and other regional beaked whale species)?	In 2021: • Sighted a total of 44 Cuvier's BWs and 67 fin whales during 17 days of survey effort from 3 September 2021 to 15 November 2021. Other efforts were curtailed by COVID-19 and weather (Schorr et al. 2022). • Collected a total of 10 genetic samples five from Cuvier's BWs, and five from fin whales. • Identified a total of 30 unique Cuvier's BWs from photographs: 12 (40%) had previous sighting histories at SOAR, including two females that were sighted with their first calves in the study. • Processed fin whale photographs collected in 2020 (n = 93) and from previous years (n = 201); the fin whale catalog now includes 1,250 individuals, of which 760 have sighting histories in Southern California. • Analyzed Argos location data from 25 Cuvier's BW LIMPET tracks collected in 2020 and 2021 using three data filtering methods (none, DAR filter, and the Freitas SDA filter) and two spatial movement models (CTCRW and continuous time state-spaced model 'foieGras'). The best method appears to be the DAR filter followed by CTCRW. • Compared kernel density home ranges estimated using six combinations of modeling and pre-filtering methods and were assessed for which model estimated locations closer to the Fastloc GPS positions. • Published two manuscripts in The Journal of the Acoustical Society of America, "Recommended snapshot length for acoustic point-transect surveys of intermittently available Cuvier's beaked whales" (Barlow et al. 2021) and "Spatial analysis of beaked whale foraging during two 12 kHz multibeam echosounder surveys" (Varghese et al. 2021). In 2020: • Sighted a total of 15 Cuvier's BWs and 10 fin whales during 11 survey days between 4 January and 8 October 2020 (Schorr et al. 2021). • Photo-IDs from these sightings, plus four whales photographed opportunistically outside of SOAR, yielded 10 unique Cuvier's BWs in 2020; four of these whales were previously identified at SOAR, with sighting histories of up to 11 years, including one mother-calf pair that remained associated 2.5 years after their first sighting together. • Collected three genetic samples in 2020: one from a Cuvier's BW and two from fin whales. • Because the COVID-19 pandemic and associated travel restrictions curtailed field efforts in 2020, some funds were re-allocated from fieldwork to support additional analyses of previously collected data, including 1) an analysis of dive behavior of tagged Risso's dolphins, and 2) an investigation of behavioral responses to sonar in Cuvier's BWs after exposure ceases. • Analysis of Cuvier's dive behavior, using Mahalanobis distance to characterize behavior patterns using a suite of variables, found that some exposure contexts produced changes in behavior that persisted for up to several days after sonar use ceased. • Published manuscripts in Marine Ecology Progress Series, "Variation in dive behavior of Cuvier's beaked whales with seafloor depth, time-of-day, and lunar illumination" (Barlow et al. 2020), Marine Mammal Science, "Abundance, survival, and annual rate of change of Cuvier's BWs (*Ziphius cavirostris*) on a Navy sonar range" (Curtis et al. 2020), and The Journal of the Acoustical Society of America "The effect of two 12 kHz multibeam mapping surveys on the foraging behavior of Cuvier's beaked whales off of southern California" (Varghese et al. 2020). • Results from BW abundance analysis at SOAR confirmed field observations since 2006: that Cuvier's BWs prefer foraging in the western part of the range, likely due to high-quality foraging habitat, despite the presence of sonar (DiMarzio et al. 2021). • Changes in vocalizations for Cuvier's and Blainvillle's BWs were observed consistently with exposure to two sources of MFAS (hull-mounted and dipping sonar). • An evaluation of the M3R LF detector algorithm at SOAR demonstrate that it can effectively localize calls from several baleen species, and the SOAR range is sometimes home to considerable baleen whale call activity. • Results indicate a decreasing trend in the number of Cuvier's baked whale GVPs per hr-hydrophone from 2010 through 2019 on SOAR and an increased trend with increasing water depth, from 1,000 to 1,800 m. • M3R conducted two field tests at SOAR in 2020 in conjunction with MarEcoTel. Of the 144 acoustic sightings logged, there were about 37 cases in which M3R directed MarEcoTel to Cuvier's BWs and five instances of direction to fin whales.

Project (Technical report for 2021)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 1)	Monitoring Questions	Accomplishments[1]
SOCAL (continued)				
[S3] Marine Mammal Monitoring on California Cooperative Oceanic Fisheries Investigation (CalCOFI) Cruises (Rice et al. 2022) [This project was formerly titled "Beaked Whale Occurrence in SOCAL using Towed Array" in 2018 and "Marine Mammal Sightings during CalCOFI Cruises" from 2004-2017].	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: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species where Navy training and testing activities occur.	• What is the seasonal occurrence and abundance/density of marine mammals and ESA-listed baleen whales within the Navy's SOCAL?	In 2021: • Assessed seasonal and interannual variation in the distribution, density, and abundance of cetaceans in the SCB from visual survey data collected during quarterly CalCOFI cruises from 2004 to 2019 (surveys were not conducted on the spring 2010 cruise nor were visual surveys conducted due to COVID-19 related restrictions from spring 2020 through spring 2021) (Rice et al. 2022). • Developed abundance and density estimates for blue, fin, humpback, and gray whales; bottlenose, Risso's, Pacific white-sided, and common dolphins; and Dall's porpoise. • Results indicated that humpback whales, bottlenose dolphins, and common dolphins showed a potential increase in abundance over time in the CalCOFI study area, while Dall's porpoise abundance has declined in recent years. In 2020: • While some CalCOFI cruises occurred, due to restrictions, no MMOs were embarked due to the COVID-19 pandemic.
[S4/H3] Navy Civilian Marine Mammal Observers on DDGs (Oedekoven and Thomas 2022) This project is also a component of HRC [H3].	*See Project H3 (above, in HRC)*			
[S5] SOCAL Soundscape Study (Rice et al. 2022)	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 the Navy's SOCAL?	In 2021: • Analyzed data recorded by HARPs deployed at sites E, H, N, and U (west and southwest of SCI) from April 2020 to April 2021 (Rice et al. 2022) to characterize ambient noise, the presence of MFAS and underwater explosions, and the LF soundscape. • Ambient noise was highest at the westernmost HARP site ("E") likely related to local wind and wave conditions. • MFAS was detected at all sites with peaks in May and November 2020 and in February and April 2021. • Explosions were detected at all sites but were highest in December 2020 and February 2021 at Site H, likely associated with the use of seal bombs. • Regarding the LF soundscape, all sites had higher sound spectrum levels in the LF range due to the dominance of ship noise at frequencies below 100 Hz and local wind and waves above 100 Hz. In 2020: • Analyzed data recorded by HARPs deployed at four sites in the SCB from November 2018 to May 2020 (Rice et al. 2021) to characterize the LF ambient soundscape. • The underwater ambient soundscape at all sites had spectral shapes with higher levels at low frequencies due to the dominance of ship noise at frequencies below 100 Hz and local wind and waves above 100 Hz. • Site H in the San Nicholas Basin generally had lower spectrum levels (less than 100 Hz) compared to the other sites due to its location away from shipping routes. However, spectrum levels below 15 Hz during spring months appear to have been influenced by strumming related to tidal flow. • Increased spectrum levels from approximately 100 to 200 Hz from March through May 2020 at Site H were related to the presence of a fish chorus, and noisy peaks in the spectrum during December 2019 at this site were due to the presence of a ship over the course of several days. • Peaks in sound levels at all sites during fall and winter months were related to the seasonally increased presence of blue whales and fin whales, respectively.

Project (Technical report for 2021)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 1)	Monitoring Questions	Accomplishments[1]
SOCAL (continued)				
[S6] Beaked Whale Cruise off Baja California, Mexico (Henderson et al. 2022)	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 ESA-listed species in Navy range complexes, testing ranges, and in specific training and testing areas. #3: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species where Navy training and testing activities occur.	• What is the occurrence and distribution of beaked whales in the waters within and outside the SOCAL?	In 2021: • As part of a continuing collaborative effort, a vessel survey was conducted off Baja California from 28 October to 9 November 2021; methods included visual surveys and passive acoustic recordings using DASBRs. • Nine BW sightings were recorded, including two identified as Cuvier's BWs; there were no confirmed sightings of BW43 or BWB. • An apparent BW hotspot was discovered in nearshore waters of Baja California, largely defined by bathymetric features. In 2020: • As part of a collaborative effort among Mexican and U.S. researchers, the U.S. Navy, NOAA Fisheries, and the Sea Shepherd Conservation Society, a vessel survey was conducted off Baja California from 15 – 28 November 2020; methods included visual, acoustic, and environmental DNA techniques for detecting and identifying marine mammals. • Although the objective of the survey was to locate and document a species of BW that had previously only been acoustically detected ("BW43"), a previously undescribed species of BW was unexpectedly encountered; visual observations and acoustic data revealed external morphological characteristics and a new echolocation pulse type that did not match any previously observed or recorded species and therefore may represent a newly described species. • In addition to this newly documented species of BW (referred to as "BWB", or BW Baja), acoustic recordings were made of two other species of BW: BW43 and Cuvier's BWs.
NWTT				
[N1/G2] Characterizing the Distribution of ESA-Listed Salmonids in Washington and Alaska (Smith and Huff 2022) This project is also a component of GOA TMAA tagging [G2] and linked to projects [G1] and [N3].	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 ESA-listed species in Navy range complexes, testing ranges, and in specific training and testing areas. #3: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species where Navy training and testing activities occur.	• What is the oceanic distribution and seasonal variability of ESA-listed salmonid species that may be important prey for the Southern Resident killer whale?	In 2021: • Deployed stationary acoustic receivers in February 2021; serviced, downloaded, and redeployed receivers in late spring 2021, and again in September 2021 (Smith and Huff 2022). • Surgically implanted Innovasea V16 acoustic transmitters in Chinook salmon near Yakutat, Alaska (n = 32), in March 2021, and near Chignik, Alaska (n = 36), in August 2021. • Detected a total of 11 Chinook salmon tagged in Kodiak, Alaska, and five tagged in Yakutat, Alaska on acoustic receiver arrays. • Deployed Vemco V9 acoustic tags (n = 86) and PSATs (n = 14) on female steelhead kelts in Willapa, Washington, eight of which have been detected at ocean receivers. • GSI indicated where the fish were originally tagged and their temporal distribution. In 2020: • Stationary acoustic receivers were retrieved, and data was downloaded in March 2020; receivers were not immediately redeployed due to COVID-19 restrictions. • Receivers were redeployed in July 2020 in a new line pattern designed to detect Chinook salmon tagged in Kodiak and Yakutat, Alaska, returning to the Columbia River. • In October 2020, 80 Chinook salmon were tagged with Vemco V16 acoustic tags in Kodiak, Alaska.

Project (Technical report for 2021)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 1)	Monitoring Questions	Accomplishments[1]
NWTT (continued)				
[N2] Characterizing the Distribution of Green Sturgeon in the Pacific Northwest (Heironimus et al. 2022)	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 ESA-listed species in Navy range complexes, testing ranges, and in specific training and testing areas. #3: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species where Navy training and testing activities occur.	• Based on coastal receiver array detections, what is the Washington State coastal distribution of green sturgeon; including typical and maximum distance from shore? • Based on coastal receiver array detections, what are the depths of Washington coastal habitats typically occupied by green sturgeon? • What is the seasonal occurrence and movement patterns of green sturgeon in Washington Pacific coastal and estuarine habitats?	In 2021: • To further the understanding of green sturgeon use of coastal Washington habitats, including in and around the Navy's coastal receiver array, in 2020-2021, the USACE, NOAA, and WDFW acoustically tagged an additional 60 green sturgeon. This increased the total number of acoustically tagged green sturgeon occupying the Navy-funded coastal array to 110 fish (Heironimus et al. 2022). • Detections of green sturgeon on coastal receiver arrays from the Columbia River to Vancouver Island, B.C. and estuarine receivers were analyzed to document habitat utilization by green sturgeon in nearshore marine habitats and seasonal movements between estuaries in the summer and coastal marine habitats from fall to spring. • Detection data was also analyzed for potential migration patterns to northern habitats, as well as whether or not these migrations occurred in the nearshore coastal environment or occurred further west in deeper marine habitats. • SNP assay data for 188 green sturgeon tissue samples collected indicated that the majority of green sturgeon sampled originated from the Northern DPS (n = 134 fish; 71%) relative to the Southern DPS (n = 54 fish; 29%). • Of the total 110 acoustically tagged green sturgeon in 2020 (n = 60) and 2021 (n = 50), 71 (65%) were assigned to the Northern DPS, 38 (35%) to the Southern DPS, and one was not assigned. In 2020: • In August 2020, 60 acoustic transmitters were implanted in green sturgeon captured and released in Grays Harbor and Willapa Bay, Washington (Heironimus et al. 2021). • Nearly all (97%) of the newly tagged fish were detected, and no mortalities were recorded. • Fin-clip samples were analyzed to determine which are from the Northern and which are from the Southern DPS. • Once genetic and acoustic data are complete, the spatial and temporal extent of green sturgeon along the Washington coastline will be evaluated. • Reviewed acoustic detection data collected from 2002 to 2019 for incidence of acoustically tagged green sturgeon in the inland waters of Washington (Puget Sound and the Strait of Juan de Fuca) (Moser et al. 2021). • Searched existing databases (OTN — http://oceantrackingnetwork.org, HYDRA — http://hydra3.sound-data.com) and networking occurred with other sturgeon researchers from Canada to California to ensure the working list of unique green sturgeon tag codes was as complete as possible. • Reviewed historic email correspondence related to Puget Sound receiver deployments to collect any detection data obtained prior to the start date for HYDRA or OTN or obtained from researchers that did not share data on either of these databases. • Analyzed detections of green sturgeon codes for spatial and temporal patterns of occurrence in Puget Sound and the Strait of Juan de Fuca.
[N3] Distribution of Southern Resident Killer Whales and their Prey in the Pacific Northwest (Hanson et al. 2022) This project is linked to projects [G2/N1] and [G1].	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: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species 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 2021: • Retrieved and redeployed five autonomous acoustic recorders (EARs and SoundTraps) in and adjacent to the Navy's NWTRC in Washington State (Hanson et al. 2022). • Analyzed acoustic data from previous deployments (2019–2020) for SRKW detections. • A recent increase in acoustic detections from the Juan de Fuca recording site suggests an increase in SRKW occurrence at the west entrance of the Strait of Juan de Fuca in the summer and fall months. • Gave a presentation at the Acoustical Society of America, "A comparison of EAR and SoundTrap performance for acoustic monitoring of resident killer whales" (Emmons et al. 2021).

Project (Technical report for 2021)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 1)	Monitoring Questions	Accomplishments[1]
GOA TMAA				
[G1] Telemetry and Genetic Identity of Chinook Salmon in Alaska (Seitz and Courtney 2022) This project is linked to projects [G2/N1] and [N3].	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 ESA-listed species in Navy range complexes, testing ranges, and in specific training and testing areas. #3: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species where Navy training and testing activities occur.	• What is the spatial distribution, movement, vertical distribution, population identity, occupied habitat and natural mortality of Chinook salmon in the GOA TMAA?	In 2021: • Tagged a total of 20 immature Chinook salmon with PSATs near Yakutat, Alaska, in March 2021. • Analyzed depth, temperature, location, and light data from 57 of the 60 tags deployed during 2020 and 2021; 30 tags released from live fish on or before the programmed pop-up date, the other 27 tagged fish experienced mortality by predation (n = 21) or unknown causes (n = 6). Deployed tags provided more than 3,720 days of data (Seitz and Courtney 2022). • Reported locations of tags were widespread across the eastern North Pacific Ocean, ranging as far west as the Bering Sea to as far east as the U.S. Pacific Northwest; models suggested that most tagged fish remained over the continental shelf within relatively close proximity (less than 500 km) to their tagging location. • Fifteen tagged individuals were inferred to have occupied the TMAA between tag deployment and pop-up date, for an aggregated total of approximately 252 days. • Tagged Chinook salmon occupied depths ranging from 0 to 464 m and experienced a thermal environment ranging from 1.8 to 19.0°C. • Presented findings from this project at the Alaska Chapter of the American Fisheries Society Annual Meeting and the Alaska Marine Science Symposium. In 2020: • Conducted fish capture by hook and line and attached PSATs to Chinook salmon in marine waters near Chignik (n = 20) and Kodiak (n = 20), Alaska. • Analyzed depth, temperature, and location data collected via the Argos System; 29 tags provided approximately 1,600 days (mean = 55 days per tag) of data. • Preliminary results indicate that 17 tagged fish experienced predation, 12 tags released from fish for unknown reasons (i.e., floaters), and the 11 remaining tags are still attached to Chinook salmon and were scheduled to report to satellites in winter/spring 2021.
[G2/N1] Characterizing the Distribution of ESA-Listed Salmonids in Washington and Alaska (Smith and Huff 2022) This project is also a component of NWTT tagging, [N1] and linked to projects [G1] and [N3].	*See Project N1/G2 (above, in NWTT)*			
[G3/M3] Pacific Marine Assessment Program for Protected Species PacMAPPS (Crance et al. 2022) PACMAPPS was also conducted in MITT [M3].	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: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species where Navy training and testing activities occur.	• What is the occurrence, density, and population identity of marine mammals in various regions of the Pacific?	In 2021: • Conducted a double platform, vessel-based, visual line-transect survey from 1 to 26 August 2021, beginning and ending in Kodiak, Alaska, for purposes of estimating cetacean abundance and trends and developing habitat density models. • Primary species sighted include North Pacific right, fin, humpback, killer, and sperm whales, and Dall's and harbor porpoise (Crance et al. 2022). • Deployed a total of 110 sonobuoys, which recorded the same species as those visually detected as well as seismic airguns and vessel noise. • A long-term bottom mounted passive acoustic recorder mooring was retrieved and redeployed after 1 year of recordings in Barnabas Trough. • Conducted a total of 20 CTD casts, collected 119 nutrient samples, and eight salinity samples. • Sampled sea surface temperature, fluorescence salinity, and wind speed continuously along the survey track.

[1] As per the regulations implementing monitoring reporting requirements (described in Section 1, Introduction), accomplishments from monitoring are reported in a cumulative fashion.
[2] Primary Research & Development and Demonstration-Validation (DEMVAL) investments for tools and techniques were supported by the Office of Naval Research Marine Mammal and Biology and the Living Marine Resource programs.

Key: °C = degrees Celsius; Argos = Advanced Research and Global Observation Satellite; ATN = Animal Telemetry Network; BW = beaked whale; BWB = BW Baja; BWC = beaked whale cross-seamount; BWCV = beaked whale circovirus; CalCOFI = California Cooperative Oceanic Fisheries Investigations; COVID-19 = coronavirus disease 2019; CRC = Cascadia Research Collective; CREEM = Centre for Research into Ecological and Environmental Modelling; CSM = Cross Seamount; CTCRW = Continuous-Time Correlated Random Walk; CTD = Conductivity, Temperature, and Depth; CY = calendar year; DAR = Douglas Distance-Angle-Rate; DASBR = Drifting Acoustic Spar Buoy Recorders; dB re 1 µPa = decibels referenced to 1 micro Pascal; DDG = guided missile destroyer; DNA = deoxyribonucleic acid; DPS = Distinct Population Segment; EAR = Ecological Acoustic Recorder; E-BREVE = Environmentally-influenced Behavioral Response Evaluations; ESA = Endangered Species Act; FM = frequency-modulated; FY = Fiscal Year; GOA TMAA = Gulf of Alaska Temporary Maritime Activities Area; GPS = Global Positioning System; GSI = Genetic stock identification; GVP = group vocal periods; HARP = High-frequency Acoustic Recording Package; hr = hour(s); HRC = Hawaii Range Complex; HMM = Hidden Markov Models; HSTT = Hawaii Southern California Training and Testing; Hz = Hertz; kHz = kilohertz; km = kilometer; LF = low-frequency; LIMPET = Low Impact Minimally Percutaneous Electronic Transmitter; LO = location only; m = meter; M3R = marine mammal monitoring on U.S. Navy ranges;

MarEcoTel = Marine Ecology and Telemetry Research; MFAS = mid-frequency active sonar; MITT = Mariana Islands Training and Testing; MMO = marine mammal observer; MTBAP = Marine Turtle Biology and Assessment Program; NARWHAL = Navy Acoustic Range Whale Analysis; NUWC = Naval Undersea Warfare Center; NWTRC = Northwest Training Range Complex; NWTT = Northwest Training and Testing; OT = observation team; OTN = Ocean Tracking Network; PAM = passive acoustic monitoring; PARR = Public Access to Research Results; PCoD = Population Consequences of Disturbance; PCR = polymerase chain reactions; photo-ID = photo-identification; PMRF = Pacific Missile Range Facility; PrU = probability of remaining undetected; PSAT = pop-up satellite archival tags; RL = received level(s); s = second(s); SCB = Southern California Bight; SCC = Submarine Command Course; SCI = San Clemente Island; SDA = Speed-Distance-Angle; SL = source level; SNP = single nucleotide polymorphism; SPOT = smart position and temperature; SOAR = Southern California Offshore Antisubmarine Warfare Range; SOCAL = Southern California Range Complex; SRKW = Southern Resident Killer Whale; TP = Trophic Position; U.S. = United States; WDFW = Washington Department of Fish and Wildlife.

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2.2 2021 Timeline and Methods of Monitoring Efforts

In this sub-section, a graphical timeline of monitoring projects is presented for each range, covering the 2021 monitoring year. The timelines include monitoring projects as well as notable items (e.g., results, outcomes).

Each timeline graphic is followed by a description of each monitoring project's methods; 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 U.S. Navy's testing and training range/study area (e.g., M = MITT; H = HRC; S = SOCAL; N = NWTT; G = GOA TMAA).

Project results can be found in the Supporting Technical Reports section at the U.S. Navy's Marine Species Monitoring Program website:

https://www.navymarinespeciesmonitoring.us/reporting/pacific/

2.2.1 MITT

A timeline of all U.S. Pacific Fleet-funded monitoring tasks implemented in the MITT Study Area in 2021 is illustrated in **Figure 3**.

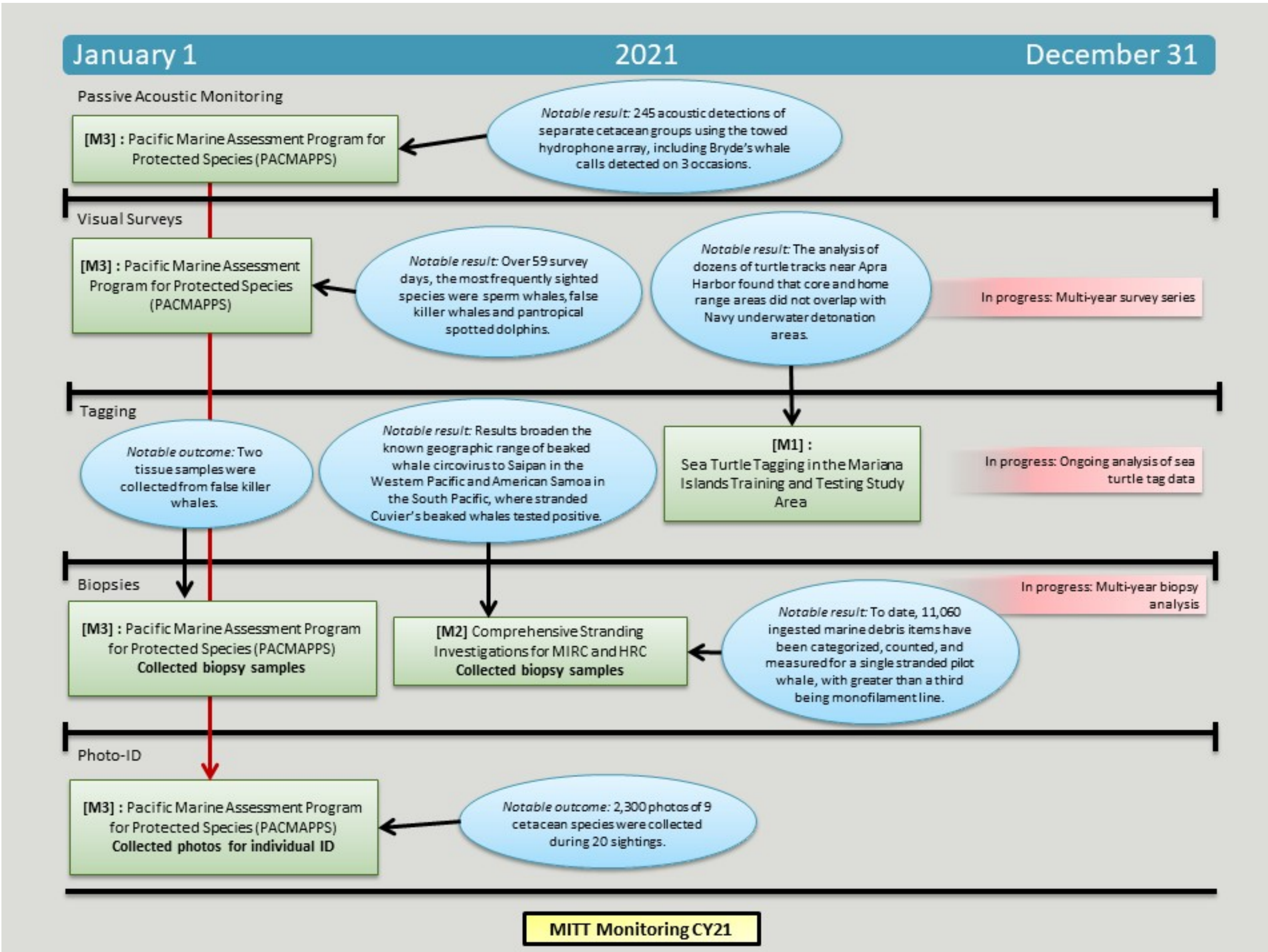

Figure 3. Timeline of 2021 projects in the Mariana Islands Training and Testing (MITT) Study Area.

[M1] Sea Turtle Tagging in the Mariana Islands Training and Testing Study Area [Gaos and Martin 2022]

The Pacific Islands Fisheries Science Center's (PIFSC) Marine Turtle Biology and Assessment Program (MTBAP) concluded a field study, initiated in 2013, of marine turtle abundance and spatial-temporal ecology in the nearshore waters of Saipan, Tinian, and Guam, and continued data processing and analysis of all available turtle tracks. Working with the Integrated Ocean Observing System, MTBAP made data from the satellite tags publicly available within the Animal Tracking Network (ATN). To improve the determination of home ranges, a new collaborative effort is underway to develop a new processing pipeline in the R Programming language that will facilitate the satellite tag data processing steps, including mapping migrations, calculating home ranges, and evaluating dive parameters (i.e., time at depth, maximum dive depth, time at temperature, and dive duration).

This work builds upon previous code developed by MTBAP, with the ultimate goal of having an agile processing pipeline that will allow rapid exploration of data trends and maximize the quality of the analyses.

[M2] Comprehensive Stranding Investigations for MIRC and HRC [West et al. 2022a, 2022b, 2022c]

The University of Hawaii Health and Stranding Lab continued to respond to and conduct comprehensive investigations of cetacean strandings in the Hawaiian and Mariana Archipelagos as well as other Pacific Island locations by performing necropsies and collecting samples. Methods were developed and validated to analyze archived tissues for newly described pathogens and to age tooth samples. Experiments were conducted to examine the degradation of deoxyribonucleic acid (DNA) over time to determine time of death, and to examine the detectability of Toxoplasmosis in degraded tissues. Historical stranding data are being compiled and augmented with data from new analyses to examine stranding patterns and causes of death. Additional analyses included:

- To assess the trophic position of a species, tissue samples were analyzed for Compound Specific Isotope Analysis of Amino Acids (CSIA-AAs) at the Biogeochemical Stable Isotope Facility at the University of Hawaii at Manoa for a minimum of 12 separate amino acids.

- To quantify the type and potential source of marine debris ingested by a stranding marine mammal, a standardized methodology protocol was developed involving categorization, counts, measurements, and weights of ingested marine debris items that were sorted into size categories, and a drying protocol was developed to ensure a dry weight was recorded that did not included the moisture retained by each of the marine debris items.

- For genetic confirmation of *Kogia* species, tissues were chosen based on availability and included kidney, spleen, gingiva, testis, skin, brain, heart, muscle, and lung. DNA was extracted using Qiagen Dneasy Blood and Tissue Kits (Qiagen, Germantown, Maryland) and amplified with polymerase chain reactions (PCRs) using primers and thermocycler conditions before genetic sequencing to diagnostically identify specimens to species.

- To investigate diseases, tissues were selected from 25 individuals that stranded in the Pacific region, dating back to 2014, to screen for the presence of cetacean morbillivirus (CeMV). Multiple genes from the Brucella genome were initially selected for assessment in order to develop a testing protocol with high specificity for detecting infections, while reducing the likelihood of false positives. All PCR amplified products were visualized using gel electrophoresis to determine suspected positive cases and submitted to the University of Hawaii Advanced Studies in Genomics, Proteomics, and Bioinformatics lab for final genetic sequencing. These sequences were then analyzed using the National Center for Biotechnology Information database's Nucleotide BLAST online tool for potential matches with *Brucella ceti* and *Brucella pinnipedialis*.

This is the same project conducted for HRC; refer to **Project [H6].**

[M3] Pacific Marine Assessment Program for Protected Species (PacMAPPS) [Yano et al. 2022]

As part of the PacMAPPS, the Mariana Archipelago Cetacean Survey (MACS) was conducted from 3 to 31 May 2021 and from 15 June to 14 July 2021 in order to characterize the abundance and distribution, population structure, and habitat preferences of cetaceans that occur in the U.S. waters around the Mariana Archipelago. Ship-based visual and passive acoustic systematic survey efforts for cetaceans occurred along parallel transect lines spaced 90 kilometers (km) apart, at a speed of 10 knots (kt) (18.5 km per hour [hr]) during daylight hours. Nearshore waters around Farallon de Pajaros, Maug, Asuncion, Agrihan, Pagan, Alamagan, Anatahan, and Sarigan were surveyed non-systematically.

Marine mammals were visually sighted and identified using 25x big eye binoculars (port and starboard observers) and one observer using 7×50 handheld binoculars or unaided eyes (center observer). Search effort, environmental conditions, and cetacean sightings were recorded using the software WinCruz. Following group-size estimation, some groups were pursued for additional data collection, including photo-identification (photo-ID) or biopsy sampling from the ship's bow. Digital single-lens reflex cameras with telephoto zoom lenses (100–400 and 70–200 millimeter) were used for taking photographs from the ship to aid in species identification, individual identification, and health and injury assessment. A towed hydrophone array was deployed approximately 300 meters (m) behind the ship from sunrise to sunset during each day of survey. PAMGuard software was used to manage data archiving and real-time monitoring of vocalizing cetaceans. Directional Fixing and Ranging (DIFAR) type 53G sonobuoys were deployed during baleen whale sightings when the ship approached the group within 1 nautical mile (nm). Drifting Acoustic Spar Buoy Recorders (DASBRs) were used to augment cetacean encounter rates, primarily for deep-diving beaked whales (BWs) and *Kogia* species and deployed to representatively sample all regions of the study area while minimizing disruption of daytime survey operations. When weather and sea conditions permitted, two Conductivity, Temperature, and Depth (CTD) casts were conducted daily: 1 hr before sunrise and another 1 hr after sunset for data on temperature, salinity, dissolved oxygen, and fluorescence from the ocean surface to depth.

PACMAPPS was also conducted in GOA TMAA; see **Project [G3]**.

2.2.2 HSTT

Monitoring in HRC and SOCAL is presented individually in the following sections.

2.2.1.1 HRC

A timeline of all U.S. Pacific Fleet-funded monitoring tasks implemented in the HRC in 2021 is illustrated in **Figure 4**.

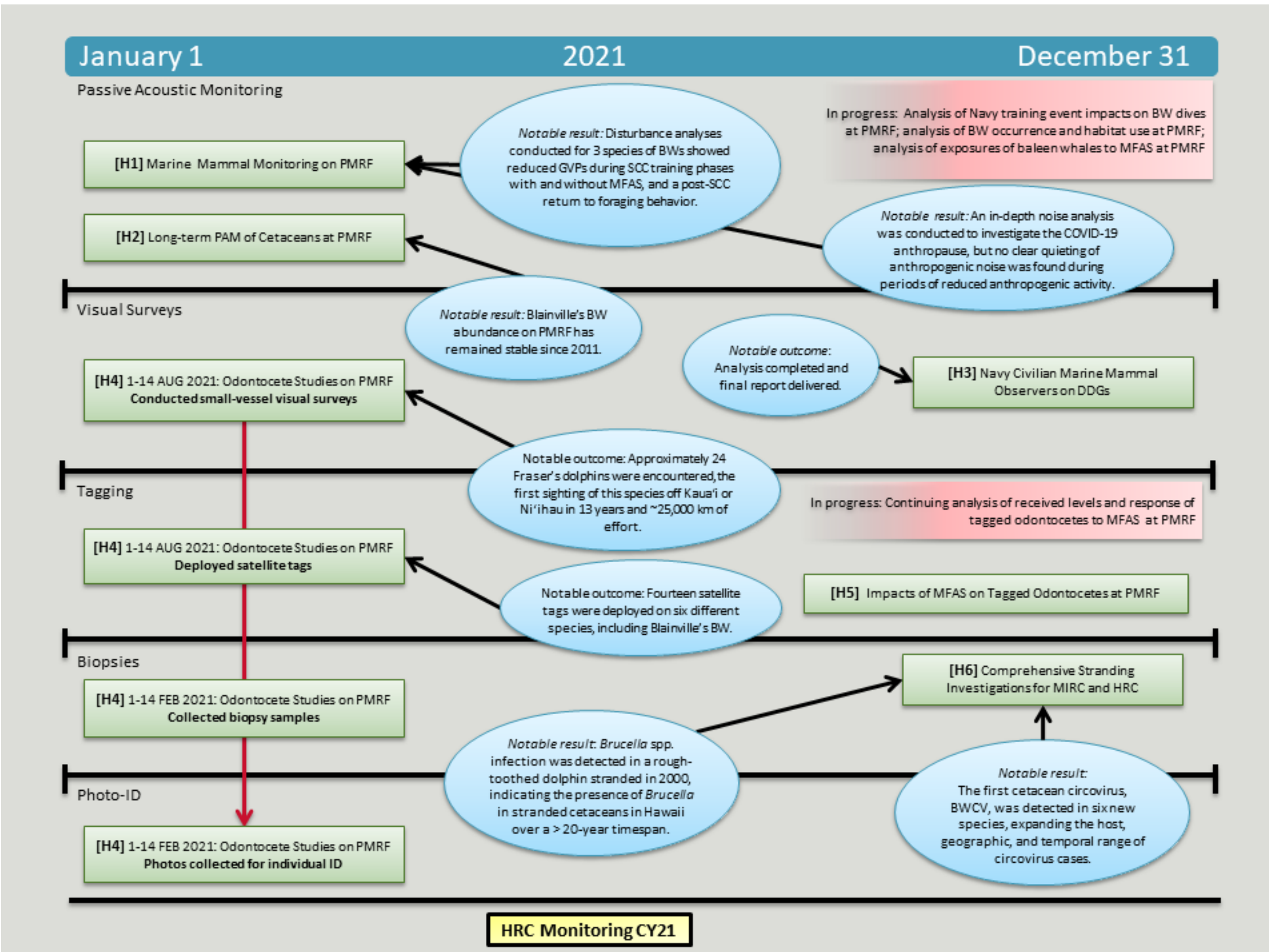

Figure 4. Timeline of 2021 projects in the Hawaii Range Complex (HRC).

[H1] Marine Mammal Monitoring on PMRF [Martin et al. 2022]

Raw acoustic recordings from 62 of the Pacific Missile Range Facility (PMRF) bottom-mounted hydrophones were used to analyze marine mammal vocalizations and mid-frequency active sonar (MFAS) transmission times and locations. Standard 45-hr full bandwidth (96 kilohertz [kHz]) recordings were used, as well as longer decimated recordings at the reduced sample rate of 6 kHz. Noise analyses conducted at PMRF characterized noise in frequency bands of interest to look for changes in noise over a wide variety of spatial and temporal scales, and to assess any impact these changes may have on detecting and localizing marine mammal vocalizations. A suite of algorithms known as the Navy Acoustic Range Whale Analysis (NARWHAL) was utilized to process recorded data for marine mammal vocalizations. Algorithms have been previously detailed in Martin et al. (2015), Manzano-Roth et al. (2016), Henderson et al. (2016, 2018), and Helble et al. (2012, 2015, 2016, 2020b), with a number of improvements made to select algorithms in 2021. For the disturbance analysis, a variety of metrics were calculated/estimated such as whale orientations (i.e., moving towards or away), ship orientations relative to the whale, and distances relative to all ships. During periods of active sonar transmission (i.e., during Submarine Command Course [SCC] as determined by Passive Acoustic Monitoring [PAM] analysis of MFAS localizations), propagation modeling was conducted to calculate sound levels that an animal may have received from multiple ships over the duration it was acoustically active. A collaboration between the Pacific Whale Acoustic Reconnaissance Project (WARP) and Naval Undersea Warfare Center (NUWC) Division Newport was also initiated to quantify ambient noise levels across recorders, and to develop and validate a method to estimate ambient noise using the archived data products recorded almost continuously by NUWC Division Newport, with periodic recordings done at PMRF. Offset values between the two systems and the packet recorder were estimated, and a "sprinkle analysis" was performed on the archived data.

[H2] Long-term Passive Acoustic Monitoring of Cetaceans at PMRF and SOAR [DiMarzio et al. 2022]

NUWC Division Newport maintains the Marine Mammal Monitoring on U.S. Navy Ranges (M3R) system, which can collect, and archive processed passive acoustic detection data on a nearly continuous basis (see also **Project [S2]**). The archive files provide an electronic record of marine mammal acoustic activity, sonar activity, and marine mammal localization data from multiple algorithms. PAM data were collected from range hydrophones at PMRF from 2011 to 2021, and at Southern California Offshore Antisubmarine Warfare Range (SOAR) from 2010 to 2021. The spatial and temporal distribution of Cuvier's BWs (*Ziphius cavirostris*) at SOAR and for Blainville's BWs (*Mesoplodon densirostris*) at PMRF were examined by evaluating their group vocal periods (GVPs). Changes in BW GVPs in response to MFAS from both hull-mounted and dipping sonar sources were examined with the help of an automated sonar detector. Tools were developed to automatically extract and characterize the ambient noise data at SOAR using archive files. Field efforts at PMRF and SOAR were also conducted in conjunction with Cascadia Research Collective (CRC) and Marine Ecology and Telemetry Research (MarEcoTel), respectively, to use the M3R system to identify relevant species and direct CRC (see **Project [H4]**; Baird et al. 2022) or MarEcoTel (see **Project [S2]**; Schorr et al. 2022) to their locations for subsequent tagging.

[H3] Navy Civilian Marine Mammal Observers on DDGs [Oedekoven and Thomas 2022]

From 2010-2019, the U.S. Navy conducted a lookout effectiveness study to assess the effectiveness of U.S. Navy lookouts in locating marine mammals during at-sea training events. As part of this study, marine mammal observers (MMOs) followed a systematic protocol to collect data, including sightings and environmental conditions, which were then pooled with other embark events for analysis. In 2021, new analytical methods were developed that allow estimation of the probability of animals approaching within a specified mitigation range without being detected (probability of remaining undetected [PrU]). These methods model the probability of detecting each animal school surfacing in two dimensions (forward of and perpendicular to the vessel), and are flexible in allowing for various patterns of animal surfacing and various experimental configurations (in terms of communication between MMO and lookout team [LT] platforms and whether repeat surfacings of the same school are recorded). New sightings rather than repeated sightings were used, and the data were analyzed in four groups according to similarity in surfacing pattern: rorquals (i.e., large baleen whales), sperm whales (*Physeter macrocephalus*), small cetaceans in small schools (six or less) and small cetaceans in large schools (more than six).

This is the same project conducted for SOCAL; refer to **Project [S4]**.

[H4] Odontocete Studies on PMRF [Baird et al. 2022]

CRC has been conducting small vessel surveys since 2011 to provide information on spatial movements and habitat-use patterns of odontocetes that are exposed to MFAS on and around PMRF before, during, and after the SCC (see Baird et al. 2019a, 2019b, 2021b, 2022). Field efforts in 2021 occurred from 1 through 14 August, immediately prior to Phase B of a SCC. Surveys were conducted in conjunction with the M3R PAM system streaming from the instrumented PMRF Range (Moretti 2017; DiMarzio et al. 2018, 2019, 2020, 2021, 2022) (See **Project [H2]**). M3R detections were used to direct the 24-foot (7.3 m) research vessel to high-priority species for satellite-tag deployment, biopsy sampling, and photo-ID in addition to providing visual validations of species for the acoustic detections. A subset of animals encountered had satellite tags attached. Tagged animals that overlap in space and time with training events will be utilized for MFAS exposure analysis (see **Project [H5]**).

[H5] Impacts of MFAS on Tagged Odontocetes at PMRF

In order to estimate sound levels received by tagged odontocetes at PMRF, positional data were interpolated in 5-minute intervals using the R-package *crawl*. Using dive data obtained from individual tags, dive depths were also estimated at each of those 5-minute locations. Further, 95% confidence interval (CI) error ellipses were calculated around each 5-minute position, with multiple radials running from source locations through error ellipses in order to model transmission loss values (and thus received levels [RLs]) from the source to the far edge of the radial and to the seafloor. RL values were then derived in three-dimensional space within the error ellipse and around the estimated depth value in order to arrive at the most accurate possible propagation-modeled RL estimate (with associated variance estimates).

In addition to these more detailed analyses of RL, the movement and dive behavior of the tagged odontocetes was examined relative to both phases of the SCC. Past analyses have focused only on Phase B, which includes the use of hull-mounted MFAS, as well as other sources of MFAS, including helo-dipping sonar and active sonobuoys. The initial part of the SCC, Phase A, does not include any of these sources or any surface-combatant vessels, but does include other surface and subsurface vessels and other sources of noise that could potentially cause behavioral responses. Therefore, odontocete behavior was examined before, during Phase A, between phases, during Phase B, and after (when all those periods were available). Movement and dive behavior were also examined in the context of normal patterns, including diel and lunar cycles, in order to put the context of any potential response into a framework of baseline variability. The HRC MFAS RL project continued in 2021, although a supporting technical report is not available at this time.

[H6] Comprehensive Stranding Investigations for MIRC and HRC [West et al. 2022a, 2022b, 2022c]

This is the same project conducted for MITT, refer to **Project [M2]**.

2.2.1.2 SOCAL

A timeline of all U.S. Pacific Fleet-funded monitoring tasks implemented in SOCAL in 2021 is illustrated in **Figure 5**.

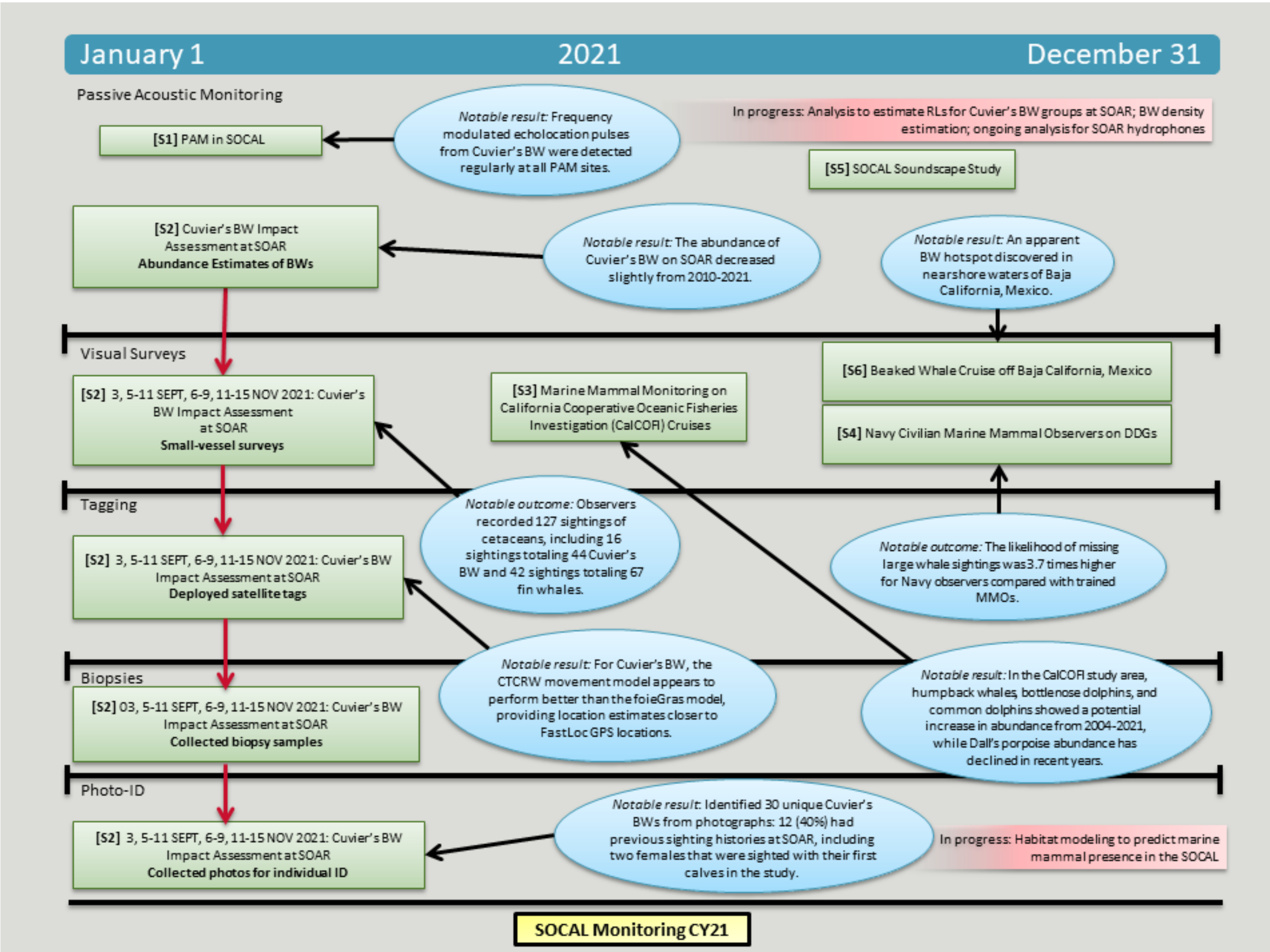

Figure 5. Timeline of 2021 projects in the Southern California Range Complex (SOCAL).

[S1] Passive Acoustic Monitoring in SOCAL [Rice et al. 2022]

Since 2009, the University of California San Diego's Scripps Institution of Oceanography (SIO) has studied marine mammal presence and acoustic behavior near naval training areas using High-frequency Acoustic Recording Packages (HARPs). HARPs can autonomously record underwater sounds from 10 Hertz (Hz) up to 200 kHz and are capable of up to approximately 1 year of continuous data storage. The goal of this project is to characterize the vocalizations of marine mammal species present in the area, determine their seasonal presence, and evaluate potential impacts from naval training and testing activities. In 2021, the study focused on BWs. Additionally, recordings were analyzed to characterize the low-frequency ambient soundscape (see **Project [S5]**), as well as the presence of MFAS and explosions. The HARPs recorded sounds between 10 Hz and 100 kHz between April 2020 and 2021 and were deployed at four sites within SOCAL: two to the west of San

Clemente Island (Site E at 1,300 m depth and Site H at 1,100 m depth) and two southwest of the island (Site N at 1,300 m depth and Site U at 1,200 m depth). For all four sites, a total of 31,037 hr (1,293 days) of acoustic data were included in the 2021 analysis. Data analyses for marine mammal and anthropogenic sounds were performed using automated computer algorithms.

[S2] Cuvier's Beaked Whale Impact Assessment at SOAR [Schorr et al. 2022; DiMarzio et al. 2022]

Small-vessel surveys were performed by MarEcoTel at SOAR in 2021 as part of an ongoing, long-term study of the distribution and demographics of BWs and fin whales that use SOAR. Surveys were conducted using a 6.5- to 7.5-m rigid-hulled inflatable boat (RHIB), launched from a shore base each morning with surveys throughout daylight hr as conditions permitted. Surveys focused on SOAR were based at Wilson Cove on the northeastern side of San Clemente Island. On days when SOAR was available for use, staff from the NUWC M3R program monitored hydrophones and directed the RHIB into areas where marine mammal vocalizations were detected. Efforts were focused on BWs in environmental conditions of Beaufort sea state (BSS) 3 or less. The species, time, latitude, longitude, group size and composition, and overall behavioral state were recorded. Detailed records of surfacing patterns were also collected for BWs. Photographs were taken for species verification and individual identification; tissue biopsies were collected from species of interest for use in ongoing assessments of population structure and stress hormone analyses; and a limited number of satellite tags were deployed to provide additional information on distribution, behavior, and overlap with U.S. Navy activities. Group sizes of Cuvier's BWs were recorded for use in abundance and density estimation on SOAR (DiMarzio et al. 2022; see **Project [H2]**). NUWC continued an ongoing project to develop estimates of abundance of Cuvier's BWs at SOAR, including investigating seasonal changes in abundance and mean GVPs as well as vocal behaviors (see **Project [H2]**). Identification photos of fin whales from directed and opportunistic data collection in 2020 (n = 93), as well as opportunistic collections from earlier years that had not been previously submitted to our catalog (n = 201), were processed in 2021. This collection brings our US West Coast fin whale catalog to 1,250 individuals, of which 760 have sighting histories in Southern California. Ten genetic samples were collected in 2021, five each from Cuvier's BWs and fin whales.

[S3] Marine Mammal Monitoring on California Cooperative Oceanic Fisheries Investigation (CalCOFI) Cruises [Rice et al. 2022]

The California Cooperative Oceanic Fisheries Investigations (CalCOFI) cruises, a joint agency field effort, have been conducted off southern California since the 1950s, and represent the only continuous, seasonal marine mammal data available for southern California. More information on the overall history of the CalCOFI program is available at: [http://www.calcofi.net/.](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. Visual surveys generally involved two observers using 7x50 Fujinon binoculars during daylight transit between CalCOFI oceanographic stations. Marine mammal sightings were logged systematically, including supporting information such as BSS. In 2021, abundance and density estimates were developed for nine commonly sighted marine mammal species using survey data collected from 2004 to 2021. Abundance and density estimates were calculated for the southern

CalCOFI region using distance sampling techniques with the "distance" package in R (Miller et al. 2019).

[S4] Navy Civilian Marine Mammal Observers on DDGs [Oedekoven and Thomas 2022]

This is the same project conducted for HRC; refer to **Project [H3]**.

[S5] SOCAL Soundscape Study [Rice et al. 2022]

As part of an ongoing study performed by SIO (see **Project [S1]**), acoustic recordings from four HARPs deployed between November 2018 and May 2020 were analyzed in 2021 in order to characterize the low-frequency ambient soundscape in the SCB. HARPs record over a broad frequency range of 10 Hz to 100 kHz, which allows quantification of the low-frequency ambient soundscape, detection of baleen whales (mysticetes), toothed whales (odontocetes), and anthropogenic sounds. To determine ambient sound levels, HARP recordings were decimated by a factor of 100 to provide an effective bandwidth of 10 Hz to 1 kHz from which Long-Term Spectral Averages were constructed with 1 Hz frequency and 5 second (s) temporal resolution. To avoid system self-noise (specifically hard drive disk writes) in daily spectral averages, five of the 5 s sound pressure spectrum levels from the middle of each 75 s acoustic record were averaged. All spectra of each day were subsequently combined as daily spectral averages. Anthropogenic sounds, including MFAS and underwater explosions, were detected using automated computer algorithms. For MFAS, a modified version of the Silbido detection system (Roch et al. 2011) was used, and the start and end of each sound or session was logged and their durations were added to estimate cumulative weekly presence. Individual explosions were detected using a matched filter detector on data decimated to a 10 kHz sampling rate, and weekly totals were reported.

[S6] Beaked Whale Cruise off Baja California, Mexico [Henderson et al. 2022]

A collaborative effort among Mexican and U.S. researchers continued with a vessel survey conducted off Baja California from 28 October to 12 November 2021. The primary objective of the survey was to locate and document two species of BW; "BW43" had previously only been detected acoustically and BW Baja (BWB) was first encountered and acoustically recorded in 2020. Data collection methods included visual and passive acoustic techniques for detecting and identifying marine mammals. Acoustic instrumentation included two DASBRs, each with a multi-channel SoundTrap ST4300 recorder (made by Ocean Instruments http://www.oceaninstruments.co.nz/), and HTI-92-WB hydrophone, and an HTI-96-min hydrophone. Data collected during visual observations included sighting start time, start latitude and longitude, species, best estimate of group size (including a minimum, maximum, and best size estimate), group behavior, and any other behavioral observations. Photographs were taken for individual identification when possible. For species other than BWs, once the species and group size had been confirmed and photographs had been collected, the sighting was ended with a final time and position update. A BW group sighting was ended if a group was not resighted after at least 30 minutes of monitoring.

2.2.3 NWTT

A timeline of all U.S. Pacific Fleet-funded monitoring tasks implemented in the NWTT Study Area in 2021 is illustrated in **Figure 6**.

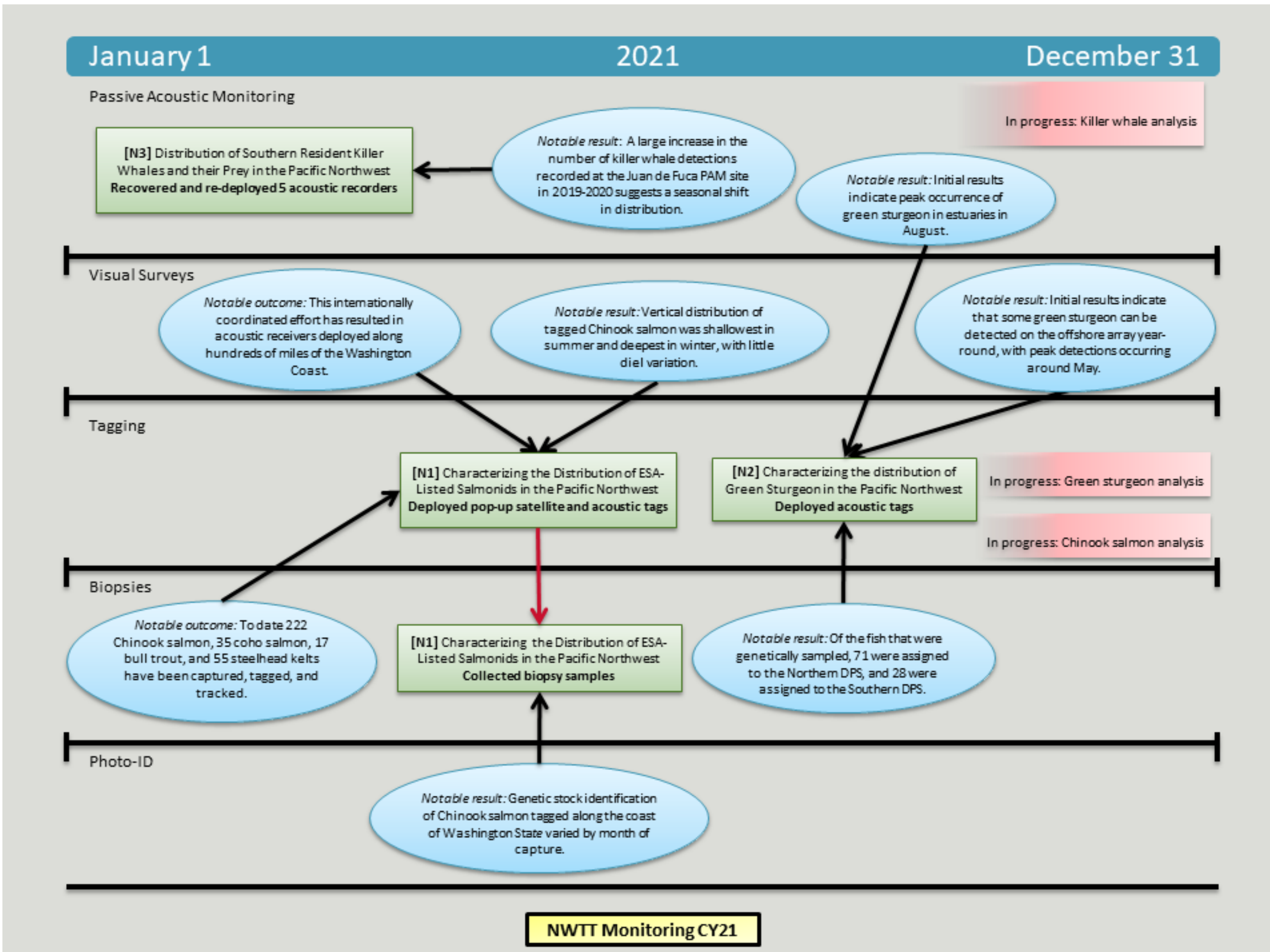

Figure 6. Timeline of 2021 projects in the Northwest Training and Testing (NWTT) Study Area.

[N1] Characterizing the Distribution of ESA-Listed Salmonids in Washington and Alaska [Smith and Huff 2022]

Since 2019, an international team of researchers, including scientists from National Oceanic and Atmospheric Administration Northwest Fisheries Science Center, the Canadian Department of Fisheries and Oceans, the University of Washington, and Oregon State University, have been examining salmonid distribution in relation to U.S. Navy training and testing activities using a stationary acoustic receiver array installed off the Washington Coast. Researchers deployed Innovasea V9 and V16 acoustic tags on Chinook salmon (*Oncorhynchus tshawytscha*), and Vemco V9 acoustic tags and pop-up satellite tags (PSATs) on steelhead (*Oncorhynchus mykiss*) kelts. Steelhead tagged with PSAT tags were transported to the mouth of Willapa Bay, outfitted with a Wildlife Computers miniPAT tag using methods developed by Michael Courtney and Andy Seitz

(University of Alaska Fairbanks), and released. PSATs were configured to release 120 to 180 days after deployment and to log temperature, depth, and light intensity for estimating fish locations. Scales and fin clips were collected to determine natal river origin, age, and life history (ocean migration as a sub-yearling versus yearling) of each individual.

This is the same project conducted for GOA TMAA; refer to **Project [G2]**.

[N2] Characterizing the Distribution of Green Sturgeon in the Pacific Northwest [Heironimus et al. 2022]

Following the success detecting acoustically tagged salmonids in the Navy-funded Washington coast acoustic array beginning in 2019, the Navy funded Washington Department of Fish and Wildlife (WDFW) biologists to help improve the knowledge of green sturgeon (*Acipenser medirostris*) migration, distribution, and habitat utilization within these same waters. Using Navy funding in 2020, WDFW acoustically tagged 50 green sturgeon using VEMCO 69-kHz V16 tags in Willapa Bay and Grays Harbor, placed two receivers at the mouth of each estuary to monitor movement between coastal and estuarine habitats and collected tissue from tagged and non-tagged fish to assign individuals to the Northern or Southern (ESA-listed) Distinct Population Segments (DPS). To further increase the number of acoustically tagged green sturgeon occupying waters around the coastal array, collaborating agencies (USACE, NMFS, and WDFW) added 60 more tags in 2020-2021. In 2021, WDFW analyzed receiver array data from the Columbia River north to Vancouver Island, B.C. and the Willapa Bay and Grays Harbor, Washington estuaries to determine the seasonal and geographic distribution patterns of these acoustically tagged green sturgeon in these waters. Further, using a genetics technique involving single nucleotide polymorphism (SNP) assay data, 188 fish from which tissues samples were collected were assigned to either the Northern DPS or Southern DPS.

[N3] Distribution of Southern Resident Killer Whales and their Prey in the Pacific Northwest [Hanson et al. 2022]

As part of an ongoing project to characterize the distribution of Southern Resident killer whales (SRKW) in and near the NWTT, five autonomous acoustic recorders (Ecological Acoustic Recorder (EARs) and SoundTraps) were recovered and deployed in September 2021. To increase detection likelihood, deployment locations were determined based on analysis of previous data collected on SRKW occurrence. Because EARs are no longer manufactured and the project is transitioning to SoundTraps, the two types of recorders were co-located where possible. A comparative assessment of the detection capabilities of the two recorder types was conducted for data from 2018-2019 at three sites: Cape Flattery Offshore, Juan de Fuca, and Columbia River. Killer whale acoustic detections were determined via manual review of acoustic data files for 2019-2020 and preliminary analysis of 2020-2021 data has begun.

2.2.4 GOA TMAA

A timeline of all U.S. Pacific Fleet-funded monitoring tasks implemented in the GOA TMAA in 2021 is illustrated in **Figure 7.**

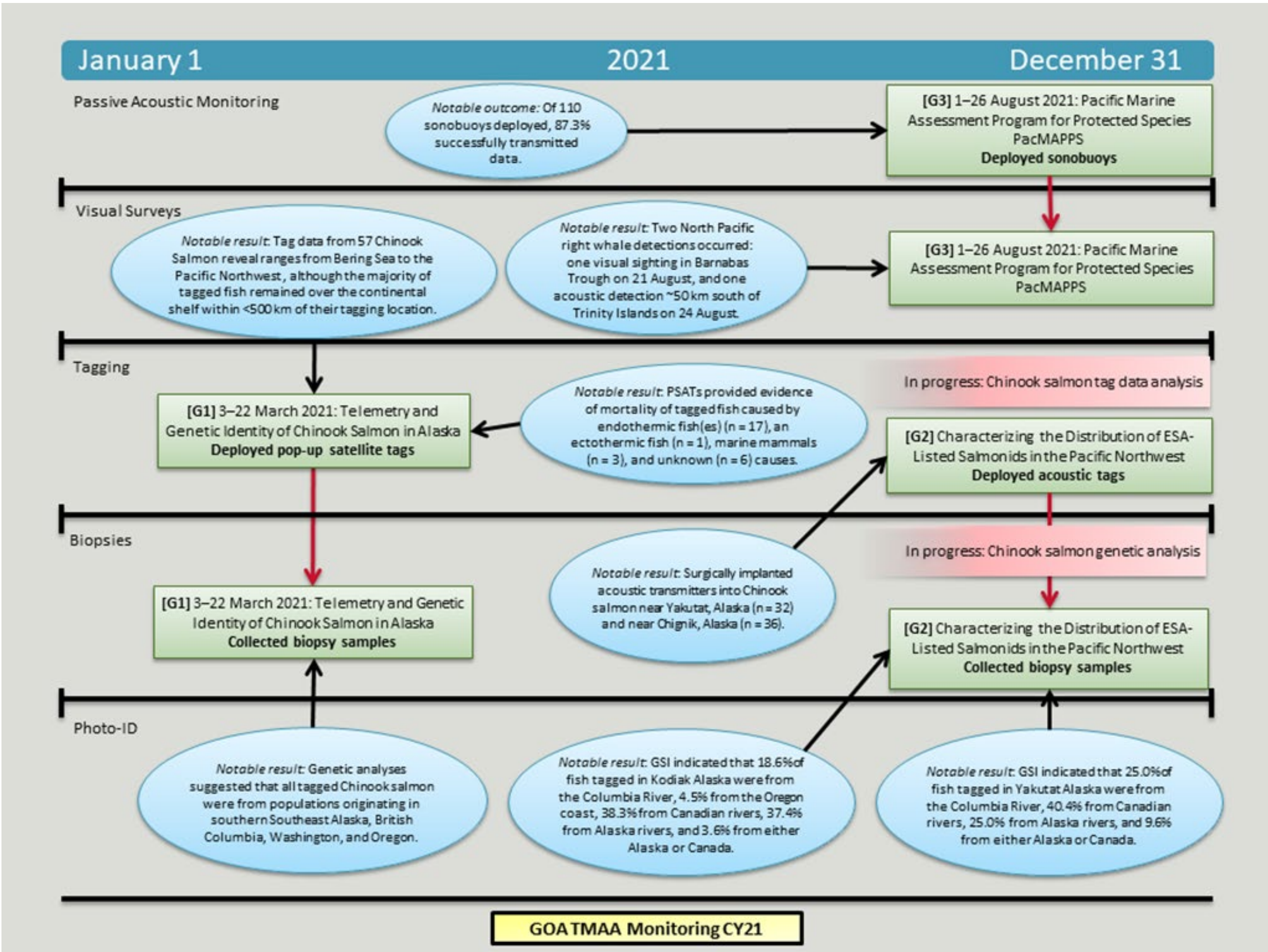

Figure 7. Timeline of 2021 Gulf of Alaska Temporary Maritime Activities Area (GOA TMAA) monitoring projects.

[G1] Telemetry and Genetic Identity of Chinook Salmon in Alaska [Seitz and Courtney 2022]

This ongoing study provides information about the at-sea distribution, genetic identity, occupied habitat, and natural mortality of Chinook salmon (*Oncorhynchus tshawytscha*) in and near the GOA TMAA, and about the overlap of occurrence between populations from western Alaska to California, particularly the Evolutionarily Significant Units that are listed under the ESA. As part of this study, large (greater than 60 cm), immature individuals were captured by hook and line, tagged with PSATs (MiniPAT, Wildlife Computers; Redmond, Washington), and released. Catch-and-release and tagging activities occurred from 3 to 22 March 2021 near Yakutat, Alaska. Fish were retrieved and brought on board the vessel and assessed for condition, signs of stress, or abnormal behavior, including external injuries, loss of scales, bleeding, loss of equilibrium, pupil dilation, abnormal coloration, frayed fins, and rapid opercular movement. Chinook salmon that were greater than 60 cm fork length and in good condition were selected for tagging, then placed in a custom-fabricated cradle and blindfolded to reduce visual stimuli that can contribute to stress and struggling (Courtney et al. 2019). Satellite tags were attached to Chinook salmon while in the cradle using a tag attachment system (Courtney et al. 2016, 2019; Strøm et al. 2017; Seitz et al. 2021). After tagging, the axillary process of a pelvic fin was removed as a tissue sample for subsequent genetic analysis. After tissue sampling, the fish were identified by tag number, photographed, and released back into the ocean. The PSATs measured and archived temperature, depth, and ambient light data at user-programmable intervals, typically between 1 and 15 s. After releasing from the fish, the tags floated to the surface of the sea and transmitted, via satellite (Advanced Research and Global Observation Satellite [Argos] System), summarized temperature and depth data (resolution 5.0–10.0 minutes), daily dawn and dusk times determined from light data, and a highly accurate end location. The PSATs were programmed to release at staggered intervals between 90- and 270-days post-tagging. Additionally, the tags were programmed to release before their scheduled pop-up date if they triggered a fail-safe mechanism by remaining at a constant depth (depth window of ± 2.5 m) for a pre-defined period (3 days).

[G2] Characterizing the Distribution of ESA-Listed Salmonids in Washington and Alaska [Smith and Huff 2022]

This is the same project conducted for NWTT; refer to **Project [N1]**.

[G3] Pacific Marine Assessment Program for Protected Species (PacMAPPS) [Crance et al. 2022]

As part of a partnership among federal agencies to conduct Multispecies Cetacean and Ecosystem Assessment Surveys (MCEAS), the 2021 PacMAPPS survey was conducted in GOA from 1 to 26 August 2021; survey goals included estimation of cetacean abundance and population trends, delineation of stock structure, and development of habitat density models in a changing environment. Ship surveys were conducted on pre-determined track lines during daylight hours and when weather and swell conditions allowed for the purpose of estimating cetacean abundance and trends and developing habitat density models. The survey area consisted of two strata: coastal (30 to 500 m isobath) and slope (500 to 4,000 m), and visual effort was conducted from two independent platforms to estimate the proportion of whales missed on the trackline. Marine mammals were visually sighted and identified using 25x big eye binoculars to obtain distribution, density, and abundance information. Transect effort was defined as a visibility greater than 2 nm, BSS less than or equal to 5, and survey speed of approximately10 kt through the water. The computer program VizSurvey was used to record all sighting, effort, and environmental conditions. Photographs and biopsy samples were collected when time and conditions allowed and for select species. Sonobuoys were deployed approximately every 2 to 3 hr while transiting and primarily deployed in DiFAR mode to obtain bearings to calling animals. Oceanographic data were collected using an underway water sampling system, as well as nightly CTD casts. Nutrient samples were collected with every CTD, while salinity samples were collected with every third cast. Active acoustics were used to collect data on the prey field using an Acoustic Doppler Current Profiler (ADCP) and an EK80 echosounder.

PACMAPPS was also conducted in MITT; see **Project [M3]**.

3 2022 Monitoring Goals

The Strategic Planning process is used to set ISOs, identify potential species of interest at a regional scale, and evaluate and select specific monitoring projects to fund or continue supporting for a given fiscal year (FY).

Continuing or new monitoring projects for calendar year 2022 are listed in **Table 2** and are also listed on the U.S. Navy's Marine Species Monitoring Program website:

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

Table 2 provides a quick summary of 2022 monitoring for MITT, HSTT (HRC and SOCAL), NWTT, and GOA TMAA. For a more detailed view of these monitoring projects, please see **Appendix C**.

Table 2. 2022 Monitoring projects for U.S. Navy Pacific ranges/study areas.

Range/Study Area	Project Title	Continuing or Proposed New Start
HRC	**Long-Term Acoustic Monitoring at PMRF**	Continuing from 2006
HRC	**Estimation of MFAS Received Levels and Behavioral Response of Marine Mammals at PMRF**	Continuing from 2011
HRC	**Use of a Scent-detection K-9 to Collect Marine Mammal Scat: Feasibility Study**	New start in 2022
SOCAL	**Cuvier's Beaked Whale and Fin Whale Population Dynamics and Impact Assessment at SOAR**	Continuing from 2016
SOCAL	**Southern California Beaked Whale Occurrence**	Continuing from 2009[1]
MITT	**Sea Turtle Tagging**	Final reporting in 2022
MITT	**Beaked Whale Occurrence and Behavior in the Marianas**	New start in 2022
HRC, SOCAL, MITT, GOA TMAA	**Pacific Marine Assessment Program for Protected Species (PacMAPPS)**	Continuing from 2017
MITT, HRC	**Comprehensive Stranding Investigations**	Continuing from 2017[2]
NWTT	**Pacific Northwest Distribution of Southern Resident Killer Whales and Prey**	Continuing from 2014[3]
NWTT	**Vessel-Based Marine Mammal Surveys in Puget Sound, Washington**	New start in 2022
NWTT	**Characterizing the Distribution of Green Sturgeon in the Pacific Northwest**	Continuing from 2020
NWTT, GOA TMAA	**Characterizing the Distribution of ESA-listed Salmonids in Washington and Alaska**	Continuing from 2018
GOA TMAA	**Telemetry and Genetic Diversity of Chinook Salmon in Alaska**	Continuing from 2020

Notes:

[1] Initial field deployment 2009, first reporting 2010; reporting from 2021 will be for beaked whales only; one HARP will be moved in 2022 to an offshore location west of San Nicolas Island to analyzed deep water beaked whale occurrence and anthropogenic sound.

[2] Added emphasis and funding focused on these investigations starting in FY20.

[3] Southern Resident Killer Whale focus 2014–2018; 2018–2021 focus on killer whale prey (ESA-listed salmonids)

Key: ESA = Endangered Species Act; FY = Fiscal Year; GOA TMAA = Gulf of Alaska Temporary Maritime Activities Area; HRC = Hawaii Range Complex; MFAS = Mid-frequency Active Sonar; MITT = Mariana Islands Training and Testing; NWTT = Northwest Training and Testing; PMRF = Pacific Missile Range Facility; SOAR = Southern California Offshore Antisubmarine Warfare Range; SOCAL = Southern California Range Complex.

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A

Abstracts/Executive Summaries from the 2021 Technical Reports

[M1] Sea Turtle Tagging in the Mariana Islands Training and Testing (MITT) Study Area

Gaos, A.R., and S.L. Martin. 2022.

In 2013, under an inter-agency agreement (IAA) between the United States Navy and the National Oceanic and Atmospheric Administration (NOAA), NOAA began conducting in-water surveys to record and quantify observations of marine turtles around the Mariana Archipelago. When observed, attempts were made to hand-capture turtles and equip them with satellite tags in an effort to better understand their spatial ecology. Since 2013 NOAA researchers have encountered a total of 517 turtles, 111 of which were captured and equipped with satellite tags, including 97 green turtles and 14 hawksbill turtles. Preliminary data analysis (i.e., previous reports) have indicated that movements and habitat use are highly neritic for the overwhelming majority of turtles, with home range estimates revealing limited movements for both species. Notwithstanding this perspective, more vagile movement patterns were also observed. The onset of the Covid19 pandemic in 2020 led to the suspension of the NOAA's fieldwork associated with this IAA, which was extended in order to leave open the possibility of conducting additional fieldwork. Nonetheless, given the ongoing NOAA restrictions of fieldwork, NOAA's Marine Turtle Biology and Assessment Program has recently switched focus to the development of a data processing pipeline that will facilitate more detailed data analyses for the final report due in 2023. Given this context, this document represents a "reduced interim report" and while it includes limited information on the methods employed throughout this IAA, more detailed analyses will be provided in the final report.

[M2/H6] Comprehensive Stranding Investigations for High Priority Species

West, K.L., J. Phipps, N. Hofmann, and I. Silva-Krott. 2022a.

This project provides support for comprehensive stranding investigations in order to obtain increased baseline information about the health of marine mammals. Such support is essential when considering the Pacific Islands region (PIR) where unique geographical challenges exist. The PIR is comprised of isolated islands, spanning over 7 million square miles across the North, South and Western Pacific basins and includes the Hawaiʻi Range Complex and the Mariana Islands Range Complex. All cetacean stranding response and investigative efforts for the PIR are centralized at a dedicated stranding facility that houses the University of Hawaiʻi (UH) Health and Stranding Lab, which plays a critical role as the only organization in the region to conduct cause of death investigations when dolphins and whales strand. This requires mounting an immediate response to each newly reported stranding event that occurs and conducting extensive necropsy examinations, including histopathology, disease surveillance, and tissue sampling in support of numerous research efforts aimed at better understanding Hawaiian cetaceans. In addition to this project facilitating advanced diagnostics in-house at the Health and Stranding Lab, we also report on progress towards increasing our knowledge of diet and trophic position of endangered main Hawaiian Islands insular false killer whales and on characterizing marine debris ingestion by abundance and mass in stranded short-finned pilot whales.

[M2/H6] Diseases of Stranded Pacific Island Marine Mammals

West, K.L., C. Clifton, C. Humann, N. Hofmann, K. Jacobson, and I. Silva-Krott. 2022b.

The University of Hawaii Health and Stranding Lab located at Marine Corps Base Hawaii (MCBH) is the only entity in the Pacific Islands region that responds to strandings, conducts necropsy and cause of death investigations, archives tissues and performs research to identify and evaluate threats to Pacific Island cetaceans (dolphins, whales, and porpoises). The work involved in this project focused on increasing our understanding of infectious diseases in the Pacific Island region by investigating circovirus, morbillivirus, and toxoplasmosis infections in cetaceans. The first cetacean circovirus, beaked whale circovirus (BWCV), was recently reported in a Longman's beaked whale (*Indopacetus pacificus*) stranded in Hawaii and represents an emergent disease with unknown population impacts. In other species, circovirus infection may cause mortality or opportunistic co-infection by other pathogens. We report on a targeted surveillance of stranded cetaceans in the Pacific basin where pathological findings suggested disease presence. Archived tissues from individuals stranded between 2000 and 2021 (n=20) were tested by polymerase chain reaction (PCR) for the presence of BWCV. Suspect positive tissue amplicons were confirmed as BWCV through sequencing. Of the screened individuals, seven animals tested positive in one or more tissues, with a single striped dolphin (*Stenella coeruleoalba*) testing positive in all six tissues. The highest rate of detection among positive cases was found in brain and liver tissues (85.7%), followed by spleen tissue (83.3%) and lung tissue (66.7%). These results expand the potential host range for BWCV into six additional odontocete species. New host species include dwarf sperm whales (*Kogia sima*) with BWCV being found in an individual that stranded on Oahu in 2000, predating the initial case of BWCV. The results also broaden the known geographic range of BWCV to Saipan in the Western Pacific and American Samoa in the South Pacific, where stranded Cuvier's beaked whales (*Ziphius cavirostris*) tested positive. In respect to the infectious disease cetacean morbillivirus (CeMV), cetaceans that had previously stranded in the Pacific Island region were screened for the presence of morbillivirus (n=25). Among the tested individuals, a single adult female pygmy killer whale (*Feresa attenuata*) that was a part of a mass stranding event was found to have multiple lymph nodes (n=3) infected with a newly discovered Fraser's dolphin strain of morbillivirus. While significant in the fact that it is only the second animal to be discovered with this strain of CeMV, the infection rate among tested animals (4%) is lower than what was observed in the last screening effort that took place in 2014 (24%). Finally, efforts to investigate the degradation characteristics of *Toxoplasma gondii*, the parasite that can cause fatal toxoplasmosis, were conducted to determine the length of time postmortem that an animal carcass can successfully be tested by PCR for presence of this disease. Findings show that detection rates remain relatively constant in the first two weeks after death, and then drop significantly, with no successful detection at 28 days of degradation. This indicates that there is a benefit to testing animals with moderate to advanced states of decomposition for presence of T. *gondii.* The results of this study that investigated three pathogens of concern have significantly increased our understanding of infectious disease in Pacific Island cetaceans while demonstrating that there is still more to be learned about their population level impacts in the central, Western, and South Pacific.

[M2/H6] Hawaii and Mariana Islands Stranding Analyses

West, K.L., C. Clifton, N. Hofmann, C. Humann, and I. Silva-Krott. 2022c.

The University of Hawaii Health and Stranding Lab located at Marine Corps Base Hawaii (MCBH) is the only entity in the Pacific Islands region that responds to strandings, conducts necropsy and cause of death investigations, archives tissues and performs research to identify and evaluate threats to Pacific Island cetaceans. The purpose of this project is to conduct analyses of historical stranding patterns and causes of mortality that incorporate quantitative estimates of stranding date, genetic identification of species when necessary, and advanced diagnostic procedures. This report focuses on describing progress associated with conducting genetic species identification for stranding events where an initial species determination was not possible. This data will be used to increase the robustness of stranding data in a historical analysis of temporal and spatial stranding patterns in the Pacific Islands. Additionally, we describe progress towards the screening of archived tissues for the presence of Brucella and Toxoplasma in stranding cases where infectious disease is suspected. This advanced diagnostic information provides the ability to more thoroughly evaluate potential causes of mortality in stranded animals from the Hawaiian and Mariana Islands.

[M3] Cetacean and Seabird Data Collected During the Mariana Archipelago Cetacean Survey (MACS), May–July 2021

Yano, K.M., M.C. Hill, E.M. Oleson, J.L.K. McCullough, and A.E. Henry. 2022.

In summer 2021, the Pacific Islands Fisheries Science Center conducted a comprehensive line transect survey for cetaceans and seabirds within the U.S. waters of the Guam and the Commonwealth of the Northern Mariana Islands exclusive economic zones. The Mariana Archipelago Cetacean Survey (MACS) 2021 project was part of the multi-year Pacific Marine Assessment Program for Protected Species (PacMAPPS) plan to conduct surveys and estimate density for cetacean species in regions of joint NOAA Fisheries, Bureau of Ocean Energy Management, and U.S. Navy interest. MACS 2021 sailed for 59 days at sea aboard the NOAA Ship *Oscar Elton Sette* in May–July, 2021 and surveyed 8,711.7 km of trackline. The team conducted visual and passive acoustic surveys during daylight hours when weather permitted. There were 77 cetacean sightings of at least 12 species. The most frequently sighted species during the project were sperm whales (*Physeter macrocephalus*, 18 sightings), false killer whales (*Pseudorca crassidens*, 10 sightings), and pantropical spotted dolphins (*Stenella attenuata*, 8 sightings). Approximately 2,300 photos of 9 cetacean species were collected for individual or species identification during 20 cetacean sightings. Two biopsy samples were collected from false killer whales. During towed array surveys there were 245 acoustic detections of cetaceans, of which 47 were linked to visually sighted groups. Twenty-two Drifting Acoustic Spar Buoy Recorders were deployed and recovered throughout the survey area and will contribute additional information on beaked whale, *Kogia*, and baleen whale distribution and abundance. The seabird observers counted 3,266 individual birds in 1,605 seabird sightings among 29 species (plus 12 additional taxa). The most frequently sighted seabird species included the Sooty Tern (*Onychoprion fuscata*, 654 individuals), Short-tailed Shearwater (*Ardenna tenuirostris*, 547 individuals), and Red-footed Booby (*Sula sula*, 368 individuals). Oceanographic sampling was conducted with twice daily CTD casts when conditions permitted, with a total of 79 casts throughout the survey area.

[H1] FY21 Annual Report on Pacific Missile Range Facility Marine Mammal Monitoring

Martin, C.R., E.E. Henderson, S.W. Martin, T.A. Helble, R.A. Manzano-Roth, B.M. Matsuyama, G.C. Alongi, and R.A. Guazzo. 2022.

This report documents Naval Information Warfare Center (NIWC) Pacific marine mammal monitoring efforts in fiscal year (FY) 2021 for Commander, Pacific Fleet (COMPACFLT) at the Pacific Missile Range Facility (PMRF), Kaua'i, Hawai'i. The following list highlights tasks completed in FY21 in support of COMPACFLT monitoring goals:

1. Raw acoustic data from 62 bottom-mounted hydrophones at PMRF were recorded at the full bandwidth sample rate of 96 kHz and at a decimated sample rate of 6 kHz. This report updates last year's report with inclusion of 3203.7 hours of new data collected from September 4, 2020, to August 26, 2021, although there was a gap in data collection between March and June of 2021 due to the failure of the legacy recorder. The new recorder was successfully installed in June 2021.

2. Abundance results for minke whales from September 4, 2020, to August 26, 2021, indicated that a maximum of ten minke whales were detected in a 10-minute snapshot period in January 2021; however, this number was inflated due to some duplicate tracks being generated, likely due to the presence of minke whales calling at the rapid call rate. This phenomenon was investigated in detail, with an examination of individual minke tracks between August 2012 and July 2017. Hidden Markov Models (HMMs) were applied to quantify the relationship between an individual animal's call rate and the distance to the closest conspecific(s). It was discovered that the probability that the rapid call rate would occur increased as the distance to the nearest minke whale decreased.

3. Abundance results for humpback whales found a maximum of only one singing whale at any given 10-minute snapshot period from October 2020 through January 2021. In addition, HMMs and generalized estimating equations (GEEs) were also applied to three years of satellite-tag track data to investigate movement and dive behavior of humpback whales in Hawai'i.

4. Abundance results for the low-frequency baleen whales found a maximum of three tracks that occurred in 10-minute snapshot periods in November and December 2020. No tracks were found in July and August of 2021, indicating no low-frequency baleen whales (namely Bryde's whales, which are potentially present year-round) were present or vocalizing at that time. When looking at individual species, there was a maximum of four fin whales in December 2020, a maximum of two Bryde's whales in October 2020, and a maximum of one each of 40-kHz downsweep calls (likely fin/sei) in December 2020 and of unknown call types in November 2020. Blue whales were detected in December 2020 and January 2021 but were not tracked due to low localization accuracy.

5. Abundance results for odontocetes from September 4, 2020, to August 26, 2021 included Blainville's, cross-seamount (BWC), and Cuvier's beaked whales, sperm whales, and killer whales. The number of Blainville's beaked whale dives was corrected based on sample validation of five FY21 baseline recordings (91% true positive rate and 9% false positive rate);

there was a maximum of 2.47 dives/hr in July 2021. The number of fully validated BWC and Cuvier's beaked whale dives occurred far less frequently than Blainville's beaked whale dives, resulting in a maximum of 0.23 dives/hr in December 2020 for BWC beaked whales and 0.23 dives/hr for Cuvier's beaked whales in July 2021. Two groups of killer whales producing the high-frequency modulated (HFM) call were detected in FY21, in December 2020 and July 2021. There was a maximum of one sperm whale track detected in two different 10-minute snapshot periods in December 2020; no other sperm whale tracks were detected in available FY21 data.

6. The statistical models developed by collaborators at the University of St. Andrews Centre for Research into Ecological and Environmental Modelling (CREEM) during the Office of Naval Research (ONR)-sponsored behavioral response evaluations (BREVE) project were finalized and given to NIWC Pacific to utilize on classified data for higher resolution analyses. HMMs were developed to examine movement behavior during the different phases of the submarine command course (SCC) training events and found that minke whales engaged in the faster, more directed movement state in the During phase, but preferred the slower, less directed state in all other phases. The minke whales also demonstrated a strong preference in the direction of their movement in the During phase, with animals north of the main area of training activity preferentially moving north, while animals west of the area of activity moved west and north (Durbach et al. 2021).

7. Disturbance analyses were conducted at PMRF for Blainville's, BWC, and Cuvier's beaked whales during the August 2021 SCC training event as well as during a unit level training (ULT) event that occurred prior to the SCC. All beaked whale dives per hour of effort during non-training phases (i.e., Pre-ULT, Post-ULT/Pre-SCC, Between, and Post-SCC phases), and during the training (ULT, which did include surface ship hull-mounted mid-frequency active sonar (MFAS), Phase A, which does not include surface ship hull-mounted MFAS, and Phase B, which does include surface ship hull-mounted MFAS) were investigated. As expected, all three species demonstrated reduced group vocal periods (GVPs) during the various training phases and a return to foraging behavior after the training.

8. An in-depth noise analysis was conducted on FY20 data to investigate whether the anthropause that has been detected in many other systems, both terrestrial and aquatic, during the coronavirus disease 2019 (COVID-19) pandemic also occurred at PMRF. This analysis looked at spectral densities across the full 96-kHz bandwidth as well as at five bands of interest to detect either a quieting in bands of anthropogenic noise or an increase in sound levels in bands of marine mammal activity. Although there were statistically significant differences across the year in all five bands, there was no clear trend related to the initial three-month period of COVID-19, and the results likely reflect natural variation in noise levels. These results could be compared to other years of data to see if similar trends are found.

9. A collaboration with Naval Undersea Warfare Center (NUWC) Newport led to the adaptation and application of the Navy Acoustic Range Whale Analysis (NARWHAL) detection, classification, localization, tracking and noise analysis algorithms on data from the Southern California Anti-Submarine Warfare Range (SOAR). Fin whale tracks from select datasets recorded by NUWC Newport between October 2012 and November 2019 were generated,

while an ambient noise analysis and calibration effort was conducted on multiple datasets recorded at SOAR and PMRF by both NUWC Newport and NIWC Pacific.

[H2] Marine Mammal Monitoring on Navy Ranges (M3R) for Beaked Whales on the Southern California Anti-Submarine Warfare Range (SOAR) and the Pacific Missile Range Facility (PMRF), 2021

DiMarzio, N., S. Jarvis, R. Morrissey, K. Dolan, A. Muniz, A. Carroll, S. Vaccaro, and S. Watwood. 2022.

In the Pacific the Marine Mammal Monitoring on Navy Ranges (M3R) program maintains systems that automatically detect, classify and localize marine mammals in real-time on the U.S. Navy's deep-water Southern California Antisubmarine Warfare Range (SOAR) in Southern California and Pacific Missile Range Facility (PMRF) off Hawai'i. Long-term archive data collected on these ranges allows for numerous types of studies on species inhabiting the ranges, including the monitoring of abundance and distribution, behavioral responses to naval activities, and habitat usage. They also provide the opportunity to study ambient noise and soundscapes.

In FY21 the M3R program had four areas of focus for SOAR and PMRF:

1. *Long-term data collection and the evaluation of the distribution and abundance of Cuvier's beaked whales at SOAR and Blainville's and Cuvier's beaked whales at PMRF.* Data from 2010-2021 was evaluated at SOAR and data from 2011-2021 at PMRF. Distribution was analyzed using beaked whale Group Vocal Periods (GVPs) detected on range, and the GVPs were converted to number of animals to estimate abundance. The Cuvier's beaked whales at SOAR exhibit a clear seasonal pattern, with the highest numbers in May, followed by the December/January timeframe. The numbers are lowest in September, followed by a less pronounced drop in March. A trend analysis shows that the sample mean number of GVPs per hour and sample mean abundance per hour has significantly dropped ($p < 2.2e\text{-}16$) between the periods of 2011-2013 ($\mu_{GVP} = 4.02$, $\mu_{Abund}=45.8$) and 2018-2020 ($\mu_{GVP} = 3.11$, $\mu_{Abund}=35.4$), though the mean # GVPs ($\mu_{GVP} = 1.72$) and mean abundance ($\mu_{Abund}=19.5$) in 2015 is lower than either of these time periods. At PMRF, the seasonal distribution of Blainville's beaked whales peaks in January and May through July, while it is lowest in September, with another dip in March. Cuvier's beaked whales, however, peak in March, during one of the low points for Blainville's beaked whales, and then the numbers drop through to September, when they are lowest. They then start to increase until reaching the March peak. Though both species reach peaks at different times, their numbers are both lowest in September. The trend analysis for Blainville's beaked whales at PMRF shows that the sample mean number of GVPs per hour and sample mean abundance per hour has significantly increased ($p < 2.2e\text{-}16$) between the periods of 2012-2014 ($\mu_{GVP} = 0.37$, $\mu_{Abund}=8.0$) and 2018-2020 ($\mu_{GVP} = 0.76$, $\mu_{Abund}=18.8$). Similarly, the sample mean number of Cuvier's beaked whale GVPs per hour has significantly increased ($p < 2.2e\text{-}16$) between the periods of 2012-2014 ($\mu_{GVP} = 0.04$) and 2018-2020 ($\mu_{GVP} = 0.26$). Note that the detection statistics have not yet been applied to the GVPs at SOAR or PMRF, and detection statistics for Cuvier's beaked whales have not yet been calculated at PMRF. Calculating Cuvier's beaked whale detection statistics

at PMRF and improving the existing detection statistics at PMRF (for Blainville's) and SOAR (for Cuvier's) should provide more accurate estimates.

2. *Accuracy analysis of the M3R low-frequency detector algorithm at SOAR in coordination with the Naval Information Warfare Center (NIWC).* The accuracy of localizations of low-frequency (LF) calls automatically generated by the M3R system installed at the SOAR was analyzed by comparing LF localizations extracted from M3R archive files to fin whale detections and localizations generated by researchers at the Naval Information Warfare Center (NIWC), San Diego through their post-processing of whole range acoustic recordings (M3R packet recorder data) for select days. The initial comparisons between the M3R and NIWC localizations were disappointing, but they identified a processor loading problem within the M3R cluster at SOAR caused by a large amount of dolphin vocal activity, particularly at night. Reprocessing of just the M3R LF spectrogram data (alone) through the LF association/localization code produced tens of thousands of LF posits, resulting in closer parity between NIWC fin tracks and M3R LF tracks. When overlaid, the M3R posits exhibit more scatter than the NIWC localizations, likely because the timing resolution of the M3R LF detector (170.67 ms) is much coarser than the timing resolution of the NIWC fin detector. The results demonstrate that M3R's LF localization routine can effectively localize calls from several baleen species, and identified steps that can be taken to improve the accuracy of the M3R LF detection and localization.

3. *Validation of the "sprinkle analysis" method to extract ambient noise from M3R archives by comparison with broadband recordings analyzed by NIWC*. A method has been developed to automatically extract ambient noise curves from M3R binary Fast Fourier Transform (FFT) archive files by averaging "single-bin" detections (detections with just a single bin about threshold) over time. This method was validated in collaboration with researchers from NIWC by comparison of the ambient curves generated by the M3R sprinkle analysis with ambient noise curves derived by NIWC from analysis of broadband recordings. Correction factors were empirically derived to align the shapes of the overlaid curves, resulting in close matches between the two. The results validate the sprinkle analysis method, though future work should include determination of system transfer functions to convert the output of the sprinkle analysis to receive levels. The sprinkle analysis will provide a straightforward way to leverage years of M3R archive files collected on the ranges to analyze the spatio-temporal distribution and long-term trends of the ambient on the Navy's undersea ranges.

4. *Support of on-site field exercises at SOAR and PMRF with real-time monitoring using the M3R system.* In FY21 M3R conducted two field tests at SOAR (October 2020 and September, 2021) in collaboration with Marine Ecology and Telemetry Research (MarEcoTel), and one field test at PMRF (in August, 2021) with Robin Baird of the Cascadia Research Collective. During these field exercises M3R team members use the M3R system to direct on-water researchers to the locations of animals, where they collect photos for photo-ID catalogs, behavorial data, biopsy data, and potentially place satellite tags on animals. At SOAR, additional planned efforts were cancelled due to COVID related travel restrictions. The focus at SOAR was on Cuvier's beaked whales and fin whales, and during the two field tests both species were acoustically detected, along with blue whales, common dolphins, and unidentified dolphins and baleen whales. The Cuvier's beaked whales, fin whales, and blue whale were all visually verified. At PMRF the following species were acoustically detected:

Blainville's and Cuvier's beaked whales, sperm whales, melon-headed whales, short-finned pilot whales, false killer whales, bottlenose dolphins, rough-toothed dolphins, Risso's dolphins, Fraser's dolphins, and unidentified dolphins and baleen whales. The Blainville's, beaked and melon-headed whales, and bottlenose and rough-toothed dolphins were visually verified, and a total of eight satellite tags were placed on four different species. M3R archive data and broadband recordings are also collected during the field tests.

[H3/S4] Effectiveness of Navy Lookout Teams in Detecting Cetaceans

Oedekoven, C., and L. Thomas. 2022.

The United States (US) Navy uses lookouts (LOs) to detect objects in the water in the vicinity of ships. One class of object that LOs are trained to detect is marine mammals[2]; this forms an important component of the Navy's procedures for marine mammal mitigation during training activities[3]. As well as dedications of marine mammals by these LOs, detections of marine mammals may also be made by other members of the ship's crew such as officers on the bridge ("watchstanders") or sonar technicians, although acoustic detections require visual confirmation. We refer to these personnel together as the "lookout team" (LT). The primary goal of this project was to determine how effective LTs are at detecting marine mammals before they entered a defined set of mitigation ranges during mid-frequency active sonar training activities. These ranges were 200, 500 and 1,000 yards. A secondary goal was to compare this effectiveness with that of trained marine mammal observers (MMOs).

In collaboration with Navy environmental personnel, we developed a field protocol for at-sea experiments, where MMOs set up trials by locating marine mammals around Navy ships training with mid-frequency active sonar and determined whether these animals were detected by the LT. We also developed new analytical methods that allow estimation of the probability of animals approaching to within a specified mitigation range without being detected (probability of remaining undetected, PrU). These methods include a model for the surfacing pattern of animal pods[4], and for the range-dependent probability of detecting a pod each time it surfaces. Crucially, the methods allow us to account for the possibility that animal pods may remain undetected by both MMOs and the LT. The methods are flexible in allowing for various patterns of animal surfacing and various experimental configurations (in terms of communication between MMO and LT positions and whether repeat surfacings of the same pod are recorded). They are, however, simplistic in assuming that there is no measurement error (in surfacing location, taxon designation and whether duplicate detections are correctly assigned), that pods only move in the vertical plane (i.e., there is negligible horizontal movement during the period when the pod is within observation range), and that the ship moves at

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[2] Seals and turtles are also included in mitigation for various activities; however, they were not included in this study.

[3] The Navy's required mitigations for each training activity are described in each Letter of Authorization (LOA), and lookout configurations are dependent on the type of ship and training activity (see AFTT and HSTT Training LOAs; Section 6(a)(2)) (NMFS 2019, 2020).

[4] We use the term "pod" to refer to a group of one or more marine mammals. This term is typically used only for cetaceans but, as we document lower down in the report, there were not enough pinniped detections to include them in the analysis.

constant speed in a straight line. We tested the new analytical methods using computer simulation and found they generally produce unbiased estimates when the model assumptions are met, although in some circumstances (including those in our at-sea study) it is not possible to estimate both detectability and surfacing pattern; in this situation if the parameters governing surfacing pattern are known then unbiased estimation of detectability, and hence PrU, is possible.

A total of 27 embarks were conducted between 2010 and 2019, mostly on destroyer class ships. These generated 716 valid sightings of animal pods. Each sighting consisted of one or more detection of a marine mammal pod by the MMO and/or LT positions; to be valid there had to be enough information recorded to derive a taxonomic code at the level needed for analysis (see below), pod size and, for each detection, a location (relative to the ship) and an observer position. There were no valid acoustic detections, and so all LT detections were generated by the LOs or watchstanders. Some species of small cetacean are known to approach ships and "bowride"; after discussion with Navy environmental personnel it was decided to exclude detections of pods observed during the sighting to engage in bowriding behavior. There were 46 such sightings, with first detections predominantly made at close ranges. After excluding these, 670 sightings remained.

Our data collection protocol asked MMOs to prioritize new sightings over repeated detections (resights) of an already-sighted school, and so resights were not recorded consistently. We therefore used analytical methods that require data only on the first detection of a pod by each position. Analysis at species level was not possible because of limited sample size, and because many sightings were not identified using a taxonomic code that refers to species, but instead to a higher taxonomic level such as "large whale" or "dolphin"[5]. We therefore divided the data into four groups according to similarity in surfacing pattern and detectability: rorquals (i.e., large baleen whales), sperm whales, small cetaceans in small pods (6 or less) (SCSP) and small cetaceans in large pods (more than 6) (SCLP). We assumed the parameters governing surfacing pattern for each group were known, and we used values derived from the literature. For the sperm whale group, for which there were only two sightings, we used the detectability parameters estimated for rorquals. There were not enough detections of pinnipeds for us to estimate range-dependent probability of detection from the detection data and, unlike sperm whales, we elected not to use the estimated detectability parameters from one of the other groups; hence, our results only cover cetaceans.

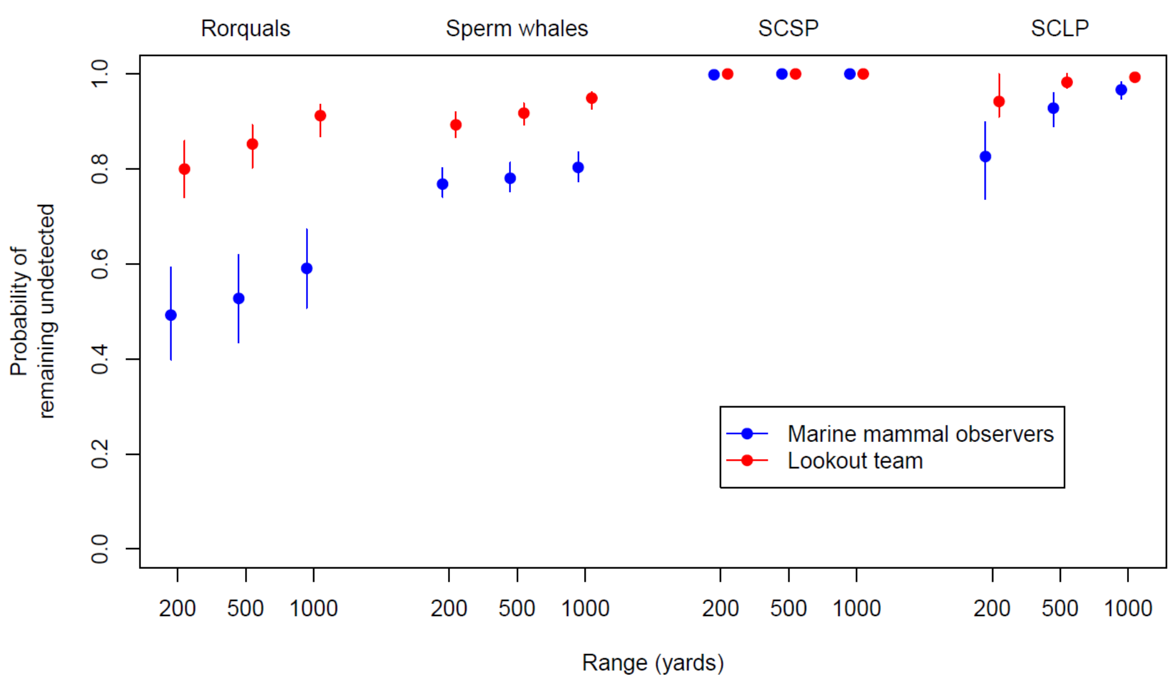
Before undertaking the modelling, we performed some exploratory analyses, including calculating a simple distance-specific index of effectiveness at 200, 500 and 1,000 yards (yds) for rorquals, SCSP and SCLP. For this analysis, we quantified LT effectiveness as the number of pods detected by the LT *before* they enter within the mitigation range divided by the total number of pods thought to have entered within the mitigation range (as estimated by the number seen by the LT or MMOs within a given distance of the ship's track). We speculate that this provides an upper bound on absolute effectiveness, because it does not take account of pods that pass through the mitigation zones undetected by either position. Estimated effectiveness was highest for rorquals: 0.35, 0.21 and 0.13 at 200, 500 and 1,000 yds for the LT and 0.74, 0.70 and 0.54 respectively for MMOs. It was lowest

[5] A full list of taxonomic codes is given in Appendix A. One reason that identification to species level was sometimes not possible was that, unlike many research cruises, Navy ships did not approach pods in order to confirm species identification.

for SCSP: 0.03, 0.03 and 0.02 respectively at 200, 500 and 1,000 yds for the LT and 0.25, 0.29 and 0.14 respectively for MMOs. The estimates for SCLP were similar to SCSP for the LT but higher than SCSP for MMOs.

Results from the modelling analysis to obtain PrU are summarized graphically in the figure on the next page. For each group, we estimated PrU at 200, 500 and 1,000 yards (yds). Please note that, although the results are quoted at these ranges, all of the data from each taxonomic group (including data beyond 1,000 yds) was used in deriving the results with these models. For rorquals the estimated PrU at 200 yds for the LT was 0.80 (95% confidence interval (CI) 0.74-0.86), rising to 0.91 (95% CI 0.87-0.94) at 1000 yds. PrU is the complement of effectiveness, so estimated absolute effectiveness was 1-0.80=0.20 at 200 yds and 1-0.91=0.09 at 1,000 yds. As expected, these values are slightly lower than the simple distance-specific index of effectiveness quoted in the previous paragraph (and this pattern held true for all such comparisons). MMOs were estimated to be considerably better, with PrU at 200 yds of 0.49 (95% CI 0.40-0.59) and at 1,000 yds of 0.59 (95% CI 0.51-0.67).

Taking the estimated detectability parameters and applying them to sperm whales, where time spent underwater is considerably higher, led to PrU for the LT of 0.89 (95% CI 0.87-0.92) at 200 yds and 0.95 (95% CI 0.93-0.96) at 1,000 yds. MMO PrU for sperm whales was 0.77 (95% CI 0.74-0.80) at 200 yds and 0.80 (95% CI 0.77-0.84) at 1,000 yds. Hence, in this case the difference between LT PrU and MMO PrU was smaller because the long dive times place an insurmountable constraint on any visual observation position, no matter how good.



Estimated probability that a pod of marine mammals of the taxonomic group shown along the top remains undetected by the Navy lookout team (blue) or marine mammal observers (red) at ranges of 200, 500 and 1000 yards from the ship. Dots show estimates and vertical lines give 95% confidence limits. Note that the sperm whale results assume their detectability while on the surface is the same as rorquals.

For small cetaceans, many of the first detections by both LT and MMO positions were at very close ranges, well within the smallest mitigation range of 200 yds, even after bowriding pods were removed. Because of this, for the SCSP group, the estimated PrU was close to 1 at all mitigation ranges tested and for both positions. We speculate that this result was caused by a combination of (a) genuinely low detectability combined with the surfacing pattern of this group, (b) fast and possibly responsive movement (attraction to the boat) by some pods, which violates a model assumption, (c) some rounding of detection distances and possibly angles, which violates another model assumption. For the SCLP group, which are assumed to have a surfacing pattern that makes them more available for detection, results improved slightly compared to the SLSP group. Estimated LT PrU for this group was 0.94 (95% CI 0.91-1.00) at 200 yds and 0.99 (95% CI 0.99-1.00) at 1,000 yds. The equivalent estimates for MMOs were 0.83 (95% CI 0.74-0.90) at 200yds and 0.97 (95% CI 0.95-0.98) at 1,000yds. Overall, for small cetaceans, we conclude that PrU is high (and hence effectiveness low) across pod sizes, caused by a combination of low detectability of small pods and possibly responsive movement of some taxa within the small cetacean groups.

We summarize our findings as follows:

1. Based on the data and analyses presented here, the ship's lookout team (LT) have approximately an 80% chance of failing to detect a pod of large baleen whales (rorquals) before they come closer than a mitigation range of 200 yards. This probability of a pod remaining undetected (PrU) rises to 85% at 500 yards and 91% at 1,000 yards.

2. The marine mammal observers (MMOs) performed better for this taxonomic group: for example, the PrU at 200 yards was lower at 49%. Note that the MMO team consisted of two dedicated observers while the LT consisted varying number of LOs depending on the type of ship and the training activity the ship was engaged in.

3. For species (sperm whales) with longer dive times but the assumed same detectability as rorquals, the PrU for both LT and MMOs was estimated to be higher (e.g., 89% for LT and 77% for MMOs at 200 yards), with less difference between the LT and MMOs.

4. For small cetaceans the majority of first detections of a pod (particularly those made by the LT) took place at very close range regardless of pod size. Estimated PrU for small pods (1-6 individuals) was close to 100% for any range, while for large pods this probability was lower for 200yds at 94% for the LT and at 83% for MMOs and for 500 yds at 98% for the LT and 93% for the MMOs. Small cetacean pods are genuinely difficult to detect, but in addition a limitation of our model was that it assumed no horizontal movement while some small cetaceans are attracted to ships and can move quickly (although we excluded pods where bowriding behavior was noted explicitly). Despite this it seems clear that PrU is high for small cetaceans.

5. We did not estimate PrU for beaked whales as none were recorded in the surveys. However, given they are not as detectable as sperm whales but have similar dive patterns, we would expect their PrU to be higher than sperm whales.

6. Our analyses assumed that the average surfacing pattern is known for each taxonomic group and used values taken from the literature. In reality, surfacing pattern varies by species and will likely differ from literature values. We undertook some sensitivity analyses and found that results were largely the same, except for sperm whales where assumptions about dive pattern made some difference to the predicted PrU. Overall our findings are unlikely to differ substantially if uncertainty and heterogeneity in surfacing could be included. Deviation of ship trajectory from the straight-line constant-speed assumption will also have some effect on results, but ship trajectory was unknown to us.

7. If further data collection were envisaged in the future, we would encourage further revision and tightening of the data recording procedures, in collaboration with the analysts.

8. Further analytical developments could include incorporation of responsive animal movement, changing ship trajectory and measurement error.

[H4] Small-boat Surveys and Satellite Tagging of Odontocetes on the Pacific Missile Range Facility, Kaua‘i, in August 2021

Baird, R.W., C.J. Cornforth, K.A. Wood, S.E. Vasquez, A.E. Harnish, and M.A. Kratofil. 2022.

As part of a long-term U.S. Navy-funded marine mammal monitoring program, from 1-14 August 2021, a combination of boat-based field effort and passive acoustic monitoring was carried out on and around the underwater hydrophone ranges of the Pacific Missile Range Facility (PMRF). The effort was timed to occur immediately prior to the start of Phase B of a Submarine Command Course, to allow for collection of movement and dive data that could be used to examine exposure and response of cetaceans to Navy mid-frequency active sonar (see Henderson et al. 2021). This interim field survey report provides a summary of boat-based survey methodology, survey effort, encounters, and satellite tags deployed. Thirteen days of field effort were funded by the U.S. Navy, and an additional day was funded by NOAA Fisheries. Over the 14 days the research vessel covered 1,252 km of trackline over 82.2 survey hours. Access to PMRF was limited on three of 14 days due to live fire exercises. Survey effort was broadly spread across the southern one-third of PMRF, to the south of PMRF, and off the south shore of Kaua‘i. There were 35 encounters with nine species of marine mammals. A group of approximately 24 Fraser’s dolphins (*Lagenodelphis hosei*) were encountered, the first sighting of this species off Kaua‘i or Ni‘ihau in Cascadia Research Collective’s (CRC’s) field effort off these islands over 13 prior years and 24,224 km of effort (Baird 2016; Baird et al. 2021). There was a sighting of a group of seven Blainville’s beaked whales (*Mesoplodon densirostris*), only the seventh sighting of this species in CRC’s prior work off of Kaua‘i or Ni‘ihau. In addition, there was one sighting each of false killer whales (*Pseudorca crassidens*), and a Hawaiian monk seal (*Neomonachus schauinslandi*), three sightings of spinner dolphins (*Stenella longirostris*), four sightings of short-finned pilot whales (*Globicephala macrorhynchus*), five sightings of melon-headed whales (*Peponocephala electra*), six sightings of common bottlenose dolphins (*Tursiops truncatus*), and 13 sightings of rough-toothed dolphins (*Steno bredanensis*). Thirteen of the sightings (37%) were cued by acoustic detections from the Navy’s hydrophone range, including the one sighting of Blainville’s beaked whales and four sightings of melon-headed whales. In total, four genetic samples were obtained (one each from a Blainville’s beaked whale and a melon-headed whale, and two from false killer whales), and 40,161 photographs were taken for individual and species identification, although individual photo-identification matching has not been undertaken. Fourteen satellite tags were deployed on six different species, including 12 depth-transmitting SPLASH10-F (Fastloc®-Global Positioning System (GPS)) tags, one location-only SPOT6 tag, and one depth-transmitting SPLASH10 tag. One of the SPLASH10-F tags failed upon impact, but location data were received from the other 13 tags, and dive data were obtained from 11 of the 12-remaining depth-transmitting tags. Data from all of the tagged individuals overlapped temporally with Phase A of the SCC, and 11 of them overlapped temporally with Phase B of the SCC. Some of the tagged individuals remained on or close to PMRF during the duration of the tag deployments.

[S1/S3/S5] Passive Acoustic Monitoring for Marine Mammals in the SOCAL Range Complex April 2020–2021 and Abundance and Density Estimates from CalCOFI Visual Surveys 2004–2021

Rice, A.C., J.S. Trickey, A. Giddings, M.A. Rafter, S.M. Wiggins, K.E. Frasier, S. Baumann-Pickering, and J.A. Hildebrand. 2022.

Passive acoustic monitoring was conducted in the Navy's Southern California Range Complex from April 2020 to 2021 to detect marine mammal and anthropogenic sounds. High-frequency Acoustic Recording Packages (HARPs) recorded sounds between 10 Hz and 100 kHz at four locations: two west of San Clemente Island (1,300 m depth, site E and 1,100 m depth, site H) and two southwest of San Clemente Island (1,300 m depth, site N and 1,200 m depth, site U). With the offshore expansion of the SOCAL range, future noise monitoring will be improved by the deployment of a recorder west of San Nicolas Island (site SN). This new site will replace site U, which is located in the Mexican Exclusive Economic Zone where instrument deployment is difficult.

While a typical southern California marine mammal assemblage is consistently detected in these recordings (Hildebrand et al., 2012), only beaked whales were analyzed for this report. The low-frequency ambient soundscape and the presence of Mid-Frequency Active (MFA) sonar and explosions are also reported.

Ambient sound levels were highest for frequencies greater than ~200 Hz at site E and lowest at site U, likely related to local wind. Peaks in sound levels at all sites during the fall and winter are related to the seasonally increased presence of blue whales and fin whales, respectively.

For marine mammal and anthropogenic sounds, data analysis was performed using automated computer algorithms. Frequency modulated (FM) echolocation pulses from Cuvier's beaked whales were regularly detected at all sites, but were detected in much higher numbers at sites E and H. At site E, detections were highest in December 2020, while at site H they peaked in October and November 2020. Hubbs' beaked whale FM pulses (previously referred to as BW37V; Rice et al. 2021) were only detected at site H in November 2020 and January 2021. The FM pulse type, BW43, thought to be produced by Perrin's beaked whale (Baumann-Pickering et al., 2014), was detected intermittently at sites H and N, and throughout the recording period at site U. No other beaked whale signal types were detected.

Two anthropogenic signals were detected: MFA sonar and explosions. MFA sonar was detected at all sites with peaks in May and November 2020 and in February and April 2021. Site H had the most MFA sonar packet detections normalized per year, while site N had the highest cumulative sound exposure levels. Site E had the lowest number of sonar packet detections, while site H had the lowest maximum cumulative sound exposure level. Explosions were detected at all sites, but were highest in December 2020 and February 2021 at site H. At site H, temporal and spectral parameters suggest association with fishing, specifically with the use of seal bombs.

Cetacean distribution, density, and abundance in the Southern California Bight were assessed through visual surveys during quarterly California Cooperative Oceanic Fisheries Investigations (CalCOFI) cruises from 2004 to 2021. Abundance and density estimates were developed for nine commonly-sighted marine mammal species. Fin whales were the most often sighted mysticete species, while short-beaked common dolphins were the most often sighted odontocete. Blue and fin whale abundance was highest in summer and fall, while humpback and grey whale abundance, as well as abundance for all odontocete species, was highest in winter and spring. In the CalCOFI study area, humpback whales, bottlenose dolphins, and common dolphins show a potential increase in abundance over time, while Dall's porpoise abundance has declined in recent years.

[S2] Cuvier's Beaked Whale and Fin Whale Surveys at the Southern California Offshore Anti-Submarine Warfare Range (SOAR)

Schorr, G.S., B.K. Rone, E.A. Falcone, E.L. Keene, D.A. Sweeney, and S.N. Coates. 2022.

The Southern California (SOCAL) portion of the Hawaii-Southern California Training and Testing (HSTT) area (SOCAL TR) is one of the United States Navy's most active training areas, particularly for mid-frequency active sonar (MFAS). Much of SOCAL lies within the Southern California Bight, a productive oceanographic region that hosts a wide variety of marine species. As part of an ongoing study of the distribution and demographics of several marine mammal species within SOCAL, we conducted 17 days of survey effort from 3 September 2021 to 15 November 2021, specifically focusing on the Southern California Anti-Submarine Warfare Range (SOAR). The primary goal of these surveys was sighting, photographing, and collecting biopsy samples from Cuvier's beaked whales (*Ziphius cavirostris*) and fin whales (*Balaenoptera physalus*). With combined effort from ancillary projects funded by the U.S. Navy's Living Marine Resources program, we had 127 sightings of cetaceans, including 16 sightings totaling 44 Cuvier's beaked whales and 42 sightings totaling 67 fin whales. Preliminary reconciliation of identification photographs of Cuvier's beaked whales from directed effort and two opportunistic sightings in 2021 included at least 30 unique individuals, which were sighted on up to three different days during the year. Twelve of these whales (40%) had previous sighting histories at SOAR, including two females that were sighted with their first calves in the study. Identification photos of fin whales from directed and opportunistic data collection in 2020 (n = 93), as well as opportunistic collections from earlier years that had not been previously submitted to our catalog (n = 201), were processed in 2021. This collection brings our US West Coast fin whale catalog to 1,250 individuals, of which 760 have sighting histories in Southern California. Nine genetic samples were collected in 2021, four from Cuvier's beaked whales and five from fin whales.

Labor originally intended to support 2021 field effort was partially re-tasked (in consultation with the Navy) to analyses of previously collected data, given the relatively limited data collected in 2020 and 2021. These included a comparison of 25 Cuvier's tracks using three data filtering methods (none, Douglas Distance-Angle-Rate (DAR) filter, and the Freitas Speed-Distance-Angle (SDA) filter) and two spatial movement models (the Continuous-Time Correlated Random Walk {CTCRW} and the continuous time state-spaced model 'foieGras') that have been used to standardize Argos location data from numerous marine mammals, as well as a comparison of the modeled locations and FastLoc GPS positions for three tags that provided both location data types. We found that applying the DAR filter to raw Argos location data produced the most consistent tracks between the two models at three different time steps, and that applying the DAR filter and then modeling positions with CTCRW produced location estimates that were most similar to GPS positions from the tag.

[S6] Beaked Whale Cruise off Baja California, Mexico [Henderson et al. 2022]

In November 2021, an expedition was conducted off the coast of Baja California, Mexico to relocate the unknown species of beaked whales encountered in 2020. Daily non-systematic searches were carried out both in the area where the 2020 group was observed as well as closer to shore off San Quintin. An apparent beaked whale hotspot was discovered in the nearshore waters, with nine beaked whale individuals or groups sighted. However, weather conditions and animal behavior precluded close approaches to identify many of the sightings to species or to obtain photo-ids or biopsy samples. However, two encounters were identified as Cuvier's beaked whales (*Ziphius cavirostris*). In addition to the beaked whales, many other species were also encountered, including short-beaked common dolphins (*Delphinus delphis*), Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), bottlenose dolphins (*Tursiops truncatus*), blue whales (*Balaenoptera musculus*), humpback whales (*Megaptera novaeangliae*), Bryde's whales (*Balaenoptera edeni*), and gray whales (*Eschrichtius robustus*). Future efforts will include a return to the hotspot to determine how persistent it is over time, and to identify the species of beaked whales that utilize the area.

[N1/G2] Characterizing the Distribution of ESA-Listed Salmonids in the Northwest Training and Testing Area with Acoustic and Pop-Up Satellite Tags

Smith, J.M., and D.D. Huff. 2022.

The Northwest Fisheries Science Center is currently conducting a study to characterize the occurrence of Chinook salmon within the Northwest Training and Testing area (NWTT). To date, we have surgically implanted acoustic transmitters into Chinook salmon along the coast of Washington (n = 142) from May to August 2019, near Kodiak, AK (n = 80) in October 2020, near Yakutat, AK (n = 32) in March 2021, and near Chignik, AK (n = 36) in August 2021. To detect acoustically tagged fish we deployed and serviced acoustic receivers along the coast of Washington (n = 107) in a 4.5 km grid from 3 nm to 10 nm offshore within the Olympic Coast National Marine Sanctuary (OCNMS) in 2019 to 2020. Receiver orientation was changed to maximize the detection of Chinook salmon tagged in Alaska in July 2020 to two dense receiver lines (North Jetty line, n = 42, Long Beach line, n = 34, 1.25 km spacing) and one sparse receiver line (Willapa line, n = 8, 4 km spacing) perpendicular to the coast. Additionally, four receivers were deployed across the mouth of the Columbia River in July 2020. In September 2021 a line of receivers was deployed north of Grays Harbor extending diagonally southward to Grays Canyon (Grays Canyon line, n = 10, 5 km spacing). Stock origins analysis using genetics indicated that 11 evolutionary significant units (ESUs) of Chinook salmon were captured along the coast of Washington. This included three ESUs that are listed as Endangered Species Act (ESA) threatened: Lower Columbia River (55.8%), Willamette Spring (2.2%), and Snake River spring (0.6%). The origin of Chinook salmon captured in Kodiak, AK consisted of six ESUs. This included two ESUs that are listed as ESA threatened: Willamette Spring

(6.3%) and Lower Columbia River (3.6%). The origin of fish captured in Yakutat, AK consisted of five ESUs. This included two ESUs that are listed as ESA threatened: Willamette Spring (16.7%) and Lower Columbia River (3.7%). To date, we have detected 13.8% of Kodiak and 15.6% of Yakutat acoustically tagged Chinook salmon. Salmon tagged in Chignik are expected to be returning to rivers starting in 2022. Once the detection histories are final, we will examine the migration route, estimated amount of time, and detection month for each ESU of detected Chinook salmon that occurred within the NWTT.

[N2] Tagging Green Sturgeon with Acoustic Transmitters for Evaluation of Habitat Use Along the Washington Coast. Interim Report

Heironimus, L.B., M.T. Sturza, and S.M. Schade. 2022.

The Southern distinct population segment (DPS) of green sturgeon *Acipenser medirostris* is federally listed as a threatened species under the U.S. Endangered Species Act. Large aggregations of both the Northern DPS and Southern DPS of green sturgeon can be found congregating in Washington's coastal estuaries mid-summer. This provides a unique opportunity to capture and study this elusive species. Existing telemetric data indicates that these fish make long migrations along the Pacific Coast with a possible year-round presence in near-shore marine waters along Washington and Oregon's coastline. The U.S. Navy is interested in the occurrence of the threatened Southern DPS of green sturgeon in the Northwest Training and Testing (NWTT) study area, which is offshore of Washington, Oregon, and northern California.

Through a multi-agency collaborative effort, multiple acoustic receiver arrays were placed along the Pacific Northwest coast and estuaries to analyze the migratory patterns of green sturgeon and other migratory species, including an offshore acoustic receiver array along the coast of Washington and Oregon (funded by the U.S. Navy and operated by the National Oceanic and Atmospheric Administration, National Marine Fisheries Service [NOAA-NMFS], a freshwater array within and at the mouth of Grays Harbor, Washington (funded by the U.S. Navy and NOAA-NMFS, operated by Washington Department of Fish and Wildlife [WDFW]), a freshwater array within and at the mouth of Willapa Bay, Washington (funded by the U.S. Navy and NOAA-NMFS, operated by WDFW and NOAA-NMFS), and a freshwater array within the Columbia River estuary, Washington (funded by NOAA-NMFS, operated WDFW). WDFW's operations to capture and sample a total of 230 green sturgeon in Grays Harbor and Willapa Bay in 2020 and 2021 was also a multi-agency collaborative effort. The U.S. Navy funded the costs associated with acoustic tags implanted in 50 of the 110 total tagged fish, and the genetic analysis of all 188 fish analyzed, including 109 tagged fish (one tagged fished was not assigned to DPS due to an error in the field collecting the genetic sample). The U.S. Army Corps of Engineers provided 10 acoustic transmitters that were implanted in fish captured in Grays Harbor in 2020. NOAA-NMFS contributed funding the 2021 tagging operations, except WDFW provided the 50 acoustic transmitters implanted in fish captured during 2021.

During the 2020 tagging period, we (WDFW) attempted to tag only the first five fish of every 10 cm FL size range so that we could collect acoustic data across a range of sizes. After this goal was met, we tagged any fish captured in good condition to meet our tagging goal (2020 goal: 60 fish tagged, 2021 goal: 50 fish tagged). If a fish was in poor condition upon capture or too many fish were captured at the same time, fish were counted and released immediately to ensure survival – this resulted in 40 green sturgeon releases without any tags applied across both years. In total, we implanted VEMCO 69-kHz V16 acoustic transmitters in 110 green sturgeon and implanted Biomark 12mm Passive Integrated Transponder (PIT) tags in 185 green sturgeon in Grays Harbor and Willapa Bay, Washington. No green sturgeon mortalities were detected as a result of this study. Using a genetics technique involving single nucleotide polymorphism (SNP) assay data, 188 total fish were assigned to either the Northern DPS (n=134 fish; 71%) or Southern DPS (n=54 fish; 29%). Of the fish implanted with acoustic tags, 71 fish (65%) were assigned to the Northern DPS, 38 fish (35%) were assigned to the Southern DPS, and one fish was not assigned.

Initial exploratory analysis of the acoustic data indicates that some green sturgeon can be detected on the offshore acoustic receiver array year-round, with peak detections occurring around May. A majority of individual fish were detected on the offshore acoustic receiver array moving back and forth between the Columbia River estuary, Willapa Bay, and Grays Harbor during this period, though some individuals displayed long migrations up the coast and were detected off the coast of British Columbia. We intend to monitor the array for another year to explore differences in the spatial and temporal use of the offshore array between the Northern and Southern DPS of green sturgeon.

[N3] Autonomous Acoustic Recorder Monitoring for Southern Resident Killer Whales and Anthropogenic Noise in Washington Waters

Hanson, B., C.K. Emmons, M. Holt, and M.O. Lammers. 2022.

Autonomous passive acoustic recorders have been used for the past 15 years to monitor the coastal occurrence of Southern Resident killer whales (SRKW), other marine mammals, and anthropogenic noise in and adjacent to the Navy's NWRTC in Washington State. The five autonomous acoustic recorders in and adjacent to the Navy's NWTRC were successfully recovered in early September 2021 and new moorings were redeployed at each site. Recovery and redeployment of the recorders, which was originally scheduled for late July 2021, were delayed until September 2021 due to logistical complications associated with COVID-19 which also delayed data processing and analyses. Recent acoustic detections on the Juan de Fuca recorder suggested an increase in SRKW occurrence at the west entrance of the Strait of Juan de Fuca in the summer and fall months. This shift in occurrence is supported by a recent decrease in sightings in the inland waters of Washington and British Columbia as well as a recent increase in visual and acoustic detections in Canadian waters adjacent to the Juan de Fuca recorder in the summer and fall months. The significance of this occurrence shift is that SRKWs have recently begun spending substantially more time in an areas adjacent to the Navy's NWTRC.

[G1] Telemetry and Genetic Identity of Chinook Salmon in Alaska: Preliminary Summary of Satellite Tags Deployed in 2020–2021

Seitz, A.C., and M.B. Courtney. 2022.

Chinook salmon (*Oncorhynchus tshawytscha*) is an iconic species found throughout the North Pacific Ocean and supports invaluable subsistence, commercial and recreational fisheries. In addition to its importance to fisheries, Chinook salmon is an important food source for many apex marine predators, including endangered southern resident killer whales (*Orcinus orca*). Currently, coast-wide changes in Chinook salmon population demographics and production have been documented from western

Alaska to California, including several Evolutionarily Significant Units (ESUs) from the U.S. Pacific Northwest that are protected under the U.S. Endangered Species Act (ESA).

The U.S. Navy (Navy) conducts at-sea training in the Temporary Maritime Activities Area (TMAA) in the Gulf of Alaska (GOA). As part of the Marine Species Monitoring Program, the Navy is interested in understanding the overlap of occurrence between populations of Chinook salmon, particularly the ESUs that are listed under the ESA, and specific Navy training activities. This is challenging, as relatively little is known about the at-sea distribution and behavior of Chinook salmon, despite the fact that most individuals reside in the ocean for the majority of their lives. Therefore, an improved understanding of the distribution and behavior of Chinook salmon in the marine environment is important when addressing potential interactions between this species and specific Navy exercises within portions of the TMAA.

To qualitatively describe the spatial distribution, movement, vertical distribution, occupied habitat, and natural mortality of Chinook salmon in the GOA, we attached pop-up satellite archival tags (PSATs) to individuals near Chignik, AK (n = 20), Kodiak, AK (n = 20), and Yakutat, AK (n = 20) in 2020–2021, and collected tissue samples for genetically determining stock-of-origin of each tagged fish.

Of the 60 PSATs deployed, data were transmitted by 57 tags, providing >3,720 days of data. Reporting locations of tags were widespread across the eastern North Pacific Ocean, ranging as far west as the Bering Sea to as far east as the U.S. Pacific Northwest. Movement models suggested that the majority of tagged fish remained over the continent shelf within relatively close proximity (<500 km) to their tagging location. While occupying waters of the North Pacific Ocean, Chinook salmon occupied depths ranging from 0 to 464 m and experienced a thermal environment ranging from 1.8 to 19.0°C. Fifteen tagged Chinook salmon were inferred to have occupied the TMAA (~252 aggregated days) while at liberty (i.e., tag deployment to pop-up date). While occupying waters of the TMAA, Chinook salmon spent the majority of their time (58%) in waters over the continental shelf, and spent a minority of their time over the continental slope (22%) and basin (20%). In addition to providing information on the horizontal and vertical distribution of Chinook salmon, PSATs provided evidence of mortality of tagged fish caused by endothermic fish(s) (n = 17), an ectothermic fish (n = 1), marine mammals (n = 3), and unknown (n = 6) causes. Genetic analyses suggested that all tagged Chinook salmon were from populations originating in southern Southeast Alaska, British Columbia, Washington, and Oregon.

While this study contained a small sample size, the tagged Chinook salmon were comprised of individuals from many populations extending from Southeast Alaska to the U.S. Pacific Northwest, making our results pertinent for many populations throughout North America, including stocks of concern and those listed under the ESA. The information about Chinook salmon gained in this study may be used to provide insights into important management issues in the North Pacific Ocean, including overlap between Chinook salmon and Navy training exercises in the GOA.

[G3] Report for the Pacific Marine Assessment Program for Protected Species (PacMAPPS) 2021 field survey

Crance, J.L., K.T. Goetz, and R.P. Angliss. 2022.

The Pacific Marine Assessment Program for Protected Species (PacMAPPS) survey occurred from 1 August to 26 August 2021, beginning and ending in Kodiak, AK. Over the course of the survey, a total of 2,330 km of on-effort tracklines were surveyed in suitable weather conditions, and a total of 667 sightings of marine mammals were documented (including duplicates and resights). Primary species sighted include North Pacific right, fin, humpback, killer, and sperm whales, and Dall's and harbor porpoise. Pinnipeds and rare birds (e.g., short-tailed albatross) were also recorded opportunistically. A total of 110 sonobuoys were deployed, of which 96 were successful deployments (i.e., sonobuoys transmitted correctly), for an overall success rate of 87.3%. Acoustically detected species were the same as those visually sighted. However, sonobuoys also recorded seismic airguns and vessel noise. A long-term bottom mounted passive acoustic recorder mooring in Barnabas Trough was retrieved and a new one deployed; the instrument recorded for a full year. A total of 20 CTD casts were conducted, and 119 nutrient and 8 salinity samples were collected. Additionally, sea surface temperature, fluorescence salinity, and wind speed were sampled continuously along the survey track, and data on the prey field were collected when possible, by the Acoustic Doppler Current Profiler (ADCP) and EK-80 echosounder.

B

2021 Publications and Conference Presentations from U.S. Navy-funded Monitoring

2021 Publications from U.S. Navy-funded Monitoring

Ampela, K., T.A. Jefferson, and M.A. Smultea. 2021. Estimation of in-water density and abundance of harbor seals. The Journal of Wildlife Management 85(4):706–712.

Baird, R.W., D.B. Anderson, M.A. Kratofil, and D.L. Webster. 2021a. Bringing the right fishermen to the table: indices of overlap between endangered false killer whales and nearshore fisheries in Hawai‘i. Biological Conservation 255.

Baird, R.W., S.D. Mahaffy, and J.K. Lerma. 2021b. Site fidelity, spatial use, and behavior of dwarf sperm whales in Hawaiian waters: using small-boat surveys, photo-identification, and unmanned aerial systems to study a difficult-to-study species. Marine Mammal Science 38(1):326–348.

Barlow, J., G. Cárdenas-Hinojosa, E.E. Henderson, D. Breese, D. López-Arzate, E. Hidalgo Pla and B.L. Taylor. 2021. Unique morphological and acoustic characteristics of beaked whales (*Mesoplodon* sp.) off the west coast of Baja California, Mexico. Marine Mammal Science 38:383–390.

Barlow, J., J.S. Trickey, G.S. Schorr, S. Rankin, and J.E. Moore. 2021. Recommended snapshot length for acoustic point-transect surveys of intermittently available Cuvier's beaked whales. The Journal of the Acoustical Society of America 149(6):3830–3840.

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Rice, A., A. Širović, J.S. Trickey, A.J. Debich, R.S. Gottlieb, S.M. Wiggins, J.A. Hildebrand, and S. Baumann-Pickering. 2021. Cetacean occurrence in the Gulf of Alaska from long-term passive acoustic monitoring. Marine Biology 168(5):1–29.

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Varghese, H.K., K. Lowell, J. Miksis-Olds, N. DiMarzio, D. Moretti, and L. Mayer. 2021. Spatial analysis of beaked whale foraging during two 12 kHz multibeam echosounder surveys. Frontiers in Marine Science 8:654184.

Submitted/In Press

Falcone, E.A., E.L. Keene, E.M. Keen, J. Barlow, J. Stewart, T. Cheeseman, C. Hayslip, and D.M. Palacios. Submitted. Movements and residency of fin whales (*Balaenoptera physalus*) in the California Current System.

Henderson, E.E., J. Aschettino, M. Deakos, D. Engelhaupt, and G.C. Alongi. Submitted. Track behavior, dive behavior, and inter-island movements of satellite-tagged humpback whales in Hawai'i. Marine Ecology Progress Series.

Jacobson, E.K., E.E. Henderson, D.L. Miller, C.S. Oedekoven, D.J. Moretti, L. Thomas. Submitted. Quantifying the response of Blainville's beaked whales to US Naval sonar exercises in Hawaii. Marine Mammal Science.

Manzano-Roth, R., E.E. Henderson, G. Alongi, C.R. Martin, S. Martin, B. Matsuyama. Submitted. Dive characteristics of Cross-Seamount beaked whales from long-term passive acoustic monitoring at the Pacific Missile Range Facility. Marine Mammal Science.

2021 Conference Presentations from U.S. Navy-funded Monitoring

Clifton, C.2021 Emerging diseases in Hawaiian cetaceans: screening for beaked whale circovirus. NOAA Fisheries 7th Meeting of the Pacific Islands Marine Animal Response Network. 23 March 2021.

Emmons, C.K., M.B. Hanson, M.M. Holt, and A. Brewer. 2021. A comparison of EAR and SoundTrap performance for acoustic monitoring of resident killer whales. The Journal of the Acoustical Society of America 150:A283.

Guazzo, R.A., T.A. Helble, G.C. Alongi, C.M. Martin, S.W. Martin, and E.E. Henderson.2021 Acoustic cues: Fin whale singing behavior on PMRF. U.S. Navy Marine Species Monitoring Annual Meeting. Virtual. Oral Presentation.

Henderson, E.E., J. Barlow, G. Cárdenas-Hinojosa, D.C. Lopez-Arzate, D. Breese, and E. Hildago.2021 Beaked Whale Expedition off Baja, Mexico, November 2020. U.S. Navy Marine Species Monitoring Annual Meeting. Virtual. Oral Presentation.

Henderson, E.E., M. Deakos, J. Aschettino, D. Engelhaupt, G. Alongi, and T. Leota. 2021Final Report on Satellite Tagging of Humpback Whales at PMRF from 2017 – 2019. U.S. Navy Marine Species Monitoring Annual Meeting. Virtual. Oral Presentation.

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Martin, S.W. 2021 Tom Norris's contributions to the acoustic density estimation of minke whales near Kauai, Hawaii. The Journal of the Acoustical Society of America 149, A17. Presentation at the 180th Meeting of the Acoustical Society of America 8-10 June 2021 (Virtual).

Henderson, E.E., and T.A. Helble. 2021Standardizing Methods and Nomenclature for Automated Detection of Navy Sonar. Presentation at the Living Marine Resources Internal Progress Review Meeting, 16-19 November 2021.

Palacios, D.M. 2021. Here, there, and everywhere: tracking humpback whale movements and habitat use off the U.S. West Coast. Oregon Department of Environmental Quality, "Thirsty for Knowledge" Seminar Series, virtual presentation, 21 January 2021.

Palacios, D.M. 2021. Here, there, and everywhere: tracking humpback whale movements and habitat use off the U.S. West Coast. University of Rhode Island, Graduate School of Oceanography, Biological Oceanography "Bio@Noon" Seminar Series, virtual presentation, 27 January 2021.

Seitz, A.C., and M.B. Courtney. 2021. How often do large immature Chinook salmon occupy offshore waters? Alaska Chapter of the American Fisheries Society Annual Meeting, virtual conference, March 2021.

Seitz, A.C., and M.B. Courtney. 2021. Satellite tagging of Chinook salmon in the Gulf of Alaska. Alaska Marine Science Symposium, virtual conference, January 2021.

Seitz, A.C., M.B. Courtney, D. Huff, and J. Smith. 2021. Telemetry and genetic identity of Chinook salmon in Alaska. U.S. Navy Marine Species Monitoring Annual Meeting, virtual conference, April 2021.

C

Details of 2022 Monitoring Projects

Table C-1. 2022 Monitoring project details for Pacific Navy study areas/ranges: HSTT (HRC and SOCAL), MITT, NWTT, and GOA TMAA.

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 1)	Continuing or Proposed New Start
Location: Hawaii Range Complex (HRC)			
Title: **Long-Term Acoustic Monitoring Utilizing the Instrumented Range at PMRF** **Methods:** Analysis of archived PMRF hydrophone recordings **Performer:** SSC Pacific; NUWC Division Newport	• What are the long-term trends in occurrence of marine mammals (e.g., minke, humpback, fin, Bryde's, Blainville's BWs) on the PMRF instrumented 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 2006
Title: **Estimation of Received Levels of MFAS and Behavioral Response of Marine Mammals at PMRF** **Methods:** PAM (PMRF), satellite and GPS tagging, photo-ID, biopsy, visual survey. **Performer:** SSC Pacific; Cascadia Research Collective; HDR, Inc.	• What is the occurrence and estimated received levels of MFAS on 'blackfish,' humpback, minke, sperm and Blainville's BWs within the PMRF instrumented range? • What are the spatial-movement and habitat-use patterns of species that are exposed to MFAS, and how do these patterns influence exposure and potential responses? • What, if any, are the short-term behavioral responses of 'blackfish' and humpback, minke, sperm, and Blainville's BWs when exposed to MFAS/explosions at different levels/conditions at PMRF instrumented range?	#3: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species 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. #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 2011

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 1)	Continuing or Proposed New Start
Location: Hawaii Range Complex (HRC) (continued)			
Title: Use of a Conservation K-9 to Detect and Collect Marine Mammal Scat Samples – Feasibility Study **Methods:** Trained conservation K-9 nose, human visual survey, and drone **Performer:** Navy K-9 handler/owner, Conservation Dogs of Hawaii, UH Marine Mammal Program, UH Health and Stranding Program	• Can a Conservation K-9 detect marine mammal scat at-sea - and at what distance - in the MHI? • What, if any, consequences to marine mammals from anthropogenic activities can be detected in marine mammal scat in the MHI?	#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. #11: Evaluate behavioral responses of marine mammals exposed to Navy training and testing activities to support PCoD. #13: Assess existing data sets which could be utilized to address the current objectives[1].	New start in 2022
Title: Comprehensive Stranding Investigations for MITT and HRC	*(See this project under MITT, below)*		

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 1)	Continuing or Proposed New Start
Location: Southern California Range Complex (SOCAL)			
Title: **Cuvier's BW and Fin Whale Population Dynamics and Impact Assessment at the Southern California Offshore Antisubmarine Warfare Range (SOAR)** **Methods:** PAM, satellite tagging, photo-ID, visual survey **Performer:** Naval Undersea Warfare Center Newport; Marine Ecology & Telemetry Research	• What are the baseline population demographics, vital rates, and movement patterns for a designated key species in the SOCAL? • 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 BWs)?	#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: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species 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: **Southern California BW Occurrence** **Methods:** PAM (moored, glider, towed-array, drifting buoys), visual survey **Performer:** Scripps Institution of Oceanography (University of California San Diego); Oregon State University	• What is the distribution of BW occurrence in the waters within and outside the SOCAL?	#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: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species 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. #8: Application of passive acoustic tools and techniques for detecting, classifying, locating, and tracking marine mammals.	Continuing from 2009, with special focus on BW since 2020

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 1)	Continuing or Proposed New Start
Location: Mariana Islands Training and Testing (MITT)			
Title: Comprehensive Stranding Investigations for MITT and HRC **Methods:** Necropsy, disease screening, genetic testing, stomach content analysis **Performer:** University of Hawaii Health and Stranding Lab	• What are the temporal and spatial patterns of odontocete strandings in the Hawaiian and Mariana Islands between 2000 and 2021? • What are the causes of mortality associated with odontocete strandings in the Hawaiian and Mariana Islands between 2000 and 2021? • What is the prevalence of diseases (morbillivirus, circovirus, toxoplasmosis) in stranded marine mammals?	#4: Evaluate potential exposure of marine mammals and ESA-listed species to Navy training and testing activities.	Continuing from 2018
Title: **Sea Turtle Tagging in the Mariana Islands Training and Testing** **Methods:** Satellite tagging, visual survey **Performer:** PIFSC Marine Turtle Biology and Assessment Program	• 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 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 ESA-listed species in Navy range complexes, testing ranges, and in specific training and testing areas. #3: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species where Navy training and testing activities occur. #4: Evaluate potential exposure of marine mammals and ESA-listed species 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.	Continuing from 2013; final reporting in 2022

Project Description	**Monitoring Questions**	**Intermediate Scientific Objectives (numbered as per Figure 1)**	**Continuing or Proposed New Start**
Location: Mariana Islands Training and Testing (MITT) (continued)			
Title: **Beaked Whale Occurrence and Behavior in the Marianas** **Methods:** PAM **Performer:** HDR, Inc.; Cornell University	• What species of marine mammals, specifically beaked whales, are present in areas defined by the Navy as priority areas? • What are their spatial and temporal patterns of acoustic behavior?	#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: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species where Navy training and testing activities occur. #4: Evaluate potential exposure of marine mammals and ESA-listed species to Navy training and testing activities. #6: Establish the regional baseline vocalization behavior, including seasonality and acoustic characteristics) of marine mammals where Navy training and testing activities occur. #8: Application of passive acoustic tools and techniques for detecting, classifying, and tracking marine mammals[1].	New start in 2022
Title: **Pacific Marine Assessment Program for Protected Species (PacMAPPS)** **Methods:** Visual survey, PAM, photo-ID, biopsy and genetic sampling, satellite tagging **Performer:** PIFSC Cetacean Research Program; SWFSC Marine Mammal and Turtle Division; AFSC Cetacean Assessment and Ecology Program	• What is the occurrence, density, and population identity of marine mammals in various regions of the Pacific?	#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: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species where Navy training and testing activities occur.	Continuing from 2017

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 1)	Continuing or Proposed New Start
Location: Northwest Training and Testing (NWTT)			
Title: Characterizing the Distribution of Green Sturgeon in the Pacific Northwest **Methods:** Acoustic tagging **Performer:** Washington Department of Fish and Wildlife	• Where have acoustically tagged green sturgeon been detected on acoustic receivers deployed in Washington coastal and estuarine waters? • Do acoustically tagged green sturgeon demonstrate a predictive seasonal movement pattern between estuaries and coastal waters? • How frequently do tagged green sturgeon move between coastal and estuarine waters? • What is the typical range of distribution for acoustically tagged green sturgeon when occurring in Washington coastal 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 ESA-listed species in Navy range complexes, testing ranges, and in specific training and testing areas. #3: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species where Navy training and testing activities occur.	Continuing from 2020
Title: Distribution of Southern Resident Killer Whales and their Prey in the Pacific Northwest **Methods:** PAM, model development, visual survey, satellite tagging, analysis of archival data, acoustic pinger tagging glider, and stationary receivers **Performer:** NMFS Northwest Fisheries Science Center; University of Washington (School of Aquatic and Fisheries Sciences); Naval Undersea Warfare Center Keyport; Oregon State University	• What are the seasonal and annual occurrence patterns of Southern Resident killer whales relative to offshore Navy training ranges? • What is the oceanic distribution and seasonal variability of ESA-listed 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 sea turtles in Navy range complexes, testing ranges, and in specific training and testing areas. #3: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species 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, with 2020 focus on salmonids
Location: Northwest Training and Testing (NWTT) (continued)			

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 1)	Continuing or Proposed New Start
Title: **Vessel-Based Marine Mammal Surveys in Puget Sound, Washington** **Methods:** Visual survey **Performer:** Marine Ecology & Telemetry Research	• What marine mammal species are present in the area? • What is the seasonal occurrence and abundance/density of cetaceans in the study area? • Which and how do environmental variables affect the distribution and abundance of species in the 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 ESA-listed species in Navy range complexes, testing ranges, and in specific training and testing areas. #3: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species where Navy training and testing activities occur.	New start in 2022
Title: **Characterizing the Distribution of ESA-Listed Salmonids in Washington and Alaska** **Methods:** Acoustic tagging, biopsy **Performer:** NOAA Northwest Fisheries Science Center	• What is the oceanic distribution and seasonal variability of ESA-listed 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: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species where Navy training and testing activities occur.	Continuing from 2018

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 1)	Continuing or Proposed New Start
Location: Gulf of Alaska Temporary Maritime Activities Area (GOA TMAA)			
Title: **Telemetry and Genetic Diversity of Chinook Salmon in Alaska** **Methods:** Acoustic tagging, satellite tagging, biopsy **Performer:** University of Alaska Fairbanks; NMFS Northwest Fisheries Science Center	• What is the spatial distribution, movement, vertical distribution, population identity, occupied habitat, and natural mortality of Chinook salmon in the GOA TMAA?	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas. #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: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species where Navy training and testing activities occur.	Continuing from 2020
Title: **Pacific Marine Assessment Program for Protected Species (PacMAPPS)**	*(See this project under MITT, above)*		

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

[2] As continuing from 2018, this project is conceptually a refinement and continuation of 2017 **Project [N3]**, "Modeling the Offshore Distribution of Chinook Salmon in the Pacific Northwest." The updated project retains substantially the same monitoring questions.

Key: AFSC = Alaska Fisheries Science Center; BW = beaked whale; ESA = Endangered Species Act; GOA = Gulf of Alaska; GPS = Global Positioning System; HRC = Hawaii Range Complex; MFAS = Mid-frequency active sonar; MHI = Main Hawaiian Islands; MITT = Mariana Islands Training and Testing; NMFS = National Marine Fisheries Service; NOAA = National Oceanic and Atmospheric Administration; NWTT = Northwest Training and Testing; PAM = Passive Acoustic Monitoring; PCoD = Population Consequences of Disturbance; photo-ID = photo identification; PIFSC = Pacific Islands Fisheries Science Center; PMRF = Pacific Missile Range Facility; SOAR = Southern California Offshore Antisubmarine Warfare Range; SOCAL = Southern California; SSC = Space and Naval Warfare Systems Center; SWFSC = Southwest Fisheries Science Center; TMAA = Temporary Maritime Activities Area; UH = University of Hawaii.

D

Animal Telemetry Tag Types

Table D-1. Summary of animal tracking tag types used on U.S. Navy-funded monitoring projects in 2021.

Tag Name	Acronym/Model	Project #	Use[1]
Acoustic Coded Transmitters	VEMCO, V9; Innovasea, V16	N1/G2, N2	Tracks the behavior patterns of small and juvenile fish. These tags are particularly suited for seamless monitoring of salmon smolt migrations. Coded pingers send acoustic pulse trains that include a unique identification number that permits identification of the specific tag. These tags can be equipped with sensors to encode temperature, depth, or both. The expected detection ranges of tags are between 200 and 1200 m, and the tags have an expected battery life of 172 to 3,650 (10 years) days, depending on the battery size and power output (V7 = 136 dB, V8 = 144 dB, V9 = 145 dB) of the tag.
Location-only	LO	H4	Provides long-term tracking information via the Argos 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).
Passive Integrated Transponder	PIT	N2	Tracks individual organisms (in this report, sea turtles) using electromagnetically coded glass-encased microchips (i.e., reliable lifetime 'barcode' for an individual animal). The animal has to be caught and scanned; data are not transmitted
Pop-up Satellite Archival Tags	PSAT	G1, N1/G2	PSATs are used to track movements of (usually large, migratory) marine animals. A PSAT (also commonly referred to as a PAT tag) is an archival tag, or data logger, that is equipped with a means to transmit the collected data via the Argos system. Location, depth, temperature, oxygen levels, and body movement data are used to answer questions about migratory patterns, seasonal feeding movements, daily habits, and survival after catch and release.
Smart Position and Temperature	SPOT, SPOT6	H4, M1	Provides data on a variety of measurements, such as temperature, salinity, and depth.
SPLASH	SPLASH, SPLASH10, SPLASH10-F	H4	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. 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 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. SPLASH10-F tags are also equipped with a Fastloc-GPS receiver that provides locations approaching the quality of those obtained from traditional GPS receivers and can do so even when the tag is only at the surface for a very short period.

[1] References: Seitz and Courtney 2021; Smith and Huff 2020, 2022; DiMarzio et al. 2022; https://wildlifecomputers.com

Key: dB = decibel(s); GB = gigabyte; GPS = Global Positioning System; LIMPET = Low Impact Minimally Percutaneous Electronic; m = meter(s); SPOT = smart position and temperature