2020 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)

Prepared For and Submitted To

National Marine Fisheries Service
Office of Protected Resources

Prepared By

Department of the Navy

In accordance with
50 Code of Federal Regulations §218.75(d),
§ 218.95(e), § 218.145(f), and § 218.155(f)

1 April 2021

Citation for this report is as follows:

DoN (Department of the Navy). 2021. *2020 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).* Prepared by the Department of the Navy. Prepared for and submitted to National Marine Fisheries Service, Silver Spring, Maryland. April 2021.

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False-killer whale (*Pseudorca crassidens*) photographed by Jordan Lerma/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 the 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 are part of the NWTT Study Area; and the Gulf of Alaska Temporary Maritime Activities Area (GOA 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 2020. It presents results and progress made during the period of 1 January 2020 to 31 December 2020. 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 2020 with additional details in Section 2 and **Appendix A**. Section 3 lists 2021 Monitoring Goals.

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

- Several ongoing projects in the HSTT study areas resulted in peer-reviewed publications in 2020, including: Blue and Fin Whale Tagging and Analysis in Support of Marine Mammal Monitoring across Multiple Navy Training Areas, Odontocete Studies at the Pacific Missile Range Facility (PMRF), Cuvier's Beaked Whale Impact Assessment at Southern California Anti-submarine Warfare Range (SOAR), and Marine Mammal Monitoring at PMRF (see **Appendix B**).
- With regard to the conceptual framework categories, several projects in calendar year 2020 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 made strides toward assessing any population *consequences* resulting from these activities by investigating population trends.

Navy range specific scientific results include the following:

MITT

- Navy provided funding to University of Hawaii stranding program which made substantial progress setting up an operational in-house laboratory to screen for pathogens known to cause disease and death in stranded marine mammals and perform accurate tooth-aging of stranded specimens. They also performed an experiment examining deoxyribonucleic acid (DNA) degradation of cetacean tissues over the course of weeks and discovered a significant linear relationship that could serve as a powerful tool to estimate time of death in stranded specimens not freshly dead at the time of stranding.

- A four-day visual survey for humpback whales was performed around Farallon de Medinilla (FDM) in the northern Mariana Islands from 29 January to 1 February 2020. A total of 9 sightings of 10 unique individual whales were made; no mother-calf pairs were found. Individuals were seen on multiple days within the survey area and engaging in typical reproductive behavior, suggesting that FDM is used as breeding habitat and not only a migration corridor.

- The COVID-19 pandemic prevented the NMFS' Marine Turtle Biology and Assessment Program from conducting Navy-funded fieldwork. Instead, effort was focused on creating a web project within the Animal Telemetry Network (ATN) and formatting existing archived data for upload, advancing the project toward fulfilling its Public Access to Research Results (PARR) requirements.

HSTT HRC

- Nearly 3,000 hours of recordings collected from 62 bottom-mounted Pacific Missile Range Facility (PMRF) hydrophones between September 2019 and 2020 were used to estimate the abundance of baleen, beaked, and sperm whales on the range and to examine responses of minke whales and Blainville's beaked whales to mid-frequency active sonar (MFAS) transmission.

- Analysis of Marine Mammal Monitoring on U.S. Navy Ranges (M3R) acoustic data on PMRF collected from 2015 to 2020 indicate Blainville's beaked whale numbers appear to be relatively consistent across years, with peaks occurring in January, December, and June; changes in group vocal periods were also consistently observed with exposure to MFAS.

- Substantially 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 Submarine Command Course (SCC) training events at PMRF off Kauai, Hawaii as well as their exposure and potential response to MFAS during these events. The highest median levels in these close exposure cases were approximately 175 decibels reference to 1 microPascal (dB re 1µPa) and maximum modeled levels exceeded 200 dB re 1µPa. While the probability of reaching those maximum levels was quite low, these results indicate that in some cases odontocetes at PMRF may experience very high received levels (RLs).

- Identified core areas (50 percent kernel densities) for the resident Hawaiian populations of bottlenose dolphins and the western community of short-finned pilot whales; each population had different proportions of the core area overlapping with PMRF, suggesting exposure to MFAS varies substantially with species.

- Tracking results from 105 humpback whales tagged in Hawaii between 1995 and 2019 showed high density in the Maui Nui region and Penguin Bank, and extensive inter-island movements. The Maui Nui region was the most heavily used by humpbacks (maximum residency time of 23.1 days), likely because the majority of whales were tagged in that region. Migratory destinations were tracked for 12 humpback whales tagged off Maui, with seven whales going to northern British Columbia and southeastern Alaska, one going to southern British Columbia, and four going to the eastern Aleutian Islands.

- Final analysis and results of the Navy-wide lookout effectiveness study is expected by the end of 2021 and will be included in the 2022 annual report.

HSTT SOCAL

- As part of a collaborative effort between the U.S. Navy, National Oceanic and Atmospheric Administration (NOAA) Fisheries, the Sea Shepherd Conservation Society, and Mexican researchers, a vessel survey was conducted off Baja California in November 2020; researchers encountered a species of beaked whale with external morphological characteristics and a new echolocation pulse type that do not match any previously observed or recorded species, and therefore may represent a newly described species. One of four Navy funded passive acoustic devices is planned for future deployment in the same area this potential new beaked whale species was detected.
- Results from M3R analysis of beaked whale abundance trends at the SOAR confirmed field observations since 2006, that Cuvier's beaked whales prefer foraging in the western part of the range, likely due to high-quality foraging habitat, despite the presence of sonar.
- Because the COVID-19 pandemic and associated travel restrictions curtailed small-vessel field efforts at SOAR, some funds were re-allocated 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 beaked whales after exposure ceases. Research was also done on acquisition of drones for future aerial photographic studies (photo identification (photo-ID), body condition, etc.); analysis of Cuvier's dive behavior at SOAR, 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.
- Conducted in-depth follow up analyses of blue and fin whale tag data collected in SOCAL from 2014 to 2017, including ecological characteristics of whale movements; use of U.S. Navy training and testing areas and NMFS-designated Biologically Important Areas (BIAs) by tagged blue and fin whales, and site fidelity, residence, and re-visitation patterns of blue and fin whales at coastal hot spots, with implications for anthropogenic exposure risk.

- Analyzed data recorded by High-frequency Acoustic Recording Packages (HARPs) deployed at four sites in the Southern California Bight (SCB) from November 2018 to May 2020 to characterize the low-frequency underwater ambient soundscape; the ambient soundscape at all sites had spectral shapes with higher levels at low frequencies owing to the dominance of ship noise at frequencies below 100 Hertz (Hz) and local wind and waves above 100 Hz. Marine mammal echolocation and vocalizations for beaked whales, blue whales, and fin whales were also analyzed.
- Conducted new population census of hauled out Guadalupe fur seals. Deployed 65 satellite tags on Guadalupe fur seals (depth-sensing tags were deployed on adults and juveniles, and location-only tags were deployed on pups); foraging behavior was observed throughout the offshore area (>2,000-meter water depth) of SOCAL that was previously considered to be a transit corridor to and from Guadalupe Island.
- Deployed two Seagliders™ in the San Nicolas Basin on 7 February 2020 to acoustically survey for baleen and sperm whales; one glider (total deployment time 50 days) was flown in deep-water areas on the shelf slope and the abyssal plain, an area seldom surveyed for marine mammals. Blue, fin, humpback, and sperm whale vocalizations were detected.

NWTT

- Characterized the movements, residence time, connectivity, and habitat use of humpback whales in the Eastern North Pacific through the use of satellite telemetry, dive behavior, genetics, and photo-ID; historical tag track data for 81 humpback whales tagged off California, Oregon, and Washington between 2004 and 2019 indicated humpback affinity for continental shelf and shelf-edge habitat.
- Based on genetic profiles of the humpbacks tagged on the West Coast, the majority of individuals from southern and central California (64 percent) assigned with highest likelihood to the Central America Distinct Population Segment (DPS), whereas the largest proportion of individuals from northern California/Oregon (47 percent) and northern Washington (48 percent) assigned with highest likelihood to the Hawaii DPS. The remaining individuals assigned to the Mexico and Western North Pacific DPSs.
- In order to characterize the distribution of ESA-listed salmonids in and near NWTT, stationary acoustic receivers were redeployed in July 2020 in a new line pattern to designed to detect Chinook salmon tagged in Kodiak, Alaska, and Yakutat, Alaska, returning to the Columbia River.
- Northwest Fisheries Science Center (NWFSC) under Navy funding reviewed acoustic detection data collected from 2002 to 2019 for incidence of acoustically tagged green sturgeon in Puget Sound and the Strait of Juan de Fuca in order to investigate spatial and temporal distribution patterns in the region.

- In August 2020, researchers from the Washington Department of Fish and Wildlife (WDFW) under Navy funding captured and released 60 green sturgeon in Grays Harbor and Willapa Bay, Washington; fish were instrumented with Vemco acoustic tags and fin clips were obtained; results will improve understanding of the spatial and temporal distribution and of green sturgeon along the Washington coastline, with stock identification.

GOA TMAA

- Of 255 humpback whales tracked by Oregon State University (OSU) from 1995 to 2019, only one was tracked within the GOA TMAA: a calf tagged at the Revillagigedo Archipelago, Mexico, in February 2003 reported locations in the northern part of the GOA TMAA from 9 June 2003 until the end of its tracking duration on 9 July 2003.
- Of 241 blue whales, 46 fin whales, and one blue/fin hybrid whale tracked by OSU from 1993 to 2018, only one fin whale tagged in California in 2006 reported locations within the GOA TMAA, and these occurred in January and February 2007; no blue whales were tracked within the GOA TMAA and only one whale, tagged in California in 2007, came within 260 kilometers (km) of the southeastern corner of the GOA TMAA.
- In order to characterize the distribution of ESA-listed salmonids in and near GOA TMAA, 40 Pop-up Satellite Archival Tag (PSAT) tags were attached to Chinook salmon near Chignik and Kodiak, Alaska, providing depth, temperature and location data; preliminary results indicate that 12 tags released from fish for unknown reasons, 17 tagged fish experienced predation, and the 11 remaining tags are still attached to Chinook salmon and are scheduled to report to satellites in winter/spring 2021.

Guadalupe fur seals on a rocky outcrop at the north end of Guadalupe Island, México. Photo credit: J. Bredvik, NAVFAC SW, Environmental Core. Permit #: SERMARNAT SGPA/DGVS/01643/19, CONANP F00.DRPBCPN.RBIG.0242/2019, and SEMAR 368/19

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PASSIVE ACOUSTIC MONITORING OF LARGE WHALES ON AND OFF THE CONTINENTAL SHELF OF SOUTHERN CALIFORNIA USING AUTONOMOUS UNDERWATER VEHICLES. [FREGOSI ET AL. 2021]

SEA TURTLE TAGGING IN THE MARIANA ISLANDS TRAINING AND TESTING (MITT) STUDY AREA: REDUCED INTERIM REPORT [GAOS AND MARTIN. 2021]

TAGGING GREEN STURGEON WITH ACOUSTIC TRANSMITTERS FOR EVALUATION OF HABITAT USE ALONG THE WASHINGTON COAST. INTERIM REPORT [HEIRONIMUS ET AL. 2021]

FY20 SUMMARY REPORT ON THE COLLABORATIVE BEAKED WHALE CRUISE OFF BAJA CALIFORNIA, MEXICO [HENDERSON ET AL. 2021A]

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LARGE WHALE TAGGING IN SUPPORT OF MARINE MAMMAL MONITORING ACROSS MULTIPLE NAVY TRAINING AREAS IN THE PACIFIC OCEAN: A SUPPLEMENTAL SYNOPSIS OF WHALE TRACKING DATA IN THE VICINITY OF THE GULF OF ALASKA TEMPORARY MARITIME ACTIVITIES AREA [PALACIOS ET AL. 2021]

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Acronyms and Abbreviations

ADB	advanced dive behavior
Argos	Advanced Research and Global Observation Satellite
ATN	Animal Tracking Network
AUV	autonomous underwater vehicles
BIA	Biologically Important Area(s)
BW	beaked whale
CalCOFI	California Cooperative Oceanic Fisheries Investigations
CFC	Conceptual Framework Category
cm	centimeter
CRC	Cascadia Research Collective
CSM	Cross Seamount
d	day
dB	decibel(s)
dB re 1μPa	decibel(s) referenced to 1 microPascal
DDG	guided missile destroyer
DEMVAL	Demonstration-Validation
DM	dive monitoring
DNA	deoxyribonucleic acid
DoN	Department of the Navy
DPS	Distinct Population Segment
DUR	dive duration monitoring
DUR+	dive duration monitoring plus
eDNA	environmental DNA
EIS	Environmental Impact Statement
ESA	Endangered Species Act
FDM	Farallon de Medinilla
FIRMA	Four Island Region Mitigation Area
FM	frequency-modulated
FY	fiscal year
GOA	Gulf of Alaska
GPS	Global Positioning System
HARP	High-frequency Acoustic Recording Package
HFM	high-frequency modulated
hr	hour(s)
HRC	Hawaii Range Complex
hSSSM	hierarchical switching state-space models
HSTT	Hawaii-Southern California Training and Testing
Hz	Hertz
ICMP	Integrated Comprehensive Monitoring Program
kHz	kilohertz
km	kilometer(s)
km2	square kilometer(s)
LIMPET	Low Impact Minimally Percutaneous Electronic Transmitter
LO	location-only
LOA	Letters of Authorization
m	meter(s)
M3R	Marine Mammal Monitoring on U.S. Navy Ranges
MarEcoTel	Marine Ecology and Telemetry Research
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
NCA/OR	northern California and Oregon
NMFS	National Marine Fisheries Service
NMS	National Marine Sanctuary
NUWC	Naval Undersea Warfare Center
NWA	Northern Washington
NWFSC	Northwest Fisheries Science Center
NWTRC	Northwest Training Range Complex
NWTT	Northwest Training and Testing
NOAA	National Oceanic and Atmospheric Administration
OEIS	Overseas Environmental Impact Statement
ONR	Office of Naval Research
OSU	Oregon State University
PAM	passive acoustic monitoring
PARR	Public Access to Research Results
PCR	polymerase chain reactions
PCoD	Population Consequences of Disturbance
photo-ID	photo-identification
PIFSC	Pacific Islands Fisheries Science Center
PMRF	Pacific Missile Range Facility
PSAT	Pop-up Satellite Archival Tag
PT MUGU	Point Mugu Sea Range
RPA	remotely piloted aircraft
RL	received level(s)
s	second(s)
SCB	Southern California Bight
SCC	Submarine Command Course
SCCA	southern/central California
SCORE	Southern California Offshore Range
SD	standard deviation
SIO	Scripps Institution of Oceanography
SL	source level
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)
SSCS	Sea Shepherd Conservation Society
SSRA-ON	Seasonal Special Reporting Area Oahu North
SSRA-OS	Seasonal Special Reporting Area Oahu South
SSRA-PB	Seasonal Special Reporting Area Penguin Bank
SSSM	switching state-space model
TMAA	Temporary Maritime Activities Area
U.S.	United States
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 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 are part of the NWTT Study Area, and the Gulf of Alaska Temporary Maritime Activities Area (GOA TMAA).

To authorize these actions, the National Marine Fisheries Service (NMFS) under the Marine Mammal Protection Act (MMPA) issued Final Rules for HSTT (NMFS 2018a, 2020j), MITT (NMFS 2015a, 2020g), NWTT (NMFS 2015d, 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 2018d, 2020h, 2020i), MITT (NMFS 2015b, 2016, 2020f), NWTT (NMFS 2015e, 2015f, 2020b, 2020c), and GOA TMAA (NMFS 2017a); and Biological Opinions (BOs) under the Endangered Species Act (ESA) for HSTT (NMFS 2018b), MITT (NMFS 2015c, 2017d, 2020e), NWTT (NMFS 2015g, 2020a), and the GOA TMAA (NMFS 2017c). The second set of 5-year authorizations and environmental planning documentation for MITT and NWTT expired during this Fiscal Year (FY) and transitioned to new 7-year authorizations in August 2020 and November 2020, respectively.

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 sixth such "multi-range"-complex annual monitoring report (see DoN 2016b, 2017, 2018b, 2019, 2020d). 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

[1] The U.S. Navy's Integrated Comprehensive Monitoring Program (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

future cycles of the ICMP, Adaptive Management Review, and Strategic Planning Processes; and provide a comprehensive view of monitoring in the Pacific Ocean 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 2020 to 31 December 2020.

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 monitoring projects are provided as supporting documents to this report (Baird et al. 2021; Deakos et al. 2021; DiMarzio et al. 2021; Fregosi et al. 2021; Gaos and Martin 2021; Heironimus et al. 2021; Henderson et al. 2021a, 2021b; Martin et al. 2021; Mellinger et al. 2021; Moser et al. 2021; Norris and Elorriaga-Verplancken 2020b; Palacios et al. 2020b, 2020c, 2021; Rice et al. 2021; Seitz and Courtney 2021; Schorr et al. 2021; Smith and Huff 2021; and West et al. 2021).

- Abstracts and executive summaries for these technical reports are in **Appendix A**.

- 2020 publications and conference presentations from U.S. Navy-funded monitoring are listed in **Appendix B** by author last name.

- Details of 2021 monitoring projects are in **Appendix C**.

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

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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.

2 Marine Species Monitoring in the Pacific

2.1 2020 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 2015a, 2015b, 2015c, 2015d, 2015e, 2015f, 2015g, 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 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 to illustrate which Intermediate Scientific Objectives are addressed by each monitoring project. **Figure 2** illustrates the relative number of monitoring questions associated with each CFC, and how this varies by range.

Following advancements in methodology made through investments by the Office of Naval Research (ONR) and others, the compliance monitoring programs have begun investing 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 shown paired with cumulative accomplishments in **Table 1**. Project accomplishments are shown starting with the year of the most recent LOA issuance. In cases where the LOA was issued partway through 2020, accomplishments for 2019 are also shown in the interest of providing context and continuity. Readers may refer to DoN (2020d, **Table 1**) for additional project accomplishments from previous years.

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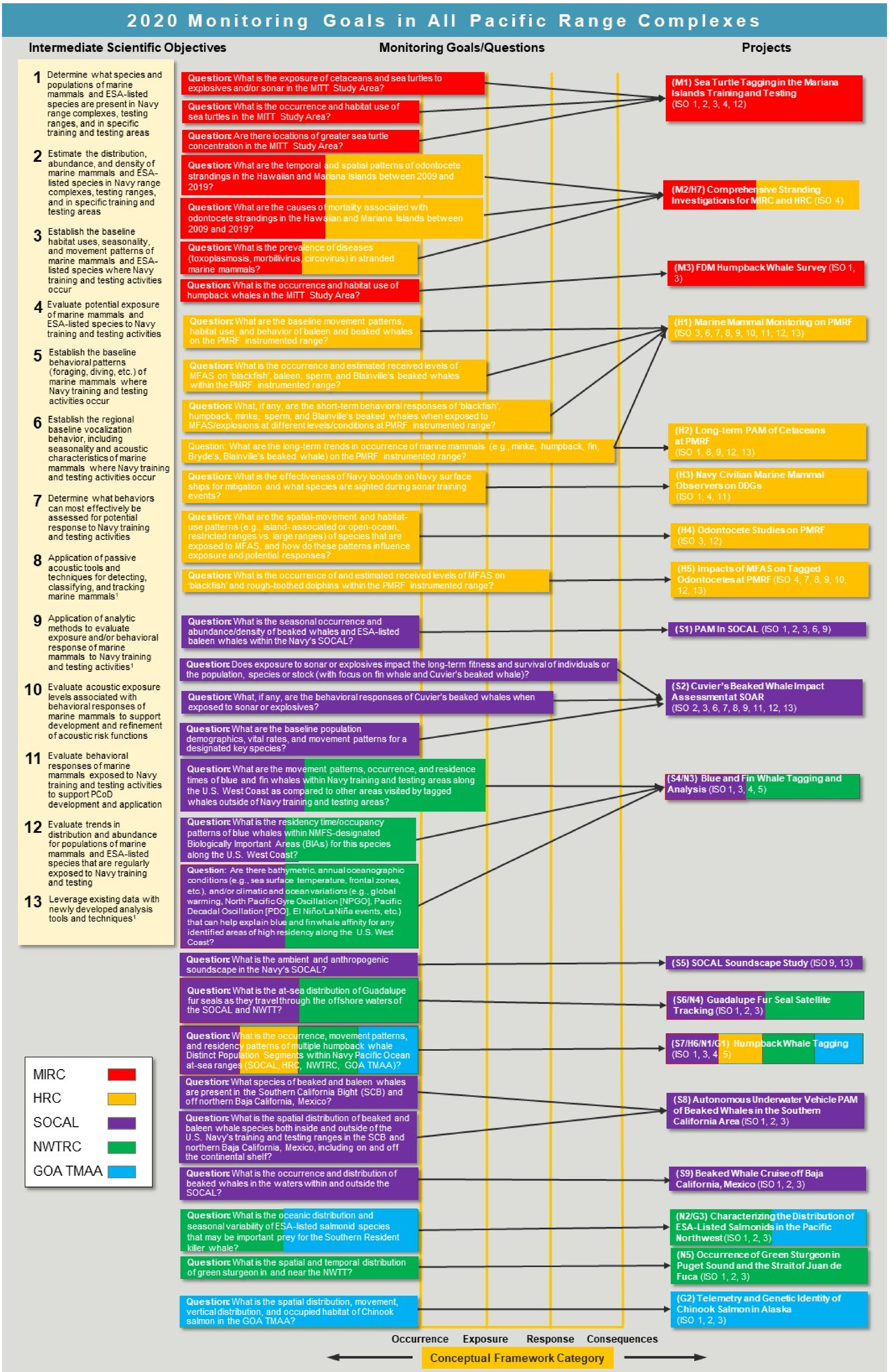

Figure 1. 2020 Monitoring goals in all Pacific range complexes by project. Primary research-and-development and demonstration-validation (DEMVAL) investments for tools and techniques supported separately by Office of Naval Research Marine Mammal and Biology and Living Marine Resource programs.

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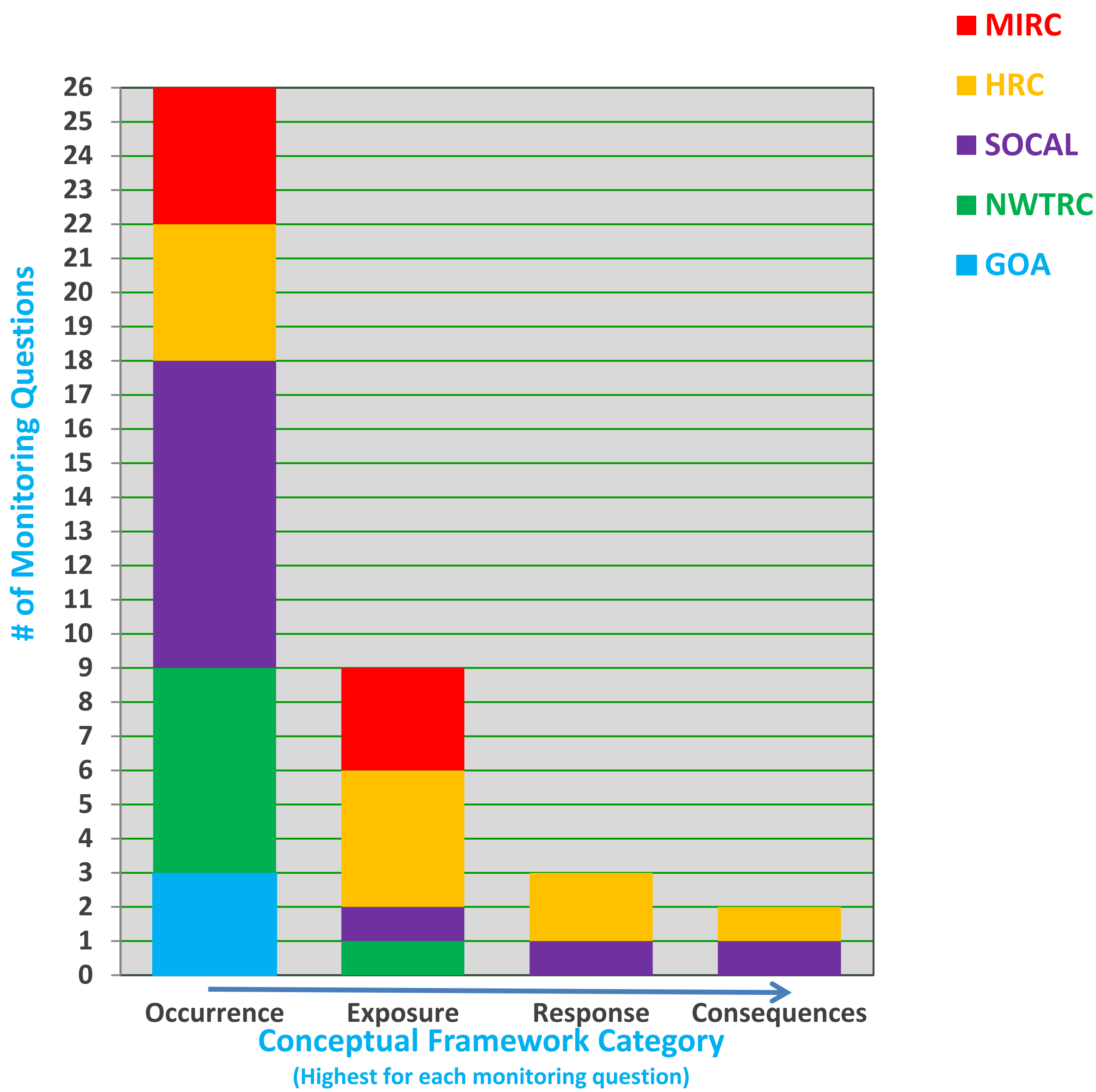

Figure 2. Numbers of monitoring questions and goals in all U.S. Navy Pacific range complexes that address the four progressive Conceptual Framework Categories for monitoring knowledge outlined by the Scientific Advisory Group. Additional Navy-funded effort under Response (not represented here) has been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

Table 1. Monitoring goals and accomplishments for training study areas/ranges in 2019 and 2020.

Project (Technical report for 2020)	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 2021)	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 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. *In 2019:* • Surveyed and satellite-tagged sea turtles along the eastern coast of Saipan (Forbidden Island, Lao Lao, and Dandan) and the northern coast of Guam (Ritidian, Anderson Air Force Base, Tarague, and Pati Point) from 1 to 11 September 2019 (Gaos et al. 2020). • Prepared a manuscript, "Reef-dwelling turtles of the Mariana Archipelago: fine-scale habitat use revealed by multiple in-water surveys and GPS telemetry", slated for publication in FY21.
[M2/H7] Comprehensive Stranding Investigations for MIRC and HRC (West et al. 2021) This project is also a component of HRC, H7.	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 2019? • What are the causes of mortality associated with odontocete strandings in the Hawaiian and Mariana Islands between 2009 and 2019? • What is the prevalence of diseases (toxoplasmosis, morbillivirus, circovirus) in stranded marine mammals?	*In 2020:* • Progress has been made towards 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 has been 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 result. • Responded to, conducted comprehensive investigations, and collected samples from strandings in Hawaii, Guam, Commonwealth of the Northern Mariana Islands, and other Pacific Islands. Sent earbone samples for analysis of potential acoustic impacts.
[M3] FDM Humpback Whale Survey (Deakos et al. 2021)	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 and habitat use of humpback whales in the MITT Study Area?	*In 2020:* • Conducted vessel-based visual surveys around FDM from 29 January to 1 February 2020. • Identified 10 unique humpback whale individuals from nine sightings over the four-day visual survey. Seven of these individuals were newly added to the Marianas photo-ID catalog (one of which had been seen in 2007 off Saipan) while the remaining three individuals were seen in prior years off Saipan and already part of the catalog. • An analysis of preferred humpback whale breeding habitat (depths less than 183 m) for the entire Mariana Archipelago revealed that FDM accounted for over 32% (354 km^2). • Humpback whales displayed breeding behavior while at FDM.

Project (Technical report for 2020)	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. 2021)	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 2020:* • Collected 2,972.2 hours 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 low-frequency 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). • Abundance results for odontocetes between September 2019 and September 2020 were estimated using a maximum number of dives per hour and included Blainville's (4.4; October 2019), Cross Seamount (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 hour before a phase of MFAS transmissions and an increase in dives per hour 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 (See Appendix B). • 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). • Submitted a manuscript to Frontiers in Marine Science, "Changes in the movement and calling behaviour of minke whales (*Balaenoptera acutorostrata*) in response to Navy training" (Durbach et al. in review). *In 2019:* • Automated classification algorithms were successful in attributing acoustic tracks recorded at PMRF to Bryde's, fin, and sei whales (Martin et al. 2020). • Automated algorithms were also successful in localizing blue whales and sperm whales at PMRF. • Conducted disturbance analyses for minke whales utilizing tools developed under an ONR project titled Behavioral Response EValuation Employing (BREVE) robust baselines and actual U.S. Navy training. • Analyzed Blainville's BW spatial distribution and dives for before, during, and after 16 SCCs. • Began analyzing whale acoustic tracks relative to environmental data to investigate how minke and other baleen whales respond to wind-wave events (E-BREVE). • Published a manuscript in Aquatic Mammals, "Quantifying the behavior of humpback whales (*Megaptera novaeangliae*) and potential responses to sonar" (Henderson et al. 2019). • Presented findings from this project at the World Marine Mammal Conference, Barcelona, Spain. • Published two manuscripts in the Journal of the Acoustical Society of America, "Use of spatial context to increase acoustic classification accuracy" (Palmer et al. 2019) and "Deep whistle contour: recall-guided learning from synthesis" (Li et al. 2019).

Project (Technical report for 2020)	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. 2021) This is a joint project with [H4] "Odontocete Studies on PMRF" and [S2] "Cuvier's Beaked Whale Impact Assessment at SOAR".	Occurrence, Exposure, Response, Consequences	#1: Determine what species and populations of marine mammals and ESA-listed 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 2020:* • Results from PMRF appears to be relatively consistent over the past six years (2015 – 2020) with peaks in January, December and June, and the lowest numbers detected in September. • 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 Autogrouper algorithm determined that only about one third of the Blainville's BW groups at PMRF are accurately detected; but 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 [H4]). Of the acoustic sightings, 25 were directed, and eight were visually verified. *In 2019:* • Examined Blainville's BW abundance and vocal behavior at PMRF from 2015 through 2018; data collected in 2019 are currently being analyzed (DiMarzio et al. 2020). • Calculated yearly and monthly abundance, mean number of GVPs, mean length of the GVPs in minutes, and the mean number of clicks detected per BW group, and examined seasonal changes in abundance and mean GVPs. • Presented findings from this project at the World Marine Mammal Conference, Barcelona, Spain. • Published in Marine Mammal Science, "Acoustic observation of the reaction of rough-toothed dolphin (*Steno bredanensis*) to vocalizations, most likely from killer whales (*Orcinus orca*), off Kaua'i" (Jarvis et al. 2019).
[H3] Navy Civilian Marine Mammal Observers on DDGs	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. #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 2020:* • Final analysis and results of the Navy-wide lookout effectiveness study is expected by the end of 2021 and will be included in the 2022 annual report. *In 2019:* • Employed MMOs on the bridge wings of a U.S. DDG from 16 to 22 February 2019 during a SCC training event (Vars et al. 2019). • Recorded marine mammal and sea turtle sightings data to assess the effectiveness of the Navy lookout team and to characterize the possible exposure of marine species to sonar training events.

Project (Technical report for 2020)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 1)	Monitoring Questions	Accomplishments[1]
HRC (continued)				
[H4] Odontocete Studies on PMRF Tag telemetry data collected was also used in Project [H5] (Baird et al. 2021)	Occurrence	#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 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. • Data collected during Navy funded surveys was used in published manuscripts 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). • Submitted a manuscript to Marine Mammal Science, “Diel and lunar variation in diving behavior of rough-toothed dolphins (*Steno bredanensis*) off Kaua’i, Hawai’i (Shaff and Baird in review). *In 2019:* • No survey was conducted in 2019 due to the August SCC event being canceled. • Presented a report to the Pacific Scientific Review Group providing insight on spotted dolphin habitat use in Hawaii based on data from individuals equipped with satellite tags, to better define stock boundaries (Baird and Webster 2019).

Project (Technical report for 2020)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 1)	Monitoring Questions	Accomplishments[1]
HRC (continued)				
[H5] Impacts of MFAS on Tagged Odontocetes at PMRF (Henderson et al. 2021b)	Occurrence, 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 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 2-dimensional model for RL and were re-analyzed with the new 3-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. *In 2019:* • In addition to estimating RLs for seven tagged odontocetes (three short-finned pilot whales, two rough-toothed dolphins, and two melon-headed whales) during SCC training events, potential responses of tagged animals were also assessed by analyzing animal tracks for any large-scale movements concurrent with sonar activity. When available, diving and surfacing behavior of tagged individuals was analyzed before, during, and after MFAS use to assess potential reactions. • To better assess variability in RL estimates, multiple metrics (mean, SD, minimum, maximum) of estimated RLs were calculated for each exposure event, both near the surface (10 m depth) and at depths meant to represent typical foraging depths for each species.
[H6/S7/N1/G1] Humpback Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean (Palacios et al. 2020b, 2020c, 2021) This project is also a component of SOCAL, NWTT, and GOA TMAA tagging, S7, N1, and G1.	*See project N1/H6/S7/G1 (below, in NWTT)*			

Project (Technical report for 2020)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 1)	Monitoring Questions	Accomplishments[1]
HRC (continued)				
[H7/M2] Comprehensive Stranding Investigations for MIRC and HRC (West et al. 2021) This project is also a component of MIRC, M2.	*See project M2/H7 (above, in MIRC)*			
SOCAL				
[S1] Passive Acoustic Monitoring in SOCAL (Rice et al. 2021)	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 and ESA-listed baleen whales within the Navy's SOCAL? • What, if any, are the spatial patterns in fin whale population structures within the Navy's SOCAL?	*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 MFA wave trains and packets normalized per year than in previous monitoring periods. *In 2019:* • Analyzed data recorded by HARPs deployed at sites E, H, and N from July 2018 to May 2019 (Rice et al. 2020) for ambient sound levels, whale presence and relative abundance, and anthropogenic sound sources. • The BW FM pulse type BW35 (newly described as of last year) was detected again at site E and H. • Overall detections were similar to previous years though some sound sources showed slight changes in number of detections at certain locations, suggesting possible shifts in activity. • Presented findings from this project at the OceanObs'19 Conference in Honolulu, Hawaii.

Project (Technical report for 2020)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 1)	Monitoring Questions	Accomplishments[1]
SOCAL (continued)				
[S2] Cuvier's Beaked Whale Impact Assessment at SOAR (Schorr et al. 2021; DiMarzio et al. 2021) 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 a designated key species in the SOCAL? • What, if any, are the behavioral responses of Cuvier's beaked whales when exposed to sonar or explosives? • Does exposure to sonar or explosives impact the long-term fitness and survival of individuals or the population, species or stock (with focus on blue whale, fin whale, humpback whale, Cuvier's beaked whale, and other regional beaked whale species)?	*In 2020:* • Sighted fifteen 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 BWs with seafloor depth, time-of-day, and lunar illumination", (Barlow et al. 2020), and 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). • Results from BW abundance analysis at SOAR confirm 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 low-frequency detector algorithm at SOAR demonstrate that it can effectively localize calls from several baleen species, and that 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 hour-hydrophone from 2010 through 2019 on SOAR and an increased trend with increasing water depth, from 1000 to 1800 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. *In 2019:* • Deployed tags on a fin whale and Risso's dolphin (Schorr et al. 2020). • Analyzed home ranges for Risso's dolphins tagged from 2009 to 2019 and Cuvier's BWs tagged from 2008 to 2017 (Schorr et al. 2020). • To assess how long it takes Cuvier's BWs to return to "baseline" diving behavior following MFAS exposure, a general additive model was created using the *mgcv* package in R with Inter-deep dive interval as the response variable (Schorr et al. 2020). • Derived preliminary vital rates for Cuvier's BWs at SOAR (Schorr et al. 2020). • Submitted to the Journal of the Acoustical Society of America, "The effect of two 12 kHz multibeam mapping surveys on the foraging behavior of Cuvier's BWs off of southern California" (Varghese et al. 2020). • Published in Frontiers in Marine Science, "Diel dive behavior of fin whales (*Balaenoptera physalus*) in the Southern California Bight" (Keen et al. 2019a),and in Aquatic Mammals, "Night and day: diel differences in ship strike risk for fin whales (*Balaenoptera physalus*) in the California Current System" (Keen et al. 2019b). • Presented findings from this project at the World Marine Mammal Conference, Barcelona, Spain. • Examined changes in Cuvier's BW abundance and vocal behavior (GVPs) at SOAR from August 2010 through October 2019 (DiMarzio et al. 2020). • Conducted five field efforts in 2019 at SOAR in conjunction with MarEcoTel to assist with visual verification of acoustic localizations and tag deployments (DiMarzio et al. 2020). • Presented findings from this project at the University of Rhode Island Biological Oceanography Poster Symposium.

Project (Technical report for 2020)	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 [This project 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 beaked whales and ESA-listed baleen whales within the Navy's SOCAL?	*In 2020:* • No cruises occurred due to COVID-19 pandemic. This project will resume next year. *In 2019:* • Reported on visual monitoring for marine mammals aboard CalCOFI cruises from July 2016 to July 2019 (Trickey et al. 2020). • Analyzed towed-array data collected during CalCOFI cruises from 2008 to 2019 for BW echolocation clicks. • BW clicks were detected on one occasion in the towed array recordings.

Project (Technical report for 2020)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 1)	Monitoring Questions	Accomplishments[1]
SOCAL (continued)				
[S4/N3] Blue and Fin Whale Tagging and Analysis This project is also a component of NWTT tagging N3.	Occurrence Exposure	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas. #3: 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. #5: Establish the baseline behavioral patterns (foraging, diving, etc.) of marine mammals where Navy training and testing activities occur.	• What are the movement patterns, occurrence, and residence times of blue and fin whales within Navy training and testing areas along the U.S. West Coast as compared to other areas visited by tagged whales outside of Navy training and testing areas? • What is the residency time/occupancy patterns of blue whales within NMFS-designated Biologically Important Areas (BIAs) for this species along the U.S. West Coast? • Are there bathymetric, annual oceanographic conditions (e.g., sea surface temperature, frontal zones, etc.), and/or climatic and ocean variations (e.g., global warming, North Pacific Gyre Oscillation [NPGO], Pacific Decadal Oscillation [PDO], El Niño/La Niña events, etc.) that can help explain blue and fin whale affinity for any identified areas of high residency along the U.S. West Coast?	*In 2020:* • In-depth follow up analyses of blue and fin whale tag data collected from 2014 to 2017 continued in 2020, including ecological characteristics of whale movements; use of U.S. Navy training and testing areas and NMFS-designated BIAs by tagged blue and fin whales, and site fidelity, residence, and re-visitation patterns of blue and fin whales at coastal hot spots, with implications for anthropogenic exposure risk. • To augment the 2014-2017 telemetry dataset, OSU has included historical blue and fin whale tag data collected from 1994 to 2008 in the analyses. Additionally, MarEcoTel has shared 77 fin whale tracks for the period 2008-2017, significantly improving coverage of fin whales for the site fidelity analysis. • Performed a comprehensive review of blue and fin whale telemetry data collected from 1993 through 2013 to assess the degree of overlap with the GOA TMAA (Palacios et al. 2021). • Of 241 blue whales, 46 fin whales, and one blue/fin hybrid whale tracked by OSU from 1993 to 2018, only one fin whale tagged in California in 2006 had locations within the TMAA, and these occurred in January and February 2007. No blue whales were tracked within TMAA and only one whale, tagged in California in 2007, came within 260 km of the southeastern corner of the TMAA. • Published manuscripts in Animal Biotelemetry: "An at-sea assessment of Argos location accuracy for three species of large whales, and the effect of deep-diving behavior on location error" (Irvine et al. 2020) and Southwestern Naturalist, "Sightings and satellite tracking of a blue/fine whale hybrid in its wintering and summering ranges in the Eastern North Pacific" (Jefferson et al. 2020). *In 2019:* • Performed detailed analyses of existing tag data from blue and fin whales tagged in 2014–2017. Analyses included 1) fine-scale feeding behavior of tagged blue and fin whales; 2) assessment of Argos tag location accuracy; 3) site fidelity and residency patterns of tagged whales, and 4) the use of U.S. Navy training and testing areas and BIAs by tagged blue and fin whales. • Processed tag data collected in 2014–2017 for use in a future exposure analysis, comparing whale tracks to known Navy training events in SOCAL using MFAS. Tag data were filtered by location quality and include animal locations within a 20-km buffer zone of SOCAL. • Published the following papers: in Frontiers in Ecology and Evolution, "Scales of blue and fin whale feeding behavior off California, USA, with implications for prey patchiness" (Irvine et al. 2019); in Frontiers in Movement Ecology, "Ecological correlates of blue whale movement behavior and its predictability in the California Current Ecosystem during the summer-fall feeding season" (Palacios et al. 2019a); in Proceedings of the National Academy of Sciences, "Memory and resource tracking drive blue whale migrations" (Abrahms et al. 2019b); and in Diversity and Distributions Journal, "Dynamic ensemble models to predict distributions and anthropogenic risk exposure for highly mobile species" (Abrahms et al. 2019a). • Presented findings of this project at the World Marine Mammal Conference, Barcelona, Spain.
[S5] SOCAL Soundscape Study (Rice et al. 2021)	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 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 low-frequency ambient soundscape. • The underwater ambient soundscape at all sites had spectral shapes with higher levels at low frequencies owing 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 (<100 Hz) compared to the other sites owing 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 ~100–200 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. *In 2019:* • Examined underwater explosive sounds detected on HARPs to determine if different signal characteristics allow them to be classified as produced by fisheries-related seal bombs or Navy ordnance used during training exercises (Rice et al. 2020; Wiggins et al. 2020).

Project (Technical report for 2020)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 1)	Monitoring Questions	Accomplishments[1]
SOCAL (continued)				
[S6/N4] Guadalupe Fur Seal Satellite Tracking (Norris and Elorriaga-Verplancken 2020b) This project is also a component of NWTT tagging, N4.	Occurrence	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas. #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 at-sea distribution of Guadalupe fur seals as they travel through the offshore waters of the SOCAL and NWTT?	*In 2020:* • In March 2020, 65 satellite tags were deployed on Guadalupe fur seals: 15 adult females, 10 juvenile females, 10 juvenile males, and 30 pups at Guadalupe Island, Mexico; depth-sensing tags were deployed on adults and juveniles, and location-only tags were deployed on pups. • The majority of animals (n=51, or 85% of tagged animals) traveled north of Guadalupe Island during all or part of the 2020 tracking period, and one tagged seal traveled into Canadian waters. • Calculated the percentage of home range overlap with four U.S. Navy training and testing areas (NWTT, SOCAL, PT MUGU, and SOAR) for all tagged seals; the greatest amount of overlap occurred with PT MUGU (≥61% for each demographic group). • The majority of dives across all periods and individuals were <60 m; however, three adult females and one juvenile female logged 21-33% of dives >60 m, and three adult females and one juvenile male recorded dives >200 m. • A large number of foraging dives were observed along portions of tracks with directed, relatively straight travel typically interpreted as transiting vs. foraging areas; most notably, foraging behavior was observed throughout the offshore area (>2,000 m water depth) of SOCAL that was previously considered to be a transit corridor to and from Guadalupe Island. • Census data collected at Guadalupe Island, Mexico and San Benito Archipelago, Mexico in summer 2018 and summer 2019 were analyzed in order to derive a population estimate for this species and identify population trends across the two study years. *In 2019:* • Conducted direct counts of Guadalupe fur seals by land- and vessel-based surveys at San Benito Archipelago from 23 to 29 July 2019 and a land- and vessel-based population survey was conducted at Guadalupe Island from 8 to 13 August 2019 (Norris and Elorriaga-Verplancken 2020a). • Used an RPA or drone to test the feasibility of aerial imagery to improve counts at Punta Sur, Guadalupe Island, to replace or supplement walk-through surveys that create a disturbance for mothers with <1-month-old pups (Norris and Elorriaga-Verplancken 2020a). • Conducted intermittent RPA surveys at both locations during boat-based surveys to develop substrate-specific correction factors to better account for animals missed from the boat (Norris and Elorriaga-Verplancken 2020a). • Analyzed dive-characteristic data for seals at Guadalupe Island (Norris and Elorriaga-Verplancken 2019).
[S7/N1/G1/H6] Humpback Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean (Palacios et al. 2020b, 2020c, 2021) This project is also a component of HRC, NWTT, and GOA TMAA tagging, H6, N1, and G1.	*See project* N1/H6/S7/G2 *(below, in NWTT)*			

Project (Technical report for 2020)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 1)	Monitoring Questions	Accomplishments[1]
SOCAL (continued)				
[S8] Autonomous Underwater Vehicle PAM of Beaked Whales in the Southern California Area (Fregosi et al. 2021; Mellinger et al. 2021)	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 species of beaked and baleen whales are present in the Southern California Bight (SCB) and off northern Baja California, Mexico? • What is the spatial distribution of beaked and baleen whale species both inside and outside of the U.S. Navy's training ranges in the SCB and northern Baja California, Mexico, including on and off the continental shelf?	*In 2020:* • Deployed two Seagliders™ in the San Nicolas Basin on 7 February 2020; one, the "abyssal glider", was piloted to survey over the abyssal plain offshore of the continental shelf break, and the other "shelf glider" was piloted to conduct transects inshore of the shelf break in water depths shallower than 2,500 m. • Programmed both gliders to survey in the vicinity of existing Navy-funded fixed acoustic sensors (HARPs) with the goal of eventually comparing the acoustic datasets collected by both types of instruments. • A series of technical challenges resulted in no useable data being collected for BWs (see Mellinger et al. 2021 for details); therefore the available data were instead analyzed for baleen whale and sperm whale vocalizations, which was originally a focus of secondary importance for the project. • Blue, fin, humpback, and sperm whale vocalizations were recorded by the abyssal glider, and fin and humpback vocalizations (no blue or sperm whales) by the shelf glider. • Detected fin whales on every day of both glider deployments, and on several days, they were present in 100% of the 10-minute recording periods. • Detected humpback whales on 48 of the 50 days of the abyssal glider's deployment, both on and off the continental shelf, and on all five days of the shelf glider recordings (continental shelf only). • The abyssal glider recorded sperm whales on 12 of the 50 recording days (n=165 confirmed detections), when the glider was located at the shelf break and over the abyssal plain. • The deep-water areas on the shelf slope and the abyssal plain are seldom surveyed for marine mammals, making the results of this study particularly valuable in improving our understanding of marine mammal occurrence and distribution in these areas. *In 2019:* • Deployments were originally scheduled for late summer 2019, but due to technical issues encountered with the glider firmware, work was rescheduled for winter/spring 2020. Deployed two Seagliders in February 2020 in the SCB to use PAM to characterize BW occurrence and distribution in and around the Navy's training ranges in the SCB, both on and off the continental shelf. Gliders will be retrieved in March 2020 after a ~45-day deployment period.
[S9] Beaked Whale Cruise off Baja California, Mexico (Henderson et al. 2021a)	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 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.

Project (Technical report for 2020)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 1)	Monitoring Questions	Accomplishments[1]
NWTT				
[N1/H6/S7/G1] Humpback Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean (Palacios et al. 2020b, 2020c, 2021) This project is also a component of SOCAL, HRC, and GOA TMAA tagging, S7, H6, 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. #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. #5: Establish the baseline behavioral patterns (foraging, diving, etc.) of marine mammals where Navy training and testing activities occur.	• What is the occurrence, movement patterns, and residency patterns of multiple humpback whale Distinct Population Segments within Navy Pacific Ocean at-sea ranges (SOCAL, HRC, NWTRC, GOA TMAA)?	*In 2020:* • Characterized the movements, residence time, connectivity, and habitat use of humpback whales in the North Pacific through the use of satellite telemetry, dive behavior, genetics, and photo-ID. • Aggregated tracking results of 105 humpback whales tagged in Hawaii between 1995 and 2019, all belonging to the Hawaii DPS; results showed high density in the Maui Nui region and Penguin Bank and extensive inter-island movements and a mean residency time of 13.1 days (Palacios et al. 2020c). • Of the five Navy areas within HRC, the Maui Nui Four Islands Area was the most heavily used by humpbacks (maximum residency time of 23.1 d) likely because most whales were tagged there. • Tracked migratory destinations for 12 humpback whales tagged off Maui, with seven whales going to northern British Columbia and southeastern Alaska, one going to southern British Columbia, and four going to the eastern Aleutian Islands. • Matched photo-IDs from 50 tagged and 157 non-tagged humpback whales to whales seen off Mexico, Russia, Aleutians, GOA, southeast Alaska, British Columbia, Washington, and Oregon. • Also analyzed historical tag track data for 81 humpback whales tagged off California, Oregon, and Washington between 2004 and 2019; results supported humpback affinity for continental shelf and shelf-edge habitat (Palacios et al. 2020b). • For humpback whales tagged on the U.S. West Coast, primarily in the Washington area, the most intensively used Navy range was NWTT, with 73% of whales (59 of 81) having locations there (maximum residency = 86.6 d). • Of the 81 whales tagged on the West Coast, 79 were genetically identified from skin biopsy samples collected during tagging efforts; the composition of haplotype frequencies suggest a differentiation between the SCCA and NCA/OR feeding aggregations that had not been previously recognized. • Based on genetic profiles of the humpbacks tagged on the West Coast, the majority of individuals from SCCA (64%) assigned with highest likelihood to the Central America DPS, whereas the largest proportion of individuals from NCA/OR (47%) and northern Washington (48%) assigned with highest likelihood to the Hawaii DPS. The remaining individuals assigned to the Mexico and Western North Pacific DPSs. • Only one humpback whale—a calf tagged at the Revillagigedo Archipelago, Mexico, in February 2003--was tracked within the GOA TMAA (Palacios et al. 2021). Locations for this whale occurred in the northern part of the TMAA from 9 June 2003 (01:46:02 GMT) until the end of its tracking duration on 9 July 2003 (22:54:11 GMT). • Presented findings from this project at the Ocean Sciences Meeting and West Coast Entanglement Science Workshop (See Appendix B). *In 2019:* • Tagged humpback whales off Washington in September and October 2019 (Mate et al. 2020) and off Hawaii in March 2019 (Mate et al. 2019a). • Observed killer whales and photographed on two occasions in 2019 (Mate et al. 2020). • Analyzed seven killer whale encounters from 2018 field efforts. Of 91 individual killer whales observed, 45 were matched to J, K, and L pods of the SRKW population. • Tracked humpback whales tagged off Washington from the northwest corner of Vancouver Island, British Columbia, Canada, to Seaside, Oregon (Mate et al. 2020). • Tracked humpback whales tagged off Maui along the entire migratory route to the southwest coast of Baranof Island in Southeast Alaska, the northern GOA, Haida Gwaii, and the Aleutian Islands (Mate et al. 2019a). • Determined sex and population/stock identification for humpback whales tagged off of Washington and Oregon in 2018; also analyzed dive characteristics (Palacios et al. 2020a). • Submitted a technical report to Pacific Life Foundation, “Tracking North Pacific Humpback Whales to Unravel Their Basin-Wide Movements (Palacios et al. 2019b). • Presented findings from this project at the World Marine Mammal Conference, Barcelona, Spain. • Ongoing analyses: genetic sex determination, population identity, individual identification, dive characteristic data, and species and stock identification.

Project (Technical report for 2020)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 1)	Monitoring Questions	Accomplishments[1]
NWTT (continued)				
[N2/G3] Characterizing the Distribution of ESA-Listed Salmonids in the Pacific Northwest (Smith and Huff 2021) This project is also a component of GOA TMAA tagging, 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. #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 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, Alaska and Yakutat, Alaska returning to the Columbia River. • In October 2020, 80 Chinook salmon were tagged with Vemco V16 acoustic tags in Kodiak, Alaska. • In February 2021, 55 steelhead kelts were instrumented with a combination of pop-up satellite tags Vemco acoustic tags in the Willapa River, Washington; an additional 80 acoustic tags are planned for deployment on Chinook salmon in Yakutat, Alaska in March 2021, and the data on the acoustic receivers will be downloaded and the receivers redeployed in the summer of 2021. *In 2019:* • Purchased and programmed 195 acoustic tags, 100 temperature tags, and 5 satellite-monitored tags (Smith and Huff 2020). • Deployed tags on Bull trout (17), Chinook salmon (142), and Coho salmon (35). • Detected tagged Chinook salmon (123) (87%) 50,533 times on 103 acoustic receivers. • Deployed 107 stationary receivers from 14 to 16 May 2019 (98 within the NWTT) and downloaded/redeployed between 31 August and 4 September 2019 (Smith and Huff 2020). • Analyzed detection history, residence times, and movement characteristics of tagged fish in order to build a species distribution model to determine suitable habitat for each species, how this may influence killer whale populations, and how this overlaps with the NWTT.
[N3/S4] Blue and Fin Whale Tagging and Genetics This project is also a component of SOCAL tagging, S4.	*See project S4/N3 (above, in SOCAL)*			
[N4/S6] Guadalupe Fur Seal Satellite Tracking (Norris and Elorriaga-Verplancken 2020b) This project is also a component of SOCAL tagging, S6.	*See project S6/N4 (above, in SOCAL)*			
[N5] Occurrence of Green Sturgeon in the Pacific Northwest (Moser et al. 2021; Heironimus et al. 2021)	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 and temporal distribution of green sturgeon in and near the NWTT?	*In 2020:* • Reviewed acoustic detection data collected from 2002 to 2019 for incidence of acoustically tagged green sturgeon in 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 networked 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 obtain 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 the Puget Sound and the Strait of Juan de Fuca. • 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 ae being 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.

Project (Technical report for 2020)	Conceptual Framework Category	Intermediate Scientific Objectives (Numbered as per Figure 1)	Monitoring Questions	Accomplishments[1]
GOA TMAA				
[G1/N1/S7/H6] Humpback Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean (Palacios et al. 2020b, 2020c, 2021) This project is also a component of SOCAL, HRC, and NWTT tagging, S7, H6, and N1.	*See project S7/N1/G1/H6 (above, in NWTT)*			
[G2] Telemetry and Genetic Identity of Chinook Salmon in Alaska (Seitz and Courtney 2021)	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, and occupied habitat of Chinook salmon in the GOA TMAA?	*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 Satellite 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 are scheduled to report to satellites in winter/spring 2021.
[G3/N2] Characterizing the Distribution of ESA-Listed Salmonids in the Pacific Northwest (Smith and Huff 2021) This project is also a component of NWTT tagging, N2.	*See project N2/G3 (above, in NWTT)*			

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

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

Key: ADB = advanced dive behavior; Argos = Advanced Research and Global Observation Satellite; ATN = Animal Telemetry Network; BIA = Biologically Important Area; BW = beaked whale; CalCOFI = California Cooperative Oceanic Fisheries Investigations; CCAL = California Current Province; dB re 1 µPa = decibels referenced to 1 micro Pascal; DDG= guided missile destroyer; DM = Dive Monitoring; DNA = deoxyribonucleic acid; DoN = Department of the Navy; DPS = Distinct Population Segment; E-BREVE = Environmentally-influenced Behavioral Response Evaluations; EAR = Ecological Acoustic Recorder; ESA = Endangered Species Act; FDM = Farallon de Medinilla; FM = frequency-modulated; FY = Fiscal Year; GOA TMAA = Gulf of Alaska Temporary Maritime Activities Area; *g*(0) = trackline detection probability; GPS = Global Positioning System; HARP = High-frequency Acoustic Recording Package; hr = hour(s); HRC = Hawaii Range Complex; hSSSM = hierarchical switching state-space model; HSTT = Hawaii Southern California Training and Testing; Hz = Hertz; kHz = kilohertz; km = kilometer; km^2 = square kilometer; LIMPET = Low Impact Minimally Percutaneous Electronic Transmitter; m = meter; M3R = marine mammal monitoring on U.S. Navy ranges; MFAS = mid-frequency active sonar; MITT = Mariana Islands Training and Testing; MMO = marine mammal observer; NCA/OR = northern California/Oregon; NMFS = National Marine Fisheries Service; NOAA = National Oceanic and Atmospheric Administration; NPGO = North Pacific Gyre Oscillation; NWTT = Northwest Training and Testing; ONI = Oceanic Niño Index; ONR = Office of Naval Research; OSU = Oregon State University; OTN = Ocean Tracking Network; PAM = passive acoustic monitoring; PCR = polymerase chain reactions; PCoD = Population Consequences of Disturbance; PDO = Pacific Decadal Oscillation; photo-ID = photo-identification; PMRF = Pacific Missile Range Facility; PSAT = pop-up satellite archival tags; PT MUGU = Point Mugu Sea Range; RL = received level(s); RPA = remotely piloted aircraft; s = second(s); SCB = Southern California Bight; SCC = Submarine Command Course; SCCA = southern/central California; SCORE = Southern California Offshore Range; SD = standard deviation: SPOT = smart position and temperature; SOAR = Southern California Offshore Antisubmarine Warfare Range; SOCAL = Southern California Range Complex; SRKW = Southern Resident killer whale; SSC Pacific = Space and Naval Warfare Systems Pacific; SSSM = switching state-space model; U.S. = United States.

2.2 Timeline of Monitoring Efforts

In this sub-section, a graphical timeline of monitoring projects is presented for each range, covering the 2020 monitoring year. The timelines include monitoring projects as well as notable items (e.g., results and 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 2020 is illustrated in **Figure 3**.

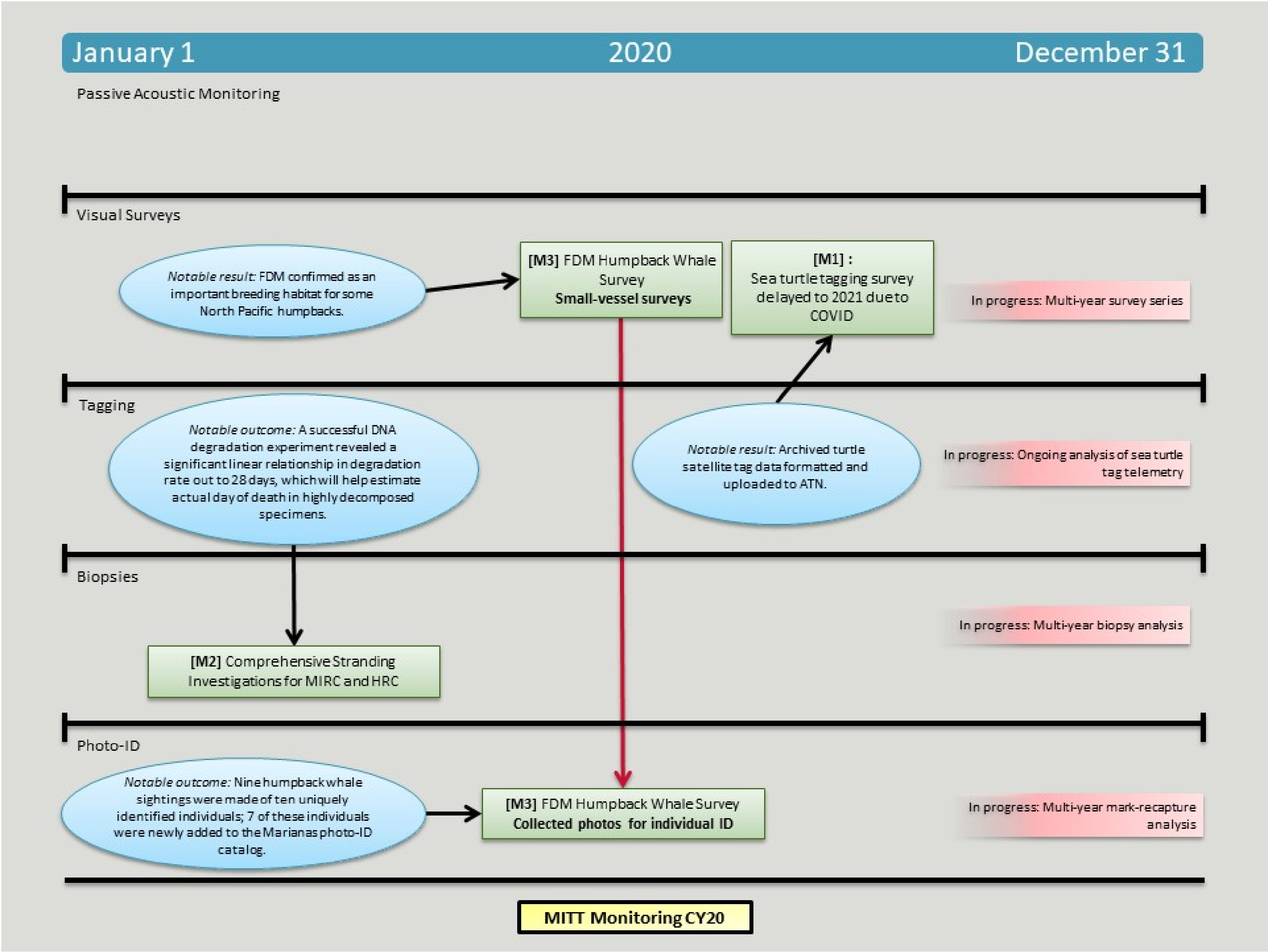

Figure 3. Timeline of 2020 projects in the Mariana Islands Training and Testing (MITT) Study Area.

[M1] Sea Turtle Tagging in the Mariana Islands Training and Testing Study Area [Gaos and Martin. 2021]

The onset of the COVID-19 pandemic in early 2020 limited the ability of Pacific Islands Fisheries Science Center's (PIFSC) Marine Turtle Biology and Assessment Program (MTBAP) to conduct field work, develop research tools, and analyze findings. Working with the Integrated Ocean Observing System, MTBAP provided public access to all of the satellite tags deployed during under the NOAA-PACFLEET IAA via the creation of a NOAA-PACFLEET web project within the Animal Tracking Network (ATN). This required MTBAP to undertake extensive data formatting and upload to ATN's data assembly center. MTBAP also worked with these partners and the satellite tag manufacturer Wildlife Computers to establish a data pipeline to feed tag telemetry data directly into ATN. This collaboration currently provides "real-time" visualization of all satellite tags deployed as part of the project. MTBAP continues working with the developers to improve the NOAA-PACFLEET web project.

[M2] Comprehensive Stranding Investigations for MIRC and HRC [West et al. 2021]

The University of Hawaii Health and Stranding Lab 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. This project has three objectives: 1) To conduct comprehensive stranding investigations for high priority species through increased capacity for in-house diagnostics; 2) To analyze archived tissues for the presence of two pathogens (circovirus and morbillivirus) and to examine the detectability of *Toxoplasma* positive animals over time and 3) To conduct analyses of historical stranding patterns and causes of mortality that incorporate quantitative estimates of stranding date and advanced diagnostic information. In order to meet these objectives, the lab acquired new instruments to conduct analyses and continued to respond to and conduct comprehensive investigations of cetacean strandings in the Hawaiian and Mariana archipelagos as well as other Pacific Island locations when possible by performing necropsies and collecting samples. Methods were developed and validated to analyze archived tissues for newly described pathogens and to age tooth samples. An experiment to examine the degradation of DNA over time to determine time of death and an experiment examining detectability of Toxoplasmosis in degraded tissues over time was conducted on tissues known to contain the pathogen by quantifying DNA concentration over time. Historical stranding data are being compiled and augmented with data from new analyses to examine stranding patterns and causes of death.

This is the same project conducted for HRC [H7].

[M3] FDM Humpback Whale Survey [Deakos et al. 2021]

A small-vessel survey for humpback whales (*Megaptera novaeangliae*) was conducted from 29 January to 1 February 2020 to better understand this species' use of shallow-water habitat around the island of Farallon de Medinilla (FDM). Gridded multibeam bathymetric data was used to map preferred humpback habitat around the Marianas Archipelago, and was examined in parallel with sighting data. A 17.7-m Riviera live-aboard was used was used to conduct opportunistic visual surveys for humpbacks around the FDM island, Anatahan, and neighboring seamounts. Three experienced Marine Mammal Observers (MMOs) used naked eye with assistance of 25x power binoculars to search for marine mammals. Environmental, sighting, and vessel global positioning system (GPS) location information were collected during survey effort. Fluke photographs were uploaded to the online repository at HappyWhale (happywhale.com; Cheeseman et al. in press), which matches fluke photographs using an automated algorithm.

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 2020 is illustrated in **Figure 4**.

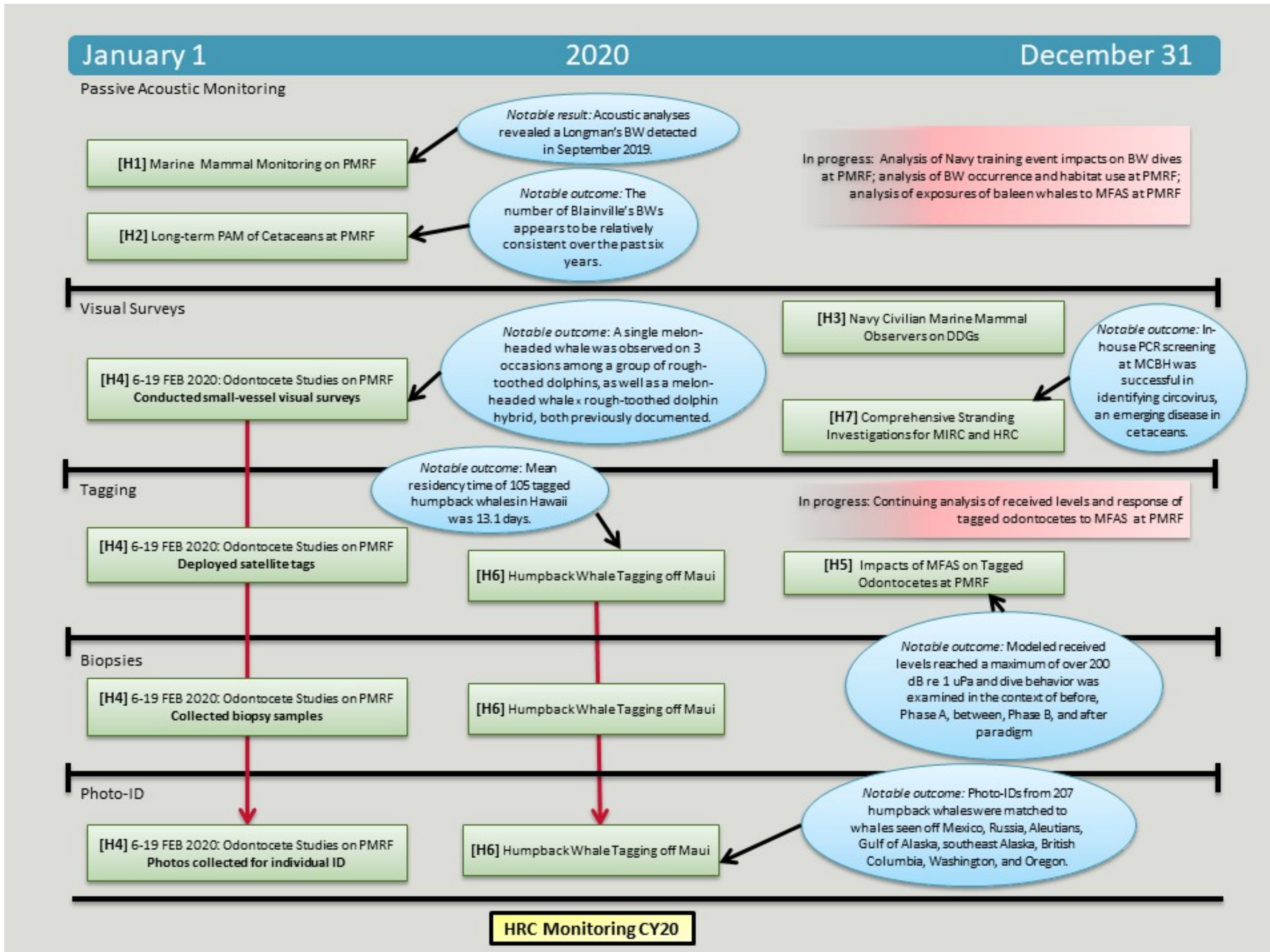

Figure 4. Timeline of 2020 projects in the Hawaii Range Complex (HRC).

[H1] Marine Mammal Monitoring on PMRF [Martin et al. 2021]

Sound recordings from Pacific Missile Range Facility (PMRF) bottom mounted hydrophones were used to analyze marine mammal vocalizations and mid-frequency active sonar (MFAS) transmissions and locations. Recordings of raw data were made using a standard full-bandwidth of 96 kilohertz (kHz) sample rate twice per month (minimum 24 hours [hr] and maximum 45 hr) and a reduced bandwidth of 6 kHz for longer duration baseline sampling of baleen whale vocalizations and lower frequency noise conditions. An additional reduced bandwidth recording was made in spring 2020 to capture any potential changes in acoustics due to the COVID-19 pandemic. Multiple algorithms were used to detect a variety of marine mammal vocalizations, MFAS transmissions, and to localize and track individual animals. For annual and long-term abundance assessments, a semi-automated Matlab localization association tracker was used for baleen and sperm whales (Martin et al. 2018; Alongi et al. 2019). This entailed examining 10-minute snapshots to count if a call was present, which allowed a census-type abundance estimate of whale counts in the study area. For species that could not be individually tracked, dive counts were used to quantify abundance. For the disturbance analysis, complex propagation modeling was employed to estimate received sound levels from multiple sonar sources.

[H2] Long-term Passive Acoustic Monitoring of Cetaceans at PMRF and SOAR [DiMarzio et al. 2021]

Naval Undersea Warfare Center (NUWC) Division Newport maintains the Marine Mammal Monitoring on U.S. Navy Ranges (M3R) system, which can be run with minimal operator intervention to collect and archive 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 2015 to 2020, and at SOAR from 2010 to 2020. The spatial and temporal distribution of Cuvier's BWs at SOAR and for Blainville's BWs 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 or MarEcoTel to their locations for subsequent tagging (see **Project S2**).

[H3] Navy Civilian Marine Mammal Observers on DDGs

Beginning in 2010, the U.S. Navy has conducted a lookout effectiveness study to assess the effectiveness of Navy lookouts in locating marine mammals and appropriately reporting them to the bridge during at-sea training events. During these embarks, MMOs followed a systematic protocol to collect data (sighting and weather information) that were pooled with other embarks for analysis of the effectiveness of U.S. Navy lookouts observing from the pilot house or the bridge wings of the Guided Missile Destroyers (DDG). Data collection ended in 2020 and a final report is expected by the end of 2021.

[H4] Odontocete Studies on PMRF [Baird et al. 2021]

CRC has been conducting this long-term marine mammal monitoring project each year since 2011, adding to prior, independent surveys extending back to 2003. Surveys are conducted in conjunction with the M3R PAM system streaming from the instrumented PMRF Range (Moretti 2017; DiMarzio et al. 2018, 2019, 2020, 2021). M3R detections are used to direct the CRC boat to animals of interest for satellite-tag deployment, biopsy sampling, and photo-identification (photo-ID) in addition to providing visual validations of species for the acoustic detections. Animals instrumented with satellite tags can provide information on spatial movements and habitat-use patterns of cetaceans that are exposed to MFAS on and around PMRF before, during, and after the SCC (see Baird et al. 2019a, 2019b, 2021). Tagged animals that overlap in space and time with training events can be utilized for MFAS exposure analysis (see **Project H5**). Because the August 2019 SCC training event at PMRF was cancelled, CRC tagging activities were completed in February 2020.

[H5] Impacts of MFAS on Tagged Odontocetes at PMRF [Henderson et al. 2021b]

Data from tagged odontocetes (pre-2020) had been previously analyzed using simpler, temporally coarser, two-dimensional MFAS received level (RL) estimations. Argos positions typically only occur once every few hours, leading to only a handful of RL estimates per animal using these earlier methods. In addition, the RLs were estimated for broad “shallow” and “deep” diving depth categories defined for each species, without integrating empirical measurements of diving behavior into the analysis. For this reanalysis effort, available positional data (which was superior for more recent tags with Fastloc GPS capabilities) were interpolated every 5-minute using the R-package *crawl*, and using dive data obtained from individual tags, dive depths were estimated at each of those 5-minute locations. Further, 95% confidence interval 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 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 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.

[H6] Humpback Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean [Palacios et al. 2020b, 2020c, 2021]

This is the same project conducted for SOCAL, NWTT, and GOA TMAA **[S7, N1, and G1], refer to Project N1**.

[H7] Comprehensive Stranding Investigations for MIRC and HRC [West et al. 2021]

This is the same project conducted for MITT [M2].

2.2.1.2 SOCAL

A timeline of all U.S. Pacific Fleet-funded monitoring tasks implemented in SOCAL in 2020 is illustrated in **Figure 5**.

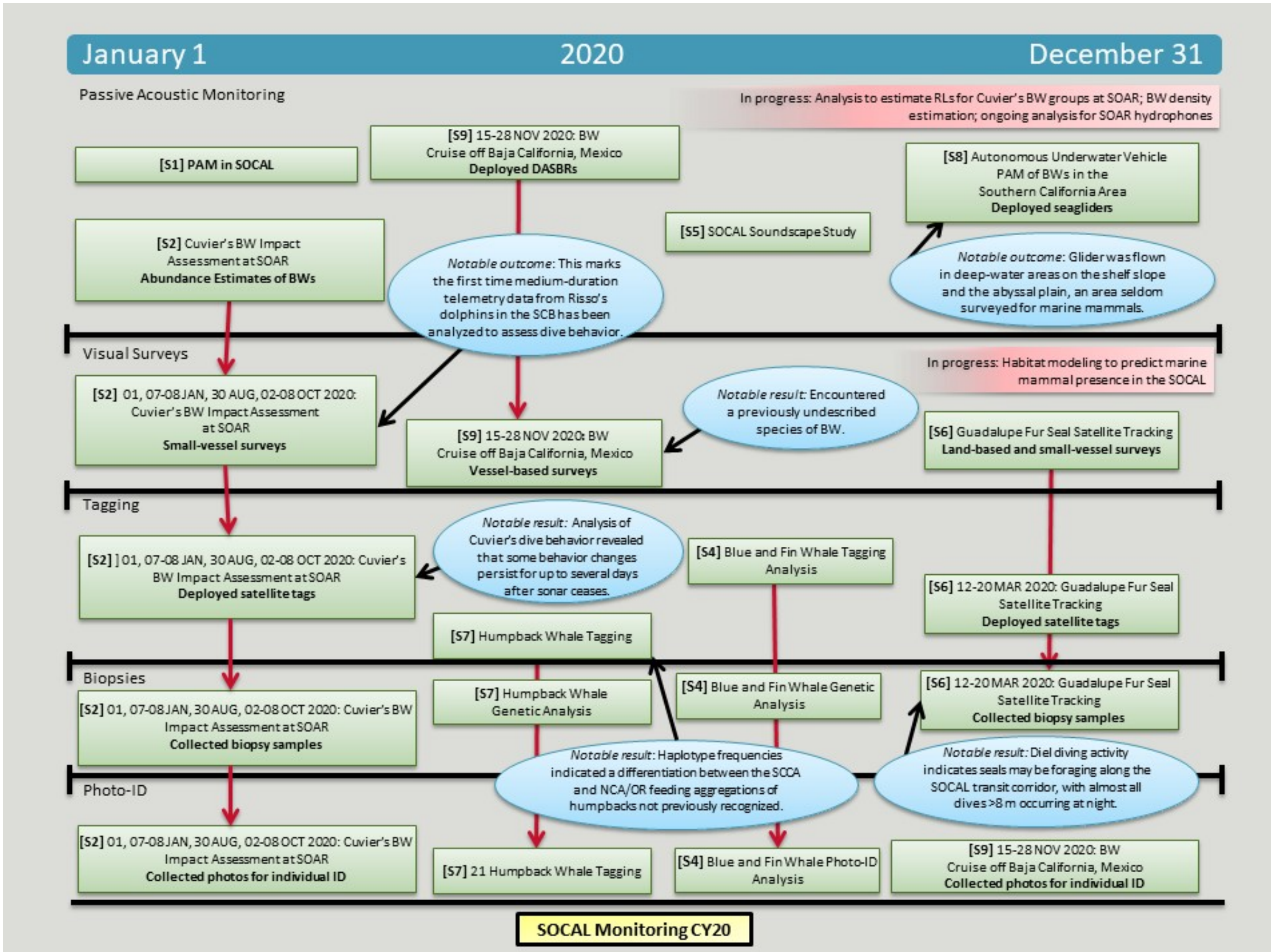

Figure 5. Timeline of 2020 projects in the Southern California Range Complex (SOCAL).

[S1] Passive Acoustic Monitoring in SOCAL [Rice et al. 2021]

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). 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 2020, the study focused on blue whales [*Balaenoptera musculus*], fin whales (*Balaenoptera physalus*), and all species of BWs. In addition, recordings were analyzed to characterize the low-frequency ambient soundscape (see **Project S5**), as well as the presence of MFAS and explosions. Rice et al. (2021) analyzed HARP data collected between November 2018 and May 2020. The HARPs recorded sounds between 10 Hz and 100 kHz and were deployed at four sites within SOCAL: two to the west of San Clemente Island (site E at 1,300 meters [m] depth and site H at 1,000 m depth) and two southwest of the Island (site N at 1,250 m depth and site U at 1,200 m depth). Site E recorded from 9 November 2019 to 8 May 2020; site H recorded from 1 June 2019 to 8 May 2020; site N recorded from 5 May 2019 to 29 April 2020, and site U recorded from 18 November 2018 to 11 June 2019 (although there was a gap from 18 to 26 November in the low- and mid-frequency data due to technical issues), and again from 6 November 2019 to 16 January 2020. For all four sites, a total of 27,817 hr (1,159 days) of acoustic data were included in the 2020 analysis. Data analysis for marine mammal and anthropogenic sounds was performed using automated computer algorithms.

[S2] Cuvier's Beaked Whale Impact Assessment at SOAR [Schorr et al. 2021; DiMarzio et al. 2021]

Small-vessel surveys were performed by MarEcoTel at SOAR in 2020 as part of an ongoing, long-term study of the distribution and demographics of BWs and fin whales that use the Range. Survey methods included tagging, biopsy sampling, and photo-ID techniques. Group sizes of Cuvier's BWs were recorded for use in abundance and density estimation on SOAR (DiMarzio et al. 2021; see **Project H2**). For encounters with BWs, detailed records of surfacing patterns were also collected for as long as contact with the group was maintained. Staff from the NUWC M3R program monitored SOAR hydrophones to assist with visual verification of acoustic localizations and tag deployments and directed the MarEcoTel rigid-hulled inflatable boats into areas where marine mammal vocalizations were detected. NUWC continued an ongoing project to develop estimates of abundance of Cuvier's BWs at SOAR, including investigating seasonal changes in abundance and mean group vocal periods, and vocal behaviors (see **Project H2**). Best-of-sighting identification photographs of fin whales and BWs were internally reconciled across annual sightings and compared to existing photo-ID catalogs curated by MarEcoTel using methods described in Falcone and Schorr (2014) to build photographic sighting histories. 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 data previously collected in the SCB. These included 1) an analysis of the movements and dive behavior of 16 Risso's dolphins (*Grampus griseus*) tagged between 2009 and 2019, and 2) an analysis of behavioral responses of 13 Cuvier's BWs tagged between 2011 and 2015 to MFAS. The latter analysis focused on baseline, exposed, and post-exposure deep dive cycles.

[S3] Marine Mammal Monitoring on California Cooperative Oceanic Fisheries Investigation (CalCOFI) Cruises

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/. 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. For the marine species monitoring program, due to the COVID-19 pandemic, no surveys occurred during 2020. This project will continue in 2021.

[S4] Blue and Fin Whale Tagging and Analysis

From 2014 to 2017, OSU's Marine Mammal Institute conducted a four-year tagging and tracking study on eastern North Pacific blue and fin whales in the offshore areas of southern California (Mate et al. 2015, 2016, 2017a, 2018). The purpose of this study was to characterize the movement patterns, occurrence, and residence times of these whales within U.S. Navy training and testing ranges, as well as BIAs, along the U.S. West Coast. Three types of Argos (satellite-monitored) tags were deployed: location-only (LO) tags, dive monitoring (DM tags); and pop-off Advanced Dive Behavior (ADB) tags (see **Appendix D**). In 2020, OSU continued more detailed analyses of this extensive telemetry dataset, including ecological characteristics of whale movements; assessment of Argos tag location accuracy; site fidelity and residency patterns of tagged whales, and the use of U.S. Navy training and testing ranges and BIAs by tagged blue and fin whales. In addition, a comprehensive review was performed of blue and fin whale telemetry data collected from 1993 through 2013 to assess the degree of overlap with the GOA TMAA (Palacios et al. 2021).

This is the same project conducted for NWTT **[N3]**.

[S5] SOCAL Soundscape Study [Rice et al. 2021]

In 2020, 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 order to characterize the low-frequency ambient soundscape in this region of 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.

[S6] Guadalupe Fur Seal Satellite Tracking [Norris and Elorriaga-Verplancken 2020b]

This is the third year of this project, which aims to assess population size and at-sea movements of Guadalupe fur seals (*Arctocephalus townsendi* or *A. philippii townsendi*). Visual surveys of Guadalupe fur seals were conducted at the San Benito Archipelago and at Guadalupe Island, Mexico.

Surveys were performed in summer 2018 and again in summer 2019 following peak pupping season, and these census data were analyzed in 2020 to derive population estimates and identify population trends across these two years. Also, in 2020, 65 Guadalupe fur seals were instrumented with satellite-monitored tags (SPLASH10-F depth-sensing tags and smart position and temperature [SPOT] 6 LO--tags, Wildlife Computers; see **Appendix D**). Depth-sensing tags were deployed on adults and juveniles, and LO tags were deployed on pups. Tag data were analyzed to characterize at-sea dive behavior and horizontal spatial use in relation to four U.S. Navy training and testing ranges and study areas: NWTT, SOCAL, Point Mugu Sea Range (PT MUGU), and SOAR.

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

[S7] Humpback Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean [Palacios et al. 2020b, 2020c, 2021]

This is the same project conducted for HRC, NWTT, and GOA TMAA **[H1, N1, and G1]**, refer to Project **N1**.

[S8] Autonomous Underwater Vehicle (AUV) PAM of Beaked Whales in the Southern California Area [Fregosi et al. 2021; Mellinger et al. 2021]

A passive acoustic monitoring survey using autonomous underwater vehicles (AUVs, or “gliders”) was conducted from 7 February to 31 March 2020 in the SCB, with the goal of characterizing the temporal and spatial distribution of odontocetes and mysticetes in the region (Fregosi et al. 2021). Initially, the focus of this project was on BWs. However, upon recovery of the gliders post-deployment, it was discovered that neither glider recorded any useable data above 2.5 kHz, well below the frequency of BW vocalizations (Mellinger et al. 2021). It was then decided to analyze the available data for baleen whale and sperm whale (*Physeter macrocephalus*) vocalizations, which was originally a focus of secondary importance for the project. Two Seagliders™ were deployed in the San Nicolas Basin on 7 February 2020. One, the “abyssal glider” (SG607), was piloted to survey over the abyssal plain offshore of the continental shelf break. The other, the “shelf glider” (SG639), was piloted to conduct several transects inshore of the shelf break in water depths shallower than 2,500 m. Both gliders were programmed to survey in the vicinity of existing U.S. Navy-funded fixed acoustic sensors (HARPs) with the goal of eventually comparing the acoustic datasets collected by both types of instruments. The shelf glider malfunctioned and stopped recording well ahead of schedule on 10 February and was recovered on 14 February. The abyssal glider completed its mission, recorded a total of 763 hr of acoustic data (4,721 sound files on a duty cycle recording 10-minute files every 15 minutes) and traveled 940 km (50 days) before being recovered on 31 March. The shelf glider surveyed successfully for 87 hr and traveled 95 km before failing. It recorded 55 hr of acoustic data in 351 files with the same duty cycle as the abyssal glider.

[S9] Beaked Whale Cruise off Baja California, Mexico [Henderson et al. 2021a]

As part of a collaborative effort among Mexican and U.S. researchers, the U.S. Navy, National Oceanic and Atmospheric Administration (NOAA) Fisheries, and the Sea Shepherd Conservation Society (SSCS), a vessel survey was conducted off Baja California from 15 to 28 November 2020. The primary objective of the survey was to locate and document a species of BW (“BW43”) that had previously only been detected acoustically. Secondary objectives included a) evaluation of the anchorage at Las Islas San Benito to determine its utility as a sheltered base for this and future efforts in the area, and b) opportunistic photography of baleen whales, particularly migrating humpback whales off the northwestern tip of Baja Sur, for purposes of photo-ID. The survey platform was the *R/V* Martin Sheen, a 19 m sailboat, the use of which was donated by SSCS. Data collection methods included visual, passive acoustic, and environmental DNA (eDNA) techniques for detecting and identifying marine mammals. Acoustic instrumentation included four Drifting Acoustic Spar Buoy Recorders (DASBRs), each with a multi-channel SoundTrap ST4300 recorder (made by Ocean Instruments http://www.oceaninstruments.co.nz/). 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 of individual dorsal fins (for dolphins) or flukes (for humpback whales) when possible. For species other than BWs, once the species and group size had been confirmed and photographs had been collected, the sighting was terminated with a final time and position update. BW groups were followed for as long as possible, with a panga (7.6 m fiberglass fishing boat) deployed when possible to get close to the group for photographs and biopsy or eDNA samples.

2.2.3 NWTT

A timeline of all U.S. Pacific Fleet-funded monitoring tasks implemented in the NWTT Study Area in 2020 is illustrated in **Figure 6**.

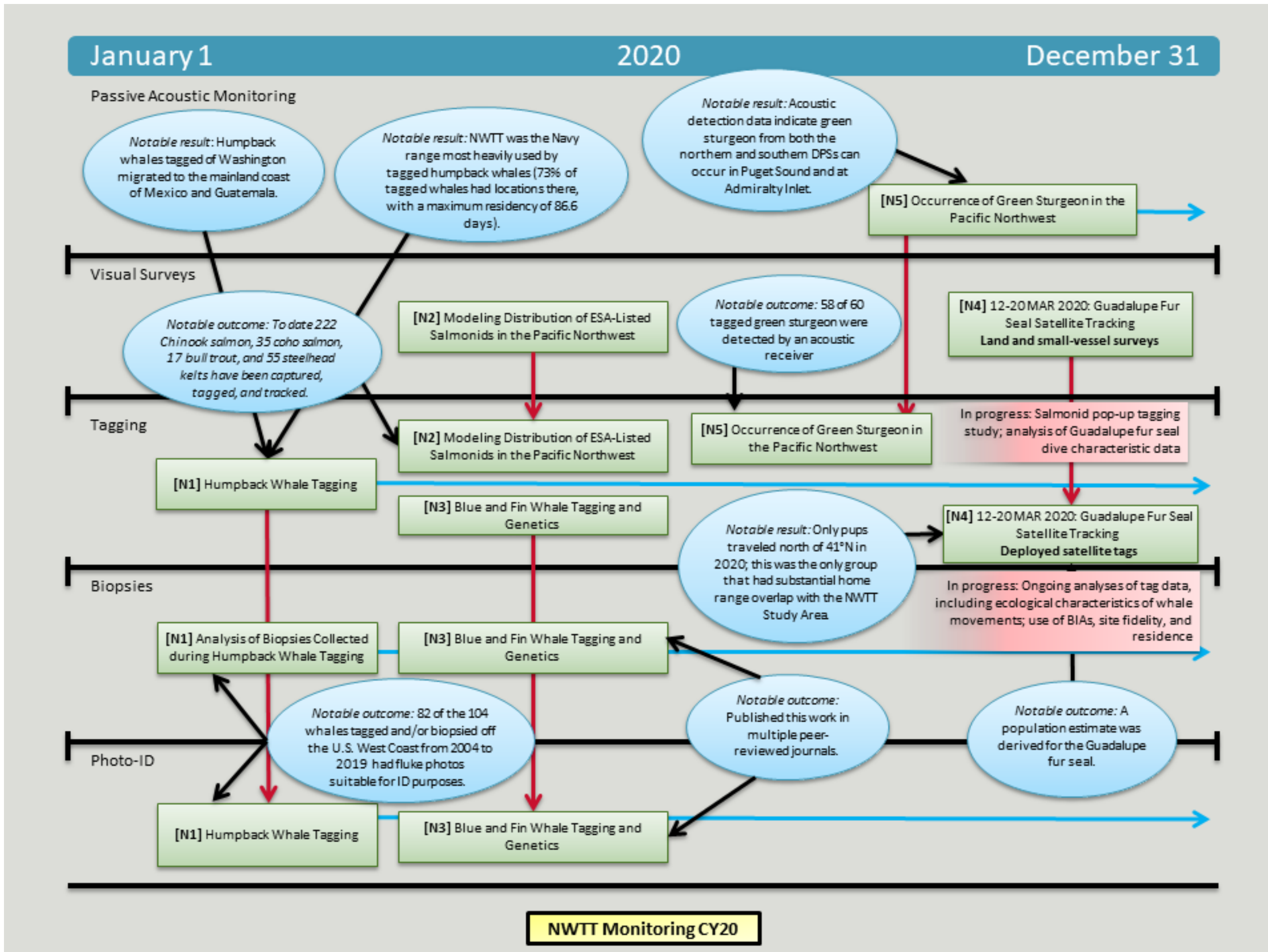

Figure 6. Timeline of 2020 projects in the Northwest Training and Testing (NWTT) Study Area.

[N1] Humpback Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean [Palacios et al. 2020b, 2020c, 2021]

Since 2012, OSU has conducted tagging and tracking studies on humpback whales in support of the U.S. Navy's efforts to meet regulatory requirements for marine mammal monitoring under the ESA and the MMPA. The primary goal of these studies has been to determine humpback whale movement patterns, occurrence, and residence times within several U.S. Navy training and testing areas in the Pacific Ocean. OSU has also conducted large whale tagging efforts at various locations in the Pacific since 1995. In 2020, tag data collected from 1995 through 2019 were aggregated, and existing humpback whale tracks were analyzed for overlap with three U.S. Navy training and testing areas: HSTT, NWTT and GOA TMAA. Fully implantable Telonics DM tags were used in 2019, providing long-term tracking information via the Argos satellite system as well as dive behavior (duration, depth, and number of lunges per dive). In addition to DM tags, fully implantable Telonics Duration Monitoring Plus (DUR+) tags were used in 2018, the latter providing the same capabilities as the DM tag except for depth. DM and DUR+ tags followed the same general physical design as OSU's earlier fully implantable LO tag used during previous tagging efforts (1997–2000, and 2015; Mate et al. 2019a). Externally mounted tags were deployed during the 1995 and 1996 tagging efforts off the islands of Kauai and Hawaii. In addition to tagging activities, researchers collected images for photo-ID, and conducted genetic analyses on tissue collected during tag placement. Dive duration, breeding-season home range, core areas of utilization, migration to the feeding areas, habitat use, and ecological/oceanographic characteristics was investigated, as well as assignment to various DPSs based on genetic information. Data from tagged whales provide valuable information on dive duration, activity levels, and other behavioral characteristics over periods spanning weeks to months.

This is the same project conducted for HRC, SOCAL, and GOA TMAA **[H6, S7, and G1]**.

[N2] Characterizing the Distribution of ESA-Listed Salmonids in the Pacific Northwest [Smith and Huff 2021]

Since 2019, an international team of researchers, including scientists from NOAA Northwest Fisheries Science Center, the Canadian Department of Fisheries and Oceans, the University of Washington, and OSU, 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 a combination of acoustic (Vemco V9 and V16), temperature, and pop-up satellite tags (PSATs) on Chinook salmon (*Oncorhynchus tshawytscha*), Coho salmon (*O. kisutch*), Bull trout (*Salvelinus confluentus*), and steelhead (*Oncorhynchus mykiss*) kelts. Data will provide critical information on spatial and temporal distribution of salmonids to inform salmon management, U.S. Navy training and testing activities, and Southern Resident killer whale conservation. Stationary acoustic receivers have been deployed along hundreds of miles of the Washington Coast, and to date 222 Chinook salmon, 35 Coho salmon, 17 Bull trout, and 55 steelhead kelts have been captured, tagged, and tracked. PSATs were configured to release 120 days (n = 5) and 180 days (n = 9) 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 vs. yearling) of each individual. In March 2020, receivers were retrieved and subsequently redeployed in July 2020 in a new line pattern designed to detect Chinook salmon tagged in Kodiak, Alaska and Yakutat, Alaska returning to the Columbia River.

This is the same project conducted for GOA TMAA, refer to **Project G3**.

[N3] Blue and Fin Whale Tagging and Analysis

This is the same project conducted for SOCAL, refer to **Project S4**.

[N4] Guadalupe Fur Seal Satellite Tracking [Norris and Elorriaga-Verplancken 2020b]

This is the same project conducted for SOCAL, refer to **Project S6**.

[N5] Occurrence of Green Sturgeon in the Pacific Northwest [Moser et al. 2021; Heironimus et al. 2021]

NWFSC, along with a coastwide consortium of researchers, has been tagging green sturgeon (*Acipenser medirostris*) since 2002. As part of a desktop historical review, acoustic detection data collected from 2002 through 2019 was reviewed for incidence of acoustically tagged green sturgeon in Puget Sound and the Strait of Juan de Fuca (Moser et al. 2021). To ensure that all detections of acoustically-tagged green sturgeon were included in this review, existing databases Ocean Tracking Network and Hydrophone Data Repository were searched and networked with other sturgeon researchers from Canada to California to ensure that the working list of unique green sturgeon tag codes was as complete as possible. Each transmitter code (individual green sturgeon) was analyzed for first detection time and location, total number of detections, and number of time blocks of detections to provide information on both the time a fish was within range of the receivers and whether it recurred in this area and, if so, how frequently. In addition, information on the sturgeon DPS assignment (if known) and the time and general location at release were compiled. Any green sturgeon tagged in their natal river (northern DPS from Rogue and Klamath, southern DPS form Sacramento) were assumed to be from that DPS. All fish captured in estuaries with unknown natal river were fin-clipped and some were later identified to DPS using genetic methods (Schreier et al. 2016).

In August 2020, Washington Department of Fish and Wildlife (WDFW) implanted acoustic transmitters in 60 green sturgeon captured in Grays Harbor and Willapa Bay, Washington (Heironimus et al. 2021). Capture efforts took place from 10 to 26 August to coincide with the period when green sturgeon congregate in the area in large numbers. A contract commercial fisher was hired to assist in capturing fish using sinking gillnets, soaked during daylight hours for approximately half hour sets. Fish caught were examined for deformities, erosion, lesions, and tags, measured to the nearest centimeter (cm) fork length, measured to the nearest cm girth, tagged with a Passive Integrated Transponder tag (see **Appendix D**) if no tags were present, and photographed. A subsample of fish was weighed to the nearest 0.5 kilogram. A small fin clip from the pelvic fin was removed for genetic analysis to determine which DPS it belonged to. Blood plasma was collected opportunistically to evaluate sex and maturity through sex-steroid analysis and a fin ray section for age analysis, and finally a V16 Vemco acoustic transmitter (69 kHz; 10-year battery life) was surgically implanted before release of the fish into the bay or estuary. Acoustic receiver arrays were located at the mouth of Grays Harbor and Willapa Bay, and detections were used to assess green sturgeon survival and transition from an estuarine to a marine environment. An offshore array was also present to detect green sturgeon migrations along the coast.

2.2.4 GOA TMAA

A timeline of all U.S. Pacific Fleet-funded monitoring tasks implemented in the GOA TMAA in 2020 is illustrated in **Figure 7.**

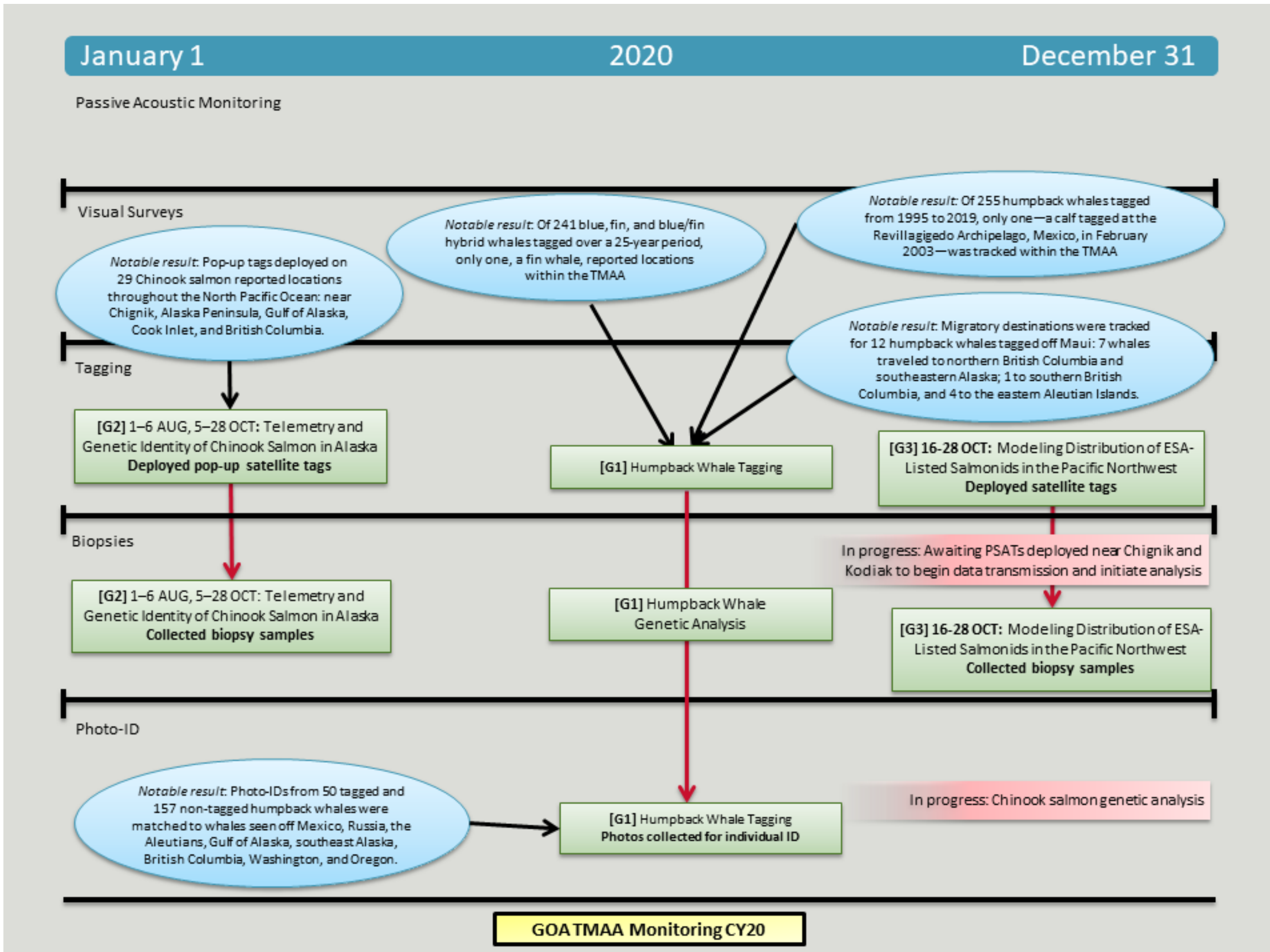

Figure 7. Timeline of 2020 Gulf of Alaska Temporary Maritime Activities Area (GOA TMAA) monitoring projects.

[G1] Humpback Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean [Palacios et al. 2020b, 2020c, 2021]

This is the same project conducted for HRC, SOCAL, and NWTT **[H6, S7, and N1]**, refer to **Project H6**.

[G2] Telemetry and Genetic Identity of Chinook Salmon in Alaska [Seitz and Courtney 2021]

In order to better understand the spatial distribution, genetic identity, and occupied habitat of Chinook salmon in and near the GOA TMAA, 40 Chinook salmon were captured by hook and line with bait or lures, and tagged with PSATs (MiniPAT, Wildlife Computers; Redmond, Washington). Catch-and-release activities occurred from 1 to 6 August 2020 near Chignik Bay, Alaska, and 5 to 28 October 2020, near Kodiak, Alaska. Fish were retrieved and brought on board the vessel and assessed for condition. Chinook salmon that were >60 cm fork length and in good condition were selected for tagging (Courtney et al. 2019). Satellite tags were attached to Chinook salmon using a tag attachment system. 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 (Argos Satellite System), summarized temperature and depth data (resolution 2.5–7.5 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 150- 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).

[G3] Characterizing the Distribution of ESA-Listed Salmonids in the Pacific Northwest [Smith and Huff 2021]

This is the same project conducted for NWTT, refer to **Project N2**.

3 2021 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 FY.

Continuing or new monitoring projects for calendar year 2021 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 below provides a quick summary of 2021 monitoring for MITT, HSTT (HRC and SOCAL), NWTT, and GOA TMAA. For a more detailed view of this monitoring, please see **Appendix C**.

Table 2. 2021 Monitoring projects for U.S. Navy Pacific Ranges/Study Areas.

Range/Study Area	Project Title	Status
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/SOCAL	**Navy Civilian Marine Mammal Observers on DDGs**	Final reporting in 2021
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	**Pacific Marine Assessment Program for Protected Species (PACMAPPS) Visual and Acoustic Survey of Cetaceans for the Mariana Islands**	New for 2021
MITT	**Sea Turtle Tagging**	Continuing from 2015 [2]
MITT and HRC	**Comprehensive Stranding Investigations**	Continuing from 2017 [3]
NWTT	**Pacific Northwest Distribution of Southern Resident Killer Whales and Prey**	Continuing from 2014 [4]
NWTT and GOA TMAA	**Characterizing 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 BWs only
[2] Field work delayed in last year of project (2020) due to COVID-19 travel restrictions
[3] Added emphasis and funding focused on these investigations starting in FY20
[4] Southern Resident killer whale focus 2014-2018; 2018-2021 focus on killer whale prey (ESA-list salmonids)

Key: DDG = guided missile destroyer; ESA = Endangered Species Act; GOA TMAA = Gulf of Alaska Temporary Maritime Activities Area; HRC = Hawaii Range Complex; MFAS = Mid-frequency Active Sonar; MIRC = Mariana Islands Range Complex; NWTT = Northwest Training and Testing; PMRF = Pacific Missile Range Facility; SOCAL = Southern California Range Complex.

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A

Abstracts/Executive Summaries from the 2020 Technical Reports

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

Gaos, A.R., and S.L. Martin. 2021.

The onset of the COVID-19 pandemic in early 2020 limited the ability of MTBAP to conduct field work, develop research tools, and analyze findings. Working with the Integrated Ocean Observing System, MTBAP provided public access to all of the satellite tags deployed during under the NOAA-PACFLEET IAA via the creation of a NOAA-PACFLEET web project within the Animal Tracking Network (ATN). This required MTBAP to undertake extensive data formatting and upload to ATN's data assembly center. MTBAP also worked with these partners and the satellite tag manufacturer Wildlife Computers to establish a data pipeline to feed tag telemetry data directly into ATN. This collaboration currently provides "real-time" visualization of all satellite tags deployed as part of the project. MTBAP continues working with the developers to improve the NOAA-PACFLEET web project.

[M2] Comprehensive Stranding Investigations: The Application of In-house Diagnostics, Disease Surveillance and Research to Further Understand the Timing and Cause of Strandings

West, K.L., C. Clifton, N. Hofmann, K. Jacobson, and I. Silva-Krott. 2021.

The University of Hawaiʻi Health and Stranding Lab located at Marine Corps Base Hawaii 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 has three objectives: 1) conduct comprehensive stranding investigations for high priority species through increased capacity for in-house diagnostics; 2) analyze archived tissues for the presence of two pathogens (circovirus and morbillivirus) and to examine the detectability of *Toxoplasma* positive animals over time, and 3) conduct analyses of historical stranding patterns and causes of mortality that incorporate quantitative estimates of stranding date and advanced diagnostic information. Progress to date includes the development of an operational in-house PCR laboratory to screen for known pathogens of concern and the development of tooth aging capabilities at Marine Corps Base Hawaii PCR screening has been conducted on archived tissues representing 20 stranded individuals for circovirus, an emerging disease in cetaceans. The 20 individuals screened for circovirus represent six different species. Of these, 35 percent (7/20) tested positive in at least two of six tissues tested by PCR which was subsequently confirmed by sequencing analysis and represents positive findings in six species. We have also built upon an initial DNA degradation experiment conducted by our laboratory to develop a quantitative tool to estimate the postmortem interval in stranded specimens that were not fresh dead at the time of stranding discovery. DNA degradation results compared among individuals, tissue types and environmental conditions indicate a significant linear relationship (r^2=0.76) in degradation rate up until 28 days postmortem. These findings can be applied to quantitatively estimate the actual day of death in stranded specimens that may be discovered stranded on a considerably different time-scale, leading to increased robustness of temporal stranding analysis in the Pacific Islands region.

[M3] Vessel-based Humpback Whale Surveys in and around Farallon de Medinilla: 29 January - 1 February 2020

Deakos, M., J. Chen, and M. Hill. 2021.

In order for the U.S. military to conduct readiness training with the Mariana Island Training and Testing Study Area (MITT), including the area around Farallon de Medinilla (FDM), the Navy is required to monitor and mitigate potential impacts of these activities on Endangered Species Act (ESA)-listed species. Segments of the North Pacific humpback whale population are known to use portions of the MITT seasonally for breeding activities, specifically Marpi Reef and shallow waters around Saipan. A small-boat visual survey for humpback whales was conducted between 29 January 2020 and 1 February 2020 to better understand the use of preferred shallow-water habitat around FDM. Over the four-day survey, nine humpback whale sightings were made of ten uniquely identified individuals. Seven of these individuals were newly added to the Marianas photo-identification catalog. Three individuals were seen in prior years off Saipan. Individuals were seen on multiple days within the survey area and engaging in typical reproductive behavior suggesting that the whales are not just migrating past FDM and the surrounding area. All sightings were made in water depths less than 183 m, which has been described as preferred breeding habitat for humpback whales. An analysis of preferred habitat for the entire Mariana Archipelago revealed that FDM accounted for 32 percent (354 square kilometers [km^2]). Of interest for future surveys are the Galvez Banks and Santa Rosa Reef, approximately 35 to 50 km south of Guam, comprising nearly 150 km^2 of preferred habitat and reef tracks 350 km to the southeast of Guam comprising of over 8,000 km^2 of preferred habitat, either of which may present additional critical breeding habitat for a segment of the North Pacific humpback whale population.

[H1] FY20 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. 2021.

This report documents Naval Information Warfare Center Pacific (NIWC Pacific) marine mammal monitoring efforts in fiscal year (FY) 2020 for Commander, Pacific Fleet (COMPACFLT) at the Pacific Missile Range Facility (PMRF), Kauai, Hawaii. The following list highlights tasks completed in FY20 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 2,972.2 hours of new data collected between 7 September 2019 and 2 September 2020. Additional decimated data were recorded in the spring of 2020 to capture potential acoustic ramifications of the COVID-19 pandemic.

2. Abundance results for baleen whales from 7 September 2019 to 2 September 2020 indicated that a maximum of four minke whales were detected in a 10-minute snapshot period in February 2020, while a maximum of three humpback whales were detected in March 2020. Similarly, there was a maximum of three tracks from the low-frequency baleen whale group that occurred in 10-minute snapshot periods in January and February 2020. Spectral correlation call templates were utilized 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).

3. For the first time, all available data collected on hydrophones with sufficient frequency response to detect low-frequency baleen whales (11 January 2011 to 2 September 2020) were processed and all tracks were fully manually validated. There was maximum of four fin whales detected in a 10-minute snapshot period in December 2017 and April 2019; a maximum of four Bryde's whales were detected in February 2017; and a maximum of two tracks with the 40 Hz downsweep call type were detected in May 2011, November 2012, and November 2018. The northwestern Pacific blue whale call type was detected and localized on November 21, 2019 (31 localized calls), and February 5, 2020 (24 localized calls).

4. Abundance results for odontocetes from 7 September 2019 to 2 September 2020 included Blainville's, Cross Seamount (CSM), and Cuvier's beaked whales, sperm whales, and killer whales. The number of FY20 Blainville's beaked whale dives were corrected based on sample validation of four FY20 baseline recordings (96 percent true positive rate and 4 percent false positive rate) and there was a monthly maximum of 4.44 dives per hour (October 2019). The number of fully validated FY20 CSM beaked whale dives had a strong diel trend at night and occurred far less frequently than Blainville's beaked whale dives, resulting in a monthly maximum of 0.45 dives per hour (July 2020). The number of fully validated FY20 Cuvier's beaked whale dives had a slightly lower number of group foraging dives per hour than CSM beaked whales, with a monthly maximum of 0.19 dives per hour (May 2020). Killer whale high-frequency modulated (HFM) call groups were not detected in any FY20 recordings. There was a maximum of four sperm whale tracks detected in a 10-minute snapshot period in April 2020.

5. Killer whale HFM call groups detected since 2002 were analyzed for a possible diurnal trend that was noticed in Martin et al. (2020). Seventy-seven percent of HFM call groups (37 of 48) began during daylight hours while the remaining 13 percent of HFM call groups were detected when the moon was over three-quarters full, indicating a very strong trend that is not just diurnal, but potentially dependent on illumination.

6. Longman's beaked whale frequency modulated (FM) clicks were documented on the 7 September 2019 recording. Future efforts will focus on tuning the beaked whale classifier to both identify the Longman's beaked whale FM click and improve the false negative rates of the Cuvier's and CSM beaked whale classifiers.

7. Disturbance analyses were conducted at PMRF for minke whales and Blainville's beaked whales during the February and August 2020 Submarine Command Course (SCC) training events.

a. The three minke whale tracks that overlapped with the February 2020 SCC were investigated. The first minke whale was not exposed to mid-frequency active sonar (MFAS) and may have demonstrated a behavioral reaction by briefly changing its call rate when the closest non-active ship was 11.9 km away and the animal was in the starboard beam sector. The second minke whale was only exposed to MFAS in in the first 5-minute bin of the track. The cumulative sound exposure level (cSEL) for the first bin, and therefore the entire track, was 157 dB cSEL re: 1μPa2s. Later in the track the second minke whale may have demonstrated a behavioral response by making an apparent heading change when the distance to the closest ship not transmitting sonar decreased from 22 km to 8.1 km. The third minke whale track had a minimum distance of 896 m to the closest ship not transmitting sonar, which is the minimum distance that we have ever reported for PMRF. Despite this close encounter, the third minke whale did not exhibit an apparent change in heading or call rate.

b. Blainville's beaked whale dives per hour of effort during non-training phases (i.e., Before, Between, and After phases), and during the SCC training event (i.e., Phase A [does not include hull mounted surface ship MFAS] and Phase B [includes surface ship hull mounted sonar]) were investigated for February and August 2020. In February 2020 there was a decrease in the number of dives per hour from the Before phase (1.98 dives/hour) to Phase A (0.24 dives/hour), an increase in dives per hour in the Between phase (1.05 dives/hour), followed by a decrease in Phase B (0.76 dives/hour), and an increase in the After phase (2.30 dives/hour). In August 2020 there was a decrease in the number of dives per hour from the Before phase (1.41 dives/hour) to Phase A (0.90 dives/hour), an increase in dives per hour in the Between phase (0.93 dives/hour), followed by a decrease in Phase B (0.64 dives/hour), and an increase in the After phase (1.45 dives/hour).

8. Under a related effort, improved disturbance analysis methods were developed for estimating the received levels (RL) on tagged marine mammals. A continuous-time correlated random walk model was fitted to the tag positions using the R package crawl (Johnson and London 2018) and estimated position errors were used to calculate whale location error ellipses. Combined with measured and modeled whale depths, RLs can be characterized for a 3D sound field. These improved methods are summarized in this report, and full methods and results will be reported separately by Henderson et al. (in prep).

9. The following noise analyses were applied to PMRF data:

a. Following the effort that investigated the Lombard effect in minke whales (Helble et al. 2020a), the Lombard effect in humpback whales was investigated and results were published by Guazzo et al. (2020). Source level and noise level were measured over the 150 to 1,000 Hz band and humpback whale song units had a median SL of 173 dB re 1 μPa at 1 m, and SLs increased by 0.53 dB/1 dB increase in background NLs.

b. One second power spectral density levels were integrated over the minke whale detection band (1,320 to 1,440 Hz) every minute and peaks in NL during the SCC were documented for the first time. In addition, daily peaks in noise in the 1,400 to 1,800 Hz band were discovered in recordings and the source is hypothesized to be from species (micronekton and/or fish) of the vertical migration in Hawaii. These peaks in noise levels from anthropogenic and natural sources have not been documented previously and further investigation is important to understanding how these types of increases in NL can impact the detection/classification and localization of whale calls.

[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), 2020

Dimarzio, N., K. Dolan, S. Watwood, Y. Luna, S. Vaccarro, L. Sparks, B. Bartley, and A. O'Neil. 2021.

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 training ranges SOAR in Southern California and 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 FY20 the M3R program had six areas of focus for SOAR and PMRF: 1) long-term data collection and the evaluation of abundance and distribution of Cuvier's beaked whales at SOAR and Blainville's beaked whales at PMRF; 2) the effect of two types of mid-frequency active sonar (MFAS), hull-mounted and dipping sonar, on Cuvier's beaked whales at SOAR and Blainville's beaked whales at PMRF; 3) evaluation of the M3R low-frequency detector algorithm at SOAR; 4) determination of Autogrouper detection statistics for Blainville's beaked whales at PMRF; 5) the development of tools to automatically characterize the ambient noise at SOAR using archive files; and 6) the support of on-site field exercises at SOAR and PMRF with real-time monitoring using the M3R system. The methods and results for each of these projects are presented and discussed.

[H4] Odontocete studies on the Pacific Missile Range Facility in February 2020: Satellite Tagging, Photo-identification, and Passive Acoustic Monitoring

Baird, R.W., C.J. Cornforth, S.M. Jarvis, N.A. DiMarzio, K. Dolan, E.E. Henderson, S.W. Martin, S.L. Watwood, S.D. Mahaffy, B.D. Guenther, J.K. Lerma, A.E. Harnish, and M.A. Kratofil. 2021.

As part of a long-term U.S. Navy-funded marine mammal monitoring program, in February 2020 a combination of vessel-based field effort and passive acoustic monitoring was carried out on and around the Pacific Missile Range Facility (PMRF) off Kaua'i prior to a Submarine Command Course scheduled for mid-February 2020. The purpose of the monitoring effort was to assess the spatial movement patterns and habitat use of cetaceans that are exposed to mid-frequency active sonar and how those patterns influence exposure and potentially responses. Results from this effort were compared with previous Cascadia Research Collective (CRC) survey effort and photo-identification and tag data from Kaua'i, based on surveys in 11 different years since 2003. During the survey, the Marine Mammal Monitoring on Navy Ranges (M3R) system was used both to direct the research vessel to potential high-priority species and to inform the research vessel when only low-priority species were detected on the range, allowing it to survey off the range and thus increase overall encounter rates with high-priority species.

Over the course of the 13-day project, there were 1,064 kilometers [km] (71.3 hours) of small-vessel survey effort, 46 sightings of seven species of odontocetes, 23 sightings of humpback whales (*Megaptera novaeangliae*), and one sighting of an unidentified odontocete. Of the 46 odontocete sightings, 20 were on PMRF representing four of seven species, and of those eight were directed by M3R acoustic detections. During the encounters, we took 26,178 photographs for species and individual identification, with photographs added to long-term CRC catalogs for short-finned pilot whales (*Globicephala macrorhynchus*), false killer whales (Pseudorca crassidens), pygmy killer whales (*Feresa attenuata*), common bottlenose dolphins (*Tursiops truncatus*), and rough-toothed dolphins (*Steno bredanensis*). Nineteen biopsy samples were taken from five species. Spinner dolphins (*Stenella longirostris*) were seen on 12 occasions, but this was a low-priority species so limited efforts were expended to work with them.

As expected based on previous CRC efforts off Kauaʻi and Niʻihau, rough-toothed dolphins were the most frequently encountered species, comprising 18 of 46 encounters with known species (39.1 percent). Ten of the 18 encounters were on PMRF. A social network analysis of photo-identification data of rough-toothed dolphins indicated that all but two of the identified individuals from this project linked to the main cluster of the resident, island-associated population. In three of the sightings a single melon-headed whale was present, as well as a melon-headed whale x rough-toothed dolphin hybrid, both of which had been previously documented off Kauaʻi during CRC's August 2017 field effort. The melon-headed whale was not approachable for tagging. For two of the three sightings of the hybrid and melon-headed whale, the individuals were not noted at the time of the encounters but were only recognized from later analysis of photographs.

Short-finned pilot whales were encountered only once, and a single SPLASH-10F depth-transmitting satellite tag that included Fastloc®-GPS capability was deployed. The group with the tagged animal had been previously documented in five different years (all off either Kauaʻi or Oʻahu) and was considered to belong to the resident western community of short-finned pilot whales. A crawl model (continuous-time correlated random walk state-space model) of the tag data produced a total of 372 locations at 1-hour intervals compared to 314 total Argos locations, and 277 combined Argos and GPS locations. Behavior (i.e., dive and surfacing) data coverage during the 12 days that behavior was recorded was 86.8 percent. Over the 16-day period during which the tag transmitted, the group spent most of its time in deep water far offshore (median depth=3,504 meters [m], median distance from shore=28.1 km based on combined Argos and GPS data), remaining in the area where the Submarine Command Course took place.

Pygmy killer whales were sighted once, in association with a single humpback whale. This group was not approachable for tagging, but identification photos were obtained for 15 individuals, none of which had been previously identified. This species is among the rarest encountered off Kauaʻi or Niʻihau; in previous CRC surveys they have only been documented on two occasions. Neither of these groups have been documented prior or subsequently, providing additional evidence that there is no resident population of this species off Kauaʻi or Niʻihau.

False killer whales were encountered on three occasions over two days (14 and 15 February 2020), with all sightings on PMRF and two in response to acoustic detections. None of the groups were approachable for tagging, but identification photos were obtained for the two encounters on 14 February 2020. Eight identifications were obtained from the first encounter on 14 February 2020, four of which had been previously documented and linked by association to the Northwestern Hawaiian Islands population of false killer whales. Only a single identification was obtained from the second encounter on 14 February 2020. While the individual had not been previously documented, it was most likely also from the Northwestern Hawaiian Islands population, given the proximity to the first encounter. Three biopsy samples were obtained, from individuals in both of the encounters on 14 February 2020. The 15 February 2020 encounter was brief (<1 minute), with a single individual lost shortly after being sighted.

Common bottlenose dolphins (hereafter bottlenose dolphins) were encountered on nine occasions, and 46 good-quality identifications of 24 distinctive individuals were obtained. Of those, 23 had been previously documented, and all were linked by association with the resident community of bottlenose dolphins from Kaua‘i and Ni‘ihau. Two SPLASH10 depth-transmitting satellite tags were deployed onto bottlenose dolphins during the project, on 15 and 17 February 2020. Both individuals tagged are known members of the resident Kaua‘i and Ni‘ihau community, and one of the two individuals had been previously tagged during a 2013 CRC field project. The tags produced 223 and 383 Argos locations over 13.9 and 20.0 days, respectively, and generally remained close to the islands (median depth = 119 m and 180 m, median distance from shore = 3.1 km and 3.7 km, respectively). Behavioral data (i.e., dive and surfacing) coverage during deployment was 100 percent for both tags.

Probability-density analyses were undertaken using 12-hour locations from crawl state-space models of tag-location data obtained for the two species for which tag data were available from this effort, incorporating data from all previous tag deployments on individuals from these populations. Core areas (50 percent kernel densities) were identified for the resident populations of bottlenose dolphins (1,852 square kilometers) and the western community of short-finned pilot whales (8,736 square kilometers). While the core areas for both populations overlap with at least part of PMRF, the differences in the proportion of the core area that overlaps with PMRF suggests that the likelihood of exposure to mid-frequency active sonar on PMRF varies substantially between populations. Continued collection of photo-identification, movement, and habitat-use data from these species allows for a better understanding of the use of the range and surrounding areas, as well as estimation of abundance and examination of trends in abundance for resident populations.

[H5] FY20 Summary Report on the Received Level Analysis of Satellite Tagged Odontocetes at the Pacific Missile Range Facility

Henderson, E.E., C. Martin, R.W. Baird, M.A. Kratofil, S.W. Martin, and B.L. Southall. 2021.

This report summarizes the development and application of substantially upgraded analytical methods to quantify the movement and diving behavior of satellite tagged odontocetes before, during, and after Submarine Command Course (SCC) training events at the Pacific Missile Range Facility (PMRF) off Kaua‘i, Hawai‘i, and their exposure and potential response to mid-frequency active sonar

(MFAS) during these events. Eleven short-finned pilot whales and seven rough-toothed dolphins were tagged between February 2011 and February 2019. These data had been previously analyzed using simpler, temporally coarser, two-dimensional MFAS received level (RL) estimations. Argos positions typically only occur once every few hours, limiting the number of RL estimates per animal using these earlier methods. In addition, the RLs were estimated for broad "shallow" and "deep" diving depth categories defined for each species, without integrating empirical measurements of diving behavior into the analysis. For this reanalysis effort, satellite tag data were re-processed through the Kalman smoothing algorithm, which compared to the previously used least-squares location data, provides greater temporal resolution in tracks and more robust estimates of positional uncertainty. Available positional data, including Fastloc GPS locations for some recent tags (including one new short-finned pilot whale and two bottlenose dolphins tagged in 2020), were interpolated every 5-min using the R-package crawl, and using dive data obtained from individual tags, dive depths were estimated at each of those 5-min locations. Further, 95% confidence interval error ellipses were calculated around each 5-min position, with multiple radials running from source locations through error ellipses in order to model transmission loss (TL) values (and thus estimate RLs) from the source to the far edge of the radial and to the seafloor. RL values were then derived for many points in the three-dimensional space within the error ellipse most likely to contain the animal at that time and around the estimated depth value in order to arrive at the most accurate possible propagation-modeled RL estimate (with associated variance estimates). A sub-set of data was also analyzed following the 100 imputed track method utilized by Schick et al. (2019), which yielded comparable results. The error ellipse method was thus applied here.

In addition to these more detailed RL analyses, 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 noise sources that could potentially cause behavioral responses. Therefore, odontocete behavior herein was examined in five phases: (1) before Phase A; (2) during Phase A; (3) between phases A and B; (4) during Phase B; and (5) after phase B (when all of those periods were applicable for the tagged individual). 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 within the context of baseline behavioral variability. This framework can only be developed because of the high sample size and long-term effort that has been conducted off Kaua'i and the other Hawaiian Islands, and is an essential facet of behavioral response analyses. In this study, while there were statistical differences in dive behavior of all three species across the periods of the SCC, there were no apparent consistent patterns indicating broad, sustained responses to MFAS (e.g., large-scale habitat abandonment). In fact, there were often inter-individual differences in how dive behavior changed across periods, with some instances of behavioral changes more apparently related to the lunar cycle than to training activity. A quantitative analysis of fine-scale individual responses to evaluate potential behavioral changes as a function of range or RL (as conducted in some dedicated behavioral response studies) was not conducted here. However, there are a few cases where a behavioral response may have occurred based on the timing of events and apparent movement, as individuals moved towards the region of activity on PMRF and then changed the direction of their travel away during a period of MFAS. However, there were also sharp changes in direction of travel during baseline and non-MFAS periods. A quantitative analysis may be able to tease apart these differences to determine what may constitute a behavioral response. Statistical methods utilizing comparable satellite-telemetered data such as those collected here are being developed in other studies and would be applicable to these data in the near future.

Although no overt, broadly evident behavioral responses seem to have occurred, there were several instances of animals occurring and apparently continuing to remain quite close to active ships. We estimate that these individuals received some of the higher levels of MFAS exposure yet documented for any marine mammal species. Although vastly improved over previous RL estimates there is still positional uncertainty in these data; while the highest median levels in these 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. While the probability of reaching those maximum levels was quite low, these results do indicate that in some cases odontocetes at PMRF may be experiencing very high RLs that could approach temporary or even permanent threshold shift levels, with further considerations regarding physiological stress responses even in the absence of behavioral response. All but two of the individuals included in this study have been determined to be part of the resident populations for these species. There is thus likely some degree of habituation that has occurred for these animals to the presence of MFAS, which may lead to a lack of strong behavioral responses. However, additional behavioral samples for most species and the potential for physiological or auditory impacts beyond behavior speaks to the need to continue these detailed tagging, behavior, and received level analyses for all odontocete species at PMRF. Such data will inform not only the short-term MFAS exposure and response questions relevant to fleet monitoring objectives but are also relevant to addressing the long-term population level consequence objectives of understanding potential impacts to these animals.

[S1/S5] Passive Acoustic Monitoring for Marine Mammals in the SOCAL Range Complex November 2018-May 2020

Rice, A.C., M. Rafter, J.S Trickey, S.M. Wiggins, S. Baumann-Pickering, and J.A. Hildebrand. 2021.

Passive acoustic monitoring was conducted in the Navy's Southern California Range Complex from November 2018 to May 2020 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 1,000 m depth, site H) and two southwest of San Clemente Island (1,250 m depth, site N and 1,200 m depth, site U).

While a typical southern California marine mammal assemblage is consistently detected in these recordings (Hildebrand et al., 2012), only a select sub-set of species including blue and fin whales, listed as "Endangered," and 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 H 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. Calls of two baleen whale species were detected: blue whale B calls and fin whale 20 Hz calls. Both species were present at all sites: blue whale B calls were highest at site E and the fin whale acoustic index, representative of 20 Hz calls, was highest at site E and lowest at site U. Blue whale B call detections peaked in August 2019 and again in October 2019 at sites H and N. Very few blue whale B calls were detected after January 2020. The fin whale acoustic index was highest from October 2019 to April 2020.

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 2019, while at site H they peaked in August 2019 and again from February to May 2020. The new beaked whale FM pulse type, BW37V (previously referred to as BW35; Rice et al. 2019, 2020), thought to be produced by Hubbs' beaked whale (Griffiths et al. 2018), was detected only in January 2020 at site E, in December 2019 and January 2020 at site H, and on only one day in March 2020 at site N. The FM pulse type, BW43, thought to be produced by Perrin's beaked whale (Baumann-Pickering et al. 2014), was detected intermittently throughout the recording period at sites N and U. No other beaked whale signal types were detected.

Two anthropogenic pulsed signals were detected: MFA sonar and explosions. MFA sonar was detected at all sites with peaks in February, August, and November 2019. Site N had the most MFAS packet detections normalized per year and the highest cumulative sound exposure levels, including events concurrent with a major naval exercise during November 2018. 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 October and November 2019 and February 2020 at site H. At site H, temporal and spectral parameters suggest primarily association with fishing, specifically with the use of seal bombs.

[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, and D.A. Sweeney. 2021.

The Southern California Range Complex (SOCAL) is one of the United States (US) Navy's most active training areas, particularly concerning the use of 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 11 days of survey effort from 4 January 2020 to 8 October 2020, 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 and fin whales. With combined effort from ancillary projects funded by the US Navy's Living Marine Resources (LMR) program, we had 36 sightings of cetaceans, including six sightings totaling 15 Cuvier's beaked whales and five sightings totaling 10 fin whales. Reconciliation of identification photographs from these sightings and four whales photographed opportunistically outside of SOAR yielded 10 unique Cuvier's beaked whales in 2020; four of these whales were previously identified at SOAR, with sighting histories of up to 11 years. This included one mother-calf pair that remained associated 2.5 years after their first sighting together. We processed 268 fin whale identifications, with 39 from Navy-funded research in 2019 and the remainder from opportunistic contributions in 2019 or before. These represented sightings of 105 unique individuals, 97 of which were identified in 2019 on an average of 1.74 days each. Thirty-nine fin whales identified in 2019 (40 percent) had been sighted in a previous year. Three genetic samples were collected, including one from a Cuvier's beaked whale and two from fin whales. There were eight environmental DNA (eDNA) samples collected during Cuvier's sightings for an ancillary project funded by the Office of Naval Research in collaboration with Oregon State University, but which may provide key data for monitoring efforts. One SMRT tag was deployed on a Cuvier's beaked whale during an ancillary effort.

Labor originally intended to support 2020 data processing was partially re-tasked (in consultation with the Navy) to analyses of previously collected data, given the limited data collected this year. These included an assessment of movements and diving behavior in Risso's dolphins in Southern California, which found that dives were deepest at night, and increased in depth during full moons and with increasing chlorophyll-*a* concentrations. Dive durations were longest and shortest around the first and third quarter moons, respectively. Movement models indicated that lunar phase, time of day, and month influence inshore/offshore movements. We also re-analyzed previously published diving data from Cuvier's beaked whales exposed to MFAS from 2011-2015 to better characterize the effects of exposure after MFAS use has ceased using an alternate approach to that presented in Schorr et al. (2020), which assessed response duration using a single behavioral metric (time between deep dives). Here, we used Mahalanobis distance to characterize behavior patterns using a suite of variables, and modeled behavior as a function of the previous exposure parameters. We found that some exposure contexts produced changes in behavior that persisted for up to several days after sonar use ceased.

[S6/N4] Guadalupe Fur Seal Population Census and Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean, 2019-2020

Norris, T.A., and F.R. Elorriaga-Verplancken. 2020.

As the population of Guadalupe fur seals (*Arctocephalus townsendi* or *A. philippii townsendi*) continues to recover, this species, which is listed as threatened in the U.S. and endangered in México, is increasingly common in their historical range extending from central México to Washington State. Relatively little is known about this species compared with other pinnipeds that occur in the California Current System. Accurate and current population estimates are lacking because censuses at the only rookery have been sparse and sporadic, and there is a paucity of data on at-sea movements because few individuals have been tracked using telemetry instruments. Therefore, the goal of this multiyear study was to better understand Guadalupe fur seal abundance, behavior, distribution, and habitat use, and to determine the degree to which this recovering population uses U.S. Navy training and testing ranges in the Northeast Pacific. During the second year of this study, censuses were performed at Guadalupe Island, México and San Benito Archipelago, México in summer 2019. Satellite tags were subsequently deployed on adult females (n = 15), juvenile females (n = 10), juvenile males (n = 10), and pups (n = 30) at Guadalupe Island in March 2020. These census and telemetry data were compared to data collected during the first project period (2018-2019). At San Benito Archipelago, twice as many animals were counted in 2019 relative to 2018, but only approximately 20 mother-pup pairs were observed at this site during both years. In contrast, at Guadalupe Island, approximately the same number of animals were observed in 2018 and 2019, but there were ~2,800 more adult females and ~2,500 fewer pups in 2019 compared with 2018.

In spring and summer 2020, Guadalupe fur seals used waters off the west coast of North America but traveled farther offshore and north (21-51°N, 108-140°W) than the animals tracked November 2018 through April 2019 (20-42°N, 112-130°W). Most animals traveled north of Guadalupe Island during all or part of both tracking periods. Adult females were distributed farther offshore in 2020 (<1,400 km from shore) than in 2018-2019 (<800 km from shore). In 2020, juvenile females also used more offshore areas to a greater extent, and a greater proportion of juvenile males used habitat south of Guadalupe Island. Only pups, which were not tracked in 2018-2019, traveled north of 41°N in 2020, and this was the only group that had substantial home range overlap with the U.S. NWTT Study Area (31 percent overlap). Overall, there was greater home range overlap with the PT MUGU (≥61 percent for each group), and group home range overlap with the Southern California (SOCAL) Range Complex was 18 to 50 percent. With the pelagic distribution of this species, the nearshore portions of each Navy range with water depths <2,000 m were used to a lesser extent (<38 percent overlap) relative to the entire area of each range, and the SOAR was used by only one juvenile male each year. Most adults and juveniles dove to shallow depths during the night, primarily <60 m, with minimal daytime diving. Large numbers of dives >8 m occurred nightly, which likely indicates foraging activity, along portions of tracks with directed, relatively straight travel over long distances that often are interpreted as transiting rather than foraging areas. Most notably, foraging behavior was observed throughout the offshore area (>2,000 m water depth) of SOCAL that previously appeared to be primarily a transit corridor to and from Guadalupe Island. These results improve our understanding of Guadalupe fur seal abundance, behavior, and use of U.S. Navy training and testing ranges in the Northeast Pacific across seasons and years, but additional census and telemetry data collected in subsequent years will further elucidate population trends and interannual and seasonal variability in habitat use and movement patterns.

[S8] Passive Acoustic Monitoring of Large Whales on and off the Continental Shelf of Southern California using Autonomous Underwater Vehicles

Fregosi, S., D. Mellinger, K. Ampela, and C.E. Bacon. 2021.

A passive acoustic monitoring survey using mobile underwater gliders was conducted from 7 February to 31 March 2020 in the Southern California Bight, with the goal of characterizing the temporal and spatial distribution of odontocetes and mysticetes in the region. Initially, the focus of this Project was on beaked whales. However, upon recovery of the gliders post-deployment, it was discovered that neither glider recorded any useable data above 2.5 kilohertz, well below the frequency of beaked whale vocalizations. It was then decided to analyze the available data for baleen whale and sperm whale (*Physeter macrocephalus*) vocalizations, which was originally a focus of secondary importance for the Project.

Two Seagliders™ were deployed in the San Nicolas Basin on 7 February 2020. One, the “abyssal glider” (SG607), was piloted to survey over the abyssal plain offshore of the continental shelf break. The other, the “shelf glider” (SG639), was piloted to conduct several transects inshore of the shelf break in water depths shallower than 2,500 meters. Both gliders were programmed to survey in the vicinity of existing United States (U.S.) Navy-funded fixed acoustic sensors (high-frequency acoustic recording packages) with the goal of eventually comparing the acoustic datasets collected by both types of instruments. The abyssal glider completed its mission, recorded a total of 763 hours of acoustic data (4,721 sound files on a duty cycle recording 10-minute files every 15 minutes) and traveled 940 kilometers (km) (50 days) before being recovered on 31 March. The shelf glider malfunctioned and stopped recording well ahead of schedule on 10 February and was recovered on 14 February. The shelf glider surveyed successfully for 87 hours and traveled 95 km before failing. It recorded 55 hours of acoustic data in 351 files with the same duty cycle as the abyssal glider.

Blue (*Balaenoptera musculus*), fin (*B. physalus*), humpback (*Megaptera novaeangliae*), and sperm whale vocalizations were recorded by the abyssal glider, and fin and humpback vocalizations (no blue or sperm whales) by the shelf glider. Fin and humpback encounters were particularly abundant. No confirmed minke whale (*Balaenoptera acutorostrata*) vocalizations were recorded by either glider. The abyssal glider recorded blue whale B calls on three separate days, all while the glider was inshore of the shelf break west of Tanner Bank. Fin whales were detected on every day of both glider deployments, and on several days, they were present in 100 percent of the 10-minute recording periods. Humpback whales were detected on 48 of the 50 days of the abyssal glider’s deployment, both on and off the continental shelf, and on all five days of the shelf glider recordings (continental shelf only). The abyssal glider recorded sperm whales on 12 of the 50 recording days (n=165 confirmed detections), when the glider was located at the shelf break and over the abyssal plain.

The deep-water areas on the shelf slope and the abyssal plain are seldom surveyed for marine mammals, making the results of this study particularly valuable in improving our understanding of marine mammal occurrence and distribution in these areas, and in and around U.S. Navy training and testing areas in the region.

[S8] Interim Report for Passive Acoustic Monitoring off Southern California using Autonomous Underwater Vehicles—Summary of Technical Issues Encountered, Lessons Learned, and Future Recommendations

Mellinger, D., S. Fregosi, and K. Ampela. 2021.

In February 2020, a passive acoustic monitoring (PAM) survey using Autonomous Underwater Vehicles (AUVs, aka "gliders") was performed off Southern California using two Seagliders™ equipped with Passive Miniature Acoustic Recorder (PMAR)-XL acoustic processing boards, manufactured by Hydroid, Inc. (formerly a subsidiary of Kongsberg Marine, now a subsidiary of Huntington Ingalls Industries). A series of delays and technological failures impacted project schedule and the ability to meet project objectives. The PMAR-XL system was not yet commercially available in 2018 at project start, and in the bench testing phase it was discovered that the gliders' firmware no longer supported the PMAR-XL acoustic processing system and had to be updated to do so. This caused the deployments, originally planned for fall 2019, to be delayed until February 2020. The glider manufacturer company changed management twice during the course of this project, resulting in limited staff availability, and exacerbating project delays. The gliders were not ready for the mission until only several days before planned deployments and had to be express shipped directly to the deployment location instead of to Oregon State University (OSU) for additional testing (as originally planned) in order to meet the planned deployment schedule and survey during the desired winter/spring season. Four days following deployment, the shelf (inshore) glider stopped recording acoustic data. The reason was later discovered to be a failed filtering capacitor for one of the hydrophones. The abyssal (offshore) glider completed its mission without incident, recording sound files when expected and of the expected amount of recording time. Soon after glider recovery and examination of the data, it was discovered that neither glider recorded sounds above 3 kilohertz, well below the target frequency for beaked whales. This was due to a system configuration issue resulting from the lack of available documentation for the newly developed processing board. Based on these experiences and the diagnostic report from the manufacturer, the PMAR-XL system was likely not mature enough for use in the Fleet-funded Marine Species Monitoring Program despite previous research and development funded by the Office of Naval Research (ONR). In response to these challenges, HDR, Inc. and OSU have produced this interim project report outlining issues encountered, documenting lessons learned in the course of the project, corrective actions taken, and recommendations for future similar work. Acoustic data collected by the gliders were instead analyzed for the presence of baleen and sperm whales, and these results are outlined in the final project report.

[S9] FY20 Summary Report on the Collaborative Beaked Whale Cruise off Baja California, Mexico

Henderson, E.E., J. Barlow, G. Cárdenas-Hinososa, D.C. Lopez-Arzate, D. Breese, and E. Hildago. 2021.

This report summarizes the field effort from 15 to 28 November 2020, to locate and document a species of beaked whales that had previously only been acoustically detected. While the species of interest was again recorded on acoustic drift buoys, a previously undescribed species of beaked whale was unexpectedly encountered instead. This new species has external morphological characteristics and a new echolocation pulse type that do not match any previously observed or recorded species and therefore may represent a newly described species. In addition to this species of beaked whale, we encountered and photographed three species of dolphin as well as humpback whales and recorded two other species of beaked whales on the acoustic recorders.

[N1/S7/G1/H6] Humpback Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean: Final Report for the Pacific Northwest Feeding Area in Summer/Fall 2019, Including Historical Data from Previous Tagging Efforts off the US West Coast

Palacios, D.M., B.R. Mate, C.S. Baker, B.A. Lagerquist, L.M. Irvine, T.M. Follett, C.E. Hayslip, and D. Steel. 2020b.

Oregon State University (OSU) conducted a tagging and tracking study on Eastern North Pacific humpback whales (*Megaptera novaeangliae*) to determine their movement patterns, occurrence, and residence times along the West Coast of the United States (US).This report presents results from field efforts conducted off the coast of northern Washington (NWA) in summer and fall 2019, as well as results from previous OSU studies of humpback whales in southern and central California (SCCA), northern California and Oregon(NCA/OR), and NWA from 2004 to 2018.Whale use of US Navy training and testing areas as well as their use of Biologically Important Areas (BIAs) and National Marine Sanctuaries (NMSs) is examined, and assignment to various Distinct Population Segments (DPSs) based on genetic information is discussed. This report also presents detailed analyses of dive behavior, ecological relationships, and photo-identification. Tracking data were obtained for a total of 81 whales, with an overall tracked duration ranging from 0.1 to 164.2 days [d] (mean = 39.1 d, standard deviation [SD] = 33.6d).The distribution of the tracked animals supported humpback whale affinity for continental shelf and shelf-edge habitat and documented extensive use of the northwestern coast of Washington and the central coast of California, and to a lesser degree, the northern California coast and the Columbia River mouth at the Oregon/Washington border. Complete or partial migrations were documented for eight whales, with recorded or presumed breeding destinations including Mexico, Guatemala, and Hawaii. The most intensively used Navy range was the Northwest Training and Testing Study Area (NWTT), with 73 percent of whales (59 of 81) having locations there and a maximum residency of 86.6 d. The second most intensively used range was Warning Area-237 (W237) of the NWTT, with 47 percent of whales having locations there and a maximum residency of 65.4 d. Only 6.2 percent of whales migrated through the Southern California Range Complex (SOCAL) and only 1.2 percent migrated through the Southern California Anti-submarine warfare Offshore Range (SOAR) subarea. Nine percent of whales had locations within Point Mugu Range Complex (PT MUGU), spending between 6.1 and 33.8 d there. Most of the occupancy in NWTT was by whales tagged in NWA and NCA/OR, and only 13 percent of whales tagged in SCCA had locations in NWTT. The occupancy of U.S. West Coast BIAs and NMSs also suggested spatial separation of whales throughout feeding areas, as there was very little overlap of locations in BIAs or NMSs of whales tagged in the different regions. The most intensively used were the Northern Washington BIA and the Olympic Coast NMS for whales tagged in NWA, the Point St. George BIA and Greater Farallones NMS for whales tagged in NCA/OR, and the Gulf of the Farallones to Monterey Bay BIA and Greater Farallones NMS for whales tagged in SCCA. A total of 79 individual whales were genetically identified from skin biopsy samples collected during tagging efforts (n = 14 from SCCA; n = 15 from NCA/OR; n = 50 from NWA). The composition of haplotype frequencies suggested a differentiation between the SCCA and NCA/OR feeding aggregations that had not been previously recognized. The relative likelihood of individual assignment to each of the four recognized DPSs in the North Pacific based on the genetic profiles indicated that the majority of individuals from SCCA (64 percent) assigned with highest likelihood to the Central America DPS, whereas the largest proportion of individuals from NCA/OR (47 percent) and NWA (48 percent) assigned with highest likelihood to the Hawaii DPS. The remaining individuals assigned to the Mexico and Western North Pacific DPSs.

[N1/S7/G1/H6] Humpback Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean: Final Report for the Hawaiian Breeding Area in Spring 2019, Including Historical Data from Previous Tagging Effort

Palacios, D.M., B.R. Mate, C.S. Baker, B.A. Lagerquist, L.M. Irvine, T. Follett, D. Steel, and C.E. Hayslip. 2020c.

Three of the 14 Distinct Population Segments (DPSs) of humpback whales (*Megaptera novaeangliae*) recently designated by the National Marine Fisheries Service (NMFS) for listing under the Endangered Species Act (ESA) based on their winter breeding areas ("Hawaii", "Mexico", and "Central America"), can be found along the western coast of North America during the feeding season. The mixing of whales from these DPSs in the feeding areas in different proportions complicates unequivocal assignment of individuals to breeding stock for management purposes without further information. As a result, there is an urgent need for data on occurrence and habitat use by these different DPSs throughout their range, as well as on their overlap with shipping traffic, fishing grounds, and areas of military operation, in order to prioritize management actions and to mitigate the impacts from these activities.

In 2019, Oregon State University (OSU) conducted a tagging and tracking study on Eastern North Pacific humpback whales to determine their movement patterns, occurrence, and residence times within United States (US) Navy training and testing areas in the Hawaiian Islands and elsewhere in the North Pacific. This work was performed under a Cooperative Ecosystem Studies Unit (CESU) agreement in support of the Navy's efforts to meet regulatory requirements for marine mammal monitoring under the ESA and the US Marine Mammal Protection Act. This report presents detailed results from the tagging, biopsy sampling, and photo-identification (photo-ID) efforts conducted in the Hawaiian Islands in 2019, as well as results from previous OSU studies of humpback whales in the Hawaiian Islands from 1995 to 2018. Whale use of Navy training and testing areas as well as their use of NMFS-identified Biologically Important Areas (BIAs) in the Hawaiian Islands and Alaska is also examined.

Fully implantable (or "consolidated type") Telonics Dive Monitoring (DM) tags were used in 2019, providing long-term tracking information via the Argos satellite system as well as dive behavior (duration, depth, and number of lunges per dive). In addition to DM tags, fully implantable Telonics Duration Monitoring Plus (DUR+) tags were used in 2018, the latter providing the same capabilities as the DM tag except for depth. DM and DUR+ tags followed the same general physical design as OSU's earlier fully implantable Location-Only (LO) tag used during previous tagging efforts (1997–2000, and 2015; Mate et al. 2019b). Externally mounted (or "anchored type") tags were deployed during the 1995 and 1996 tagging efforts off the islands of Kauai and Hawaii (Mate et al. 1998).

Twenty-five humpback whales were tagged off Maui in March 2019. Argos locations were received from 24 of the 25 tags, with tracking periods ranging from 0.1 to 81.3 days (d) (mean = 21.4 d, standard deviation [SD] = 20.2 d, n = 24). A total of 101 humpback whales were tagged by OSU in the Hawaiian Islands prior to 2019, covering the period 1995 to 2000, 2015, and 2018. Of these, 85 were deployed off Maui (in 1997, 1998, 1999, 2000, 2015, and 2018); 10 were deployed off Kauai (in 1995, 1996, and 1997); and six were deployed off Hawaii (in 1996). Tracking data were obtained for 81 whales prior to 2019 (the remaining tags provided no locations), with tracking durations ranging from 0.04 to 160.0 d. Tracking periods (for fully implantable tags deployed from 1995 to 2019) for whales that migrated away from the Hawaiian Islands (median = 38.2, maximum = 160.0 d, n = 36) were longer than for whales that were only tracked within the islands (median = 7.7, maximum = 44.4 d, n = 60). Hierarchical switching state-space models (hSSSM) were applied to the Argos locations from the tags deployed in 2018 and 2019 (duty-cycled at 6 hours [h]/d), and conventional switching state-space models (SSSM) to the Argos locations from the historical LO tags (which were programmed with less frequent duty cycles) for the purpose of generating regularly spaced tracks with annotated behavioral state for use in analyses of movement behavior and identification of migration phases.

The aggregate tracking results within the Hawaiian Islands support results of previous photo-ID studies and aerial surveys, showing highest densities of whales in the Maui Nui region (the inner waters of the "four-island region" of Maui, Molokai, Lanai, and Kahoolawe), where most of the whales were tagged, as well as Penguin Bank, and extensive inter-island movements. The results also identify high use of Middle Bank and the Papahanaumokuakea Marine National Monument by some whales in 2019. Mean residence time in the Hawaiian Islands from tagging to departure (for whales with known departure date from the islands) for the aggregate tracking data was 13.1 d (range = 1.1-42.8 d, SD = 9.4 d, n = 39), lending support to earlier studies that found that there is a rapid turnover of individuals in this breeding area during the winter season. Migratory destinations were tracked for 12 humpback whales tagged off Maui, with seven whales going to northern British Columbia and southeastern Alaska, one going to southern British Columbia, and four going to the eastern Aleutian Islands, supporting the findings of previous telemetry, genetic, and photo-ID studies. One of the latter four whales continued on to the Kamchatka Peninsula (Russia), while another traveled to the western end of the Aleutian Island chain off Kamchatka, then to the Bowers Basin in the southwestern Bering Sea, and ultimately north into the Gulf of Anadyr (Russia), just south of the Bering Strait.

In terms of movement behavior, state-space model output for 86 tracks ≥ 3 d in duration (range = 3-176 d) indicated that locations classified as "area-restricted searching" occurred primarily in the breeding (n = 2,159 SSSM/hSSSM locations; 50.4 percent) as well as feeding (n = 528 SSSM/hSSSM locations; 12.3 percent) areas, while "transiting" locations were the predominant behavioral mode while migrating (n = 1,598 SSSM/hSSSM locations; 37.3 percent). Movement speed was somewhat slower in the feeding areas (mean = 1.42 km/h, median = 0.85 km/h, SD = 1.55 km/h, n = 528 SSSM/hSSSM locations) than in the breeding area (mean = 1.62 km/h, median = 1.20 km/h, SD = 1.38 km/h, n = 2,159 SSSM/hSSSM locations), while it was substantially higher during migration (mean = 4.65 km/h, median = 4.61 km/h, SD = 2.39 km/h, n = 1,598 SSSM/hSSSM locations). However, travel speeds during the migration phase were not sustained but showed variation over time and among individual animals, including both high- frequency oscillations as well as longer periods of increased and decreased speed lasting several days.

Five Navy areas within the Hawaii Range Complex (HRC) were considered in this report: Four Island Region Mitigation Area (FIRMA), Humpback Whale Seasonal Special Reporting Area Oahu North (SSRA- ON), Humpback Whale Seasonal Special Reporting Area Oahu South (SSRA-OS), Humpback Whale Seasonal Special Reporting Area Penguin Bank (SSRA-PB), and Barking Sands Tactical Underwater Range and Underwater Range Expansion, combined (BS-Merge). Of these, FIRMA was the most heavily used by humpback whales, with 95 percent of tracked whales spending time there (maximum residency of 23.1 d). This was unsurprising, as 96 of the 105 tracked whales were tagged within FIRMA. Area SSRA-PB was the next most heavily used, with 66 percent of whales spending time there (maximum residency of 23.8 d), followed by SSRA-OS (25 percent of whales, maximum residency of 1.3 d) and then SSRA-ON (23 percent of whales, maximum residency of 1.5 d). Only 11 percent of tracked whales spent time within BS-Merge (three of five tagged in Kauai, nine of 96 tagged in Maui, none of four tagged in Hawaii), with maximum residency in this area of 1.4 d. This low use was not surprising, given the range's close proximity to Kauai and the small sample size of whales tagged in Kauai. More tagging off Kauai would improve our understanding of BS-Merge use by humpback whales while in the Hawaiian Islands and help determine whether the minimal use noted here is simply a function of tagging location bias. None of the 12 humpback whales tagged in the Hawaiian Islands from 1995 to 2019 that reached a migratory destination were tracked within any Navy training areas along the U.S. West Coast or in the Gulf of Alaska, but our small sample size of migrating whales reaching a feeding destination likely contributed to this finding.

Of the three Biologically Important Areas (BIAs) that have been designated for humpback whales in the Hawaiian Islands, two (Kauai-Niihau and Hawaii) did not overlap (completely) with Navy areas. Of these, Kauai was the most heavily used by humpback whales tagged from 1995 to 2019, with 14 percent of tracked whales (15 of 105, five of which were tagged there) having locations there (maximum residency of 3.5 d). Six percent of tracked whales (six of 105, four of which were tagged there) had locations in the Hawaii BIA, with a maximum residency of 6.2 d. More tagging off the islands of Hawaii and Kauai would further our understanding of BIA use in those areas. Ninety-one percent of tracked whales (96 of 105) had locations in a region surrounding the islands defined by the 200-meter (m) isobath as its inner boundary and 50 km from shore as its outer boundary, with a maximum residency of 30.2 d.

Of the seven humpback whales migrating to the northwestern coast of the U.S. and Canada, four were tracked within the Southeast Alaska BIA, with a maximum residency of 70 d. Humpback whale use of feeding-area BIAs outside the Southeast Alaska BIA was minimal (two whales were tracked within the Aleutians BIA and none in the Shumagin or Bristol Bay BIAs), due in part to the small number of whales tracked to these areas, but also to the whales' preference for the southern and western side of the Aleutian Island chain. An area of high use approximately 160 km south of Akutan Island and Unimak Pass by two humpback whales tagged 19 years apart highlights this area as important feeding habitat for some humpbacks. The north and west coasts of Haida Gwaii (British Columbia, Canada) were also shown to be high-use areas.

Tags summarized dives for a mean of 62.0 percent of the tracking duration across 2018 and 2019. Dives in the breeding areas were generally shallow (<100 m), with a mean of 64 percent of recorded dive behavior occurring in the upper 30 m of the water column. Occasional dives reached 400 m; however, maximum dive depth was likely limited by bottom depth in many cases, and there were no discernible spatial patterns to dive behavior. Dive behavior during migration was generally similar to behavior in the breeding areas. However, for the first 7 to 14 d of migration whales consistently made deep (>200 m), long-duration (>15 minutes [min]) dives at night. The purpose of these dives is unclear but may be related to acoustic orientation or magnetic navigation. Dives of tagged whales in the feeding areas near Haida Gwaii were shallow, with no temporal trends except one whale from 2019, which made deeper, longer duration dives during the day, suggesting it was employing a different foraging strategy compared to other tagged whales using the area.

Biopsy samples were collected from 23 of 25 tagged whales off Maui in 2018 and from 21 of 25 tagged whales and one untagged whale off Maui in 2019. Mitochondrial deoxyribonucleic acid (DNA) sequences of the combined samples resolved seven haplotypes for the consensus region of 500 base-pairs. All haplotypes have been previously described for North Pacific humpback whales. All samples were identified by a unique multi-locus genotype of at least 14 loci in 2018 and 11 loci in 2019, indicating that each sample represented an individual whale. The 45 individuals represented five females and 40 males. The DNA profiles of all 45 individuals were compared to an unpublished database of DNA profiles representing 3,351 individual humpback whales from the North Pacific. This "DNA register" represents a shared archival resource held by OSU's Cetacean Conservation and Genomics Laboratory, in collaboration with regional contributors, following the technical standards for DNA profiling used in the SPLASH program (Baker et al. 2013). Five matches (i.e., genotype recaptures) were detected: two to individuals sampled in the Hawaiian Islands in 2004, two to individuals sampled in the northern Gulf of Alaska (one in 2004 and one in 2009), and one to an individual sampled in northern British Columbia in 2005. A sixth genotype recapture was documented between a whale tagged by OSU in the Hawaiian Islands in 1999 and a whale sampled in southeastern Alaska in 2019, 20 years after tagging.

Of the 50 whales tagged off Maui in 2018 and 2019, 36 had fluke photos that could be used for identification purposes. Twenty-six of these have been identified in the Happywhale photo-ID database, with matches to the Hawaiian Islands, Mexico (Baja California), western Gulf of Alaska, northern Gulf of Alaska, southeastern Alaska, and northern Washington/southern British Columbia.

The ID of a whale that was biopsied but not tagged was matched in Happywhale to the Hawaiian Islands and southeastern Alaska. A total of 157 photo-IDs were collected of non-tagged whales off Maui during 2018 and 2019, 93 of which had matches in Happywhale. These included matches to the Hawaiian Islands and Mexico (mainland), as well as to Russia, eastern Aleutian Islands, western Gulf of Alaska, northern Gulf of Alaska, southeastern Alaska, northern British Columbia, northern Washington/southern British Columbia, and Oregon.

With the second year of this CESU agreement to study humpback whales in the Hawaiian Islands through satellite telemetry, dive behavior, genetics, and photo-ID, we have characterized this DPS' breeding-season occupation, connectivity, and residence time, and use of Navy training and testing areas as well as NMFS-designated BIAs. The results of this study have also revealed the complex migratory linkages of this DPS to high-latitude feeding areas. Field efforts in the Hawaiian Islands so far have concentrated around the Maui Nui region. Additional years of sampling with increased effort during different parts of the reproductive season, in other parts of the main Hawaiian Islands (e.g., Kauai and Hawaii) as well as in the northwestern Hawaiian Islands (in waters of the Papahanaumokuakea Marine National Monument) would provide valuable information to address outstanding questions about the humpback whale population using this extensive breeding area, as well as its broader connections to remote feeding areas throughout the North Pacific Ocean, some of which may be related to reproductive timing.

[N1/S7/G1/H6] Large Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean: A Supplemental Synopsis of Whale Tracking Data in the Vicinity of the Gulf of Alaska Temporary Maritime Activities Area

Palacios, D.M., B.A. Lagerquist, T.M. Follett, C.E. Hayslip, and B.R. Mate. 2021.

Since 2012, Oregon State University (OSU) has been conducting tagging and tracking studies on large whales in support of the U.S. Navy's efforts to meet regulatory requirements for marine mammal monitoring under the Endangered Species Act and the Marine Mammal Protection Act. The primary goal of these studies has been to determine whale movement patterns, occurrence, and residence times within several Navy training and testing areas in the Pacific Ocean, as reported extensively in a series of previous Technical Reports. Although no tagging was done within the Gulf of Alaska Temporary Maritime Activities Area (TMAA), and no whales tagged by OSU in other Navy training and testing areas during these studies were tracked to the GOA TMAA, data from other OSU efforts indicated that previously tagged whales have occurred within the GOA TMAA. Here we provide a brief synthesis of OSU's tagging studies in the North Pacific Ocean, focusing on whale occurrence within and in the vicinity of the GOA TMAA. Four species are addressed: humpback whales (*Megaptera novaeangliae*), gray whales (*Eschrichtius robustus*), blue whales (*Balaenoptera musculus*), and fin whales (*B. physalus*).

Of 255 humpback whales tracked by OSU from 1995 to 2019, only one was tracked within the GOA TMAA. This whale was tagged at the Revillagigedo Archipelago, Mexico, in February 2003. Additionally, the track of one whale tagged in Southeast Alaska in July 1997 crossed the southeast corner of the GOA TMAA but reported no locations within it. Five other humpback whales tagged in

Hawaii were tracked on trajectories toward the Gulf of Alaska, but their tags stopped transmitting before they reached their migratory destinations. One untagged whale photographed in Hawaii in 2015 had been encountered previously in the GOA TMAA in July 2013. Eight additional whales photographed in Hawaii in 2015 and 2019 have been encountered in Prince William Sound, Alaska, both before and after our sampling, indicating the possibility of travel through the GOA TMAA during their migrations.

Of 69 gray whales tracked by OSU from 1996 to 2013, three were tracked within the GOA TMAA and the tracks of two more whales crossed its boundary. These five whales were tagged at Ojo de Liebre Lagoon, Mexico, in 2005. An additional five whales tagged in Ojo de Liebre Lagoon were tracked migrating from the western coast of North America to the eastern Aleutian Islands and into the Bering and Chukchi Seas, but large data gaps in their tracks precluded an examination of their northbound route across the Gulf of Alaska, including the GOA TMAA.

Finally, of 241 blue whales, 46 fin whales, and one blue/fin hybrid whale tracked by OSU from 1993 to 2018, only one fin whale tagged in California in 2006 had locations within the GOA TMAA in January and February 2007. No blue whales were tracked within the GOA TMAA and only one whale, tagged in California in 2007, came within 260 km of the southeastern corner of the GOA TMAA.

[N2] 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. 2021.

The Northwest Fisheries Science Center conducted a study to characterize the distribution of salmonids (Chinook salmon, coho salmon, bull trout) within the Northwest Training and Testing (NWTT) area in 2019. In May 2019, we deployed 107 stationary receivers in a grid pattern along the coast of Washington State. We retrieved, downloaded, and redeployed stationary receivers in September 2019. Receivers were retrieved and downloaded in March 2020 and not redeployed due to COVID-19 restrictions. In July 2020, receivers were redeployed in a new line pattern designed to detect Chinook salmon tagged in Kodiak, AK and Yakutat, AK returning to the Columbia River. In October 2020, we tagged 80 Chinook salmon with acoustic transmitters in Kodiak, AK. In February 2021 we tagged 14 steelhead kelts with pop-up satellite tags and 41 steelhead kelts with acoustic tags in the Willapa River, WA. We plan to tag 80 Chinook salmon with acoustic tags in in Yakutat, AK in March. We plan to download and redeploy acoustic receivers in the summer of 2021.

[N5] Occurrence of Green Sturgeon in Puget Sound and the Strait of Juan de Fuca: A review of Acoustic Detection Data Collected from 2002 to 2019

Moser, M.L., K. Andrews, S. Corbett, B.E. Feist, and M. Moore. 2021.

Information on green sturgeon occurrence in Puget Sound and the Strait of Juan de Fuca is needed to ensure that potentially harmful human actions do not impact this species, particularly the southern distinct population segment (DPS), which is listed as threatened under the U.S. Endangered Species

Act. We reviewed acoustic detection data from 2002 to 2019 for incidence of acoustically tagged green sturgeon in these areas.

Acoustic receiver coverage expanded in Puget Sound from 2002 to 2008, at the same time that 350 acoustically tagged green sturgeon of known origin were at large (67% from the southern DPS). During this time, 17 green sturgeon were detected in Puget Sound: 4 from the southern DPS, 12 from the northern DPS and 1 of unknown origin. After 2008, no green sturgeon were detected on central or southern Puget Sound receiver lines, even though over 400 tagged sturgeon of known origin were at large (83 percent from the southern DPS). However, at Admiralty Inlet (northern Puget Sound), six green sturgeon were detected during 2013–2018: four from the northern DPS, one from the southern DPS, and one of unknown origin.

A receiver line was operated at the Strait of Juan de Fuca starting in 2004, and by 2019, 210 green sturgeon had been detected at this line. Of these fish, 97 were identified as southern DPS, 39 as northern DPS, and the remaining fish were of unknown origin. That is, of the known-origin green sturgeon detected at the Strait of Juan de Fuca line, 71 percent were members of the southern DPS. These data indicated that green sturgeon use the Strait of Juan de Fuca as a corridor, residing at receiver sites for relatively short periods as they pass through the strait. Few of these fish were detected subsequently at Admiralty Inlet, suggesting that most of the acoustically tagged population move northward into the Strait of Georgia after transiting the Strait of Juan de Fuca.

Acoustic detection data indicated that green sturgeon from both the northern and southern DPSs can occur in Puget Sound and at Admiralty Inlet, but at low rates relative to their presence in the Strait of Juan de Fuca. Our results support the decision by NOAA Fisheries to designate the Strait of Juan de Fuca as an area of high conservation value for southern DPS green sturgeon. These results also confirm earlier findings that Puget Sound is of lower conservation value to southern DPS green sturgeon, based on the lower rate of detections in this area. However, these data have implicit biases associated with receiver placement and origin of the tagged population. To address these concerns, tagging of green sturgeon captured in Puget Sound or the Strait of Juan de Fuca, along with genetic sampling for DPS determination, could increase sample sizes and help resolve patterns of spatial and temporal habitat use in these important areas.

[N5] 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. 2021.

Large aggregations of both the Northern distinct population segment (DPS) and ESA-listed Southern DPS of the green sturgeon *Acipenser medirostris* 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 evaluating the impacts of military training and testing operations to protected species and, for the purpose of this project, is specifically interested in assessing impacts to the threatened Southern DPS of green sturgeon. In August 2020, we implanted acoustic transmitters in 60 green sturgeon captured and released in Grays Harbor and Willapa Bay, Washington. Nearly all (97%) of the newly tagged fish have been detected since the tagging event, the missing detections are likely related to the loss of one receiver at the entrance to Willapa Bay. Thus far no green sturgeon mortalities were detected as a result of this study. Assignment to either the Northern or Southern DPS cannot be visually assessed, therefore, we are awaiting genetic analysis of the fin-clip samples to complete this genetic assignment. Additionally, we are awaiting acoustic data collection from the offshore array, operated by NOAA Fisheries. When both the genetic and acoustic data becomes available, we intend to further evaluate the spatial and temporal extent of green sturgeon detections along the Washington coastline.

[G2] Telemetry and Genetic Identity of Chinook Salmon in Alaska: Preliminary Summary of Satellite Tags Deployed in 2020

Seitz, A.C., and M.B. Courtney. 2021.

Information about the spatial distribution, movement, vertical distribution, and occupied habitat of fishes is important for understanding several aspects of their ecology, including potential impacts of human activities. 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 Chinook salmon Evolutionarily Significant Units (ESUs) and Navy training activities. Therefore, to qualitatively describe the spatial distribution, movement, vertical distribution, occupied habitat, and natural mortality of Chinook salmon in the Gulf of Alaska, we attached pop-up satellite archival tags (PSATs) to individuals near Chignik, AK (n = 20) and Kodiak, AK (n = 20). To date, 29 of the 40 PSATs have reported to satellites, providing approximately 1,600 days of depth, temperature, and location data. Reporting locations of tags were widespread across the North Pacific Ocean, ranging as far west as the Alaska Peninsula to as far east as the coast of central British Columbia, Canada. Preliminary analyses of depth and temperature data documented tagged Chinook salmon occupying waters from 0 to 237 m in depth, while experiencing a thermal environment of 4–15°C. Furthermore, diagnostic evidence from tag data provided evidence that 17 Chinook salmon experienced predation by endothermic fish(s) (n = 14), an ectothermic fish (n = 1), and a marine mammal (n = 1), 11–113 days after tagging. Currently, we are waiting for 11 PSATs deployed on Chinook salmon to transmit archived data to satellites on their programmed pop-up dates. We are also preparing to deploy 20 additional PSATs on Chinook salmon near Yakutat, AK, during late-winter 2021. Once all transmitted PSAT data are received, comprehensive data analyses will commence. These analyses will provide insights into the spatial distribution, movement, vertical distribution, occupied habitat, and natural mortality of Chinook salmon in the North Pacific Ocean, from which overlap with Navy training activities can be inferred.

B

2020 Publications and Conference Presentations from Navy-Funded Monitoring

2020 Publications from Navy-Funded Monitoring Through February 2021

(Beaked whale references from other geographical areas included)

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C

Details of 2021 Monitoring Projects

Table C-1. 2021 Monitoring projects details for Pacific Navy Study Areas/Ranges: HSTT (HRC and SOCAL), MITT, NWTT, 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 and 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

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 1)	Continuing or Proposed New Start
Location: Hawaii Range Complex (HRC) (continued)			
Title: **Estimation of Received Levels of MFAS and Behavioral Response of Marine Mammals at PMRF** **Methods:** PAM (PMRF), tagging (GPS LIMPET tags if available), photo-ID, biopsy, visual survey. **Performer:** SSC Pacific; Cascadia Research Collective, and 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 mammals1. #9: Application of analytic methods to evaluate exposure and/or behavioral response of marine mammals to Navy training and testing activities. #10: Evaluate acoustic exposure levels associated with behavioral responses of marine mammals to support development and refinement of acoustic risk functions. #12: Evaluate trends in distribution and abundance for populations of protected species that are regularly exposed to sonar and underwater explosives. #13: Assess existing data sets which could be utilized to address the current objectives[1].	Continuing from 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: **Navy Civilian Marine Mammal Observers on DDGs** **Methods:** Visual observers embarked on DDG during training exercise **Performer:** U.S. Navy and HDR, Inc.	• What is the effectiveness of Navy lookouts on Navy surface ships for mitigation and what species are sighted during sonar training events? (This project spans all Navy at-sea ranges.)	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing range, and in specific training and testing area. #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.	From 2010 to 2020, final reporting 2021

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 and 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: **Navy Civilian Marine Mammal Observers on DDGs**	*(see this project under HRC, above)*	*(see this project under HRC, above)*	*(see this project under HRC, above)*

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 1)	Continuing or Proposed New Start
Location: Southern California Range Complex (SOCAL) (continued)			
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 2020 focus specially on BWs
Title: **Guadalupe Fur Seal Population Census and Satellite Tracking** **Methods:** Tagging, visual survey (land census) **Performer:** The Marine Mammal Center, Sausalito, California	• What is the at-sea distribution of Guadalupe fur seals as the travel through the offshore waters of the SOCAL and NWTT?	#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.	From 2018, ending 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: **Humpback Whale Survey at FDM** **Methods**: Visual, photo-ID **Performer:** HDR, Inc.	• What is the winter occurrence of humpback whales at FDM?	#1: Determine what species and populations of marine mammals and ESA-listed species are present in Navy range complexes, testing ranges, and in specific training and testing areas.	New start: 2020 Jan-Feb survey
Title: Comprehensive Stranding Investigations for MITT and HRC **Methods:** necropsy, disease screening, genetic testing **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 2009 and 2019? • What are the causes of mortality associated with odontocete strandings in the Hawaiian and Mariana Islands between 2009 and 2019? • 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 2017

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: **Sea Turtle Tagging in the Mariana Islands Training and Testing** **Methods:** 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 2015
Title: **Pacific Marine Assessment Program for Protected Species (PACMAPPS) - Visual and Acoustic Survey of Cetaceans for the Mariana Islands** **Methods:** Visual survey, PAM, photo-id, biopsy and genetic sampling, satellite tagging **Performer:** PIFSC Cetacean Research Program	• What is the occurrence, density, and population identity of marine mammals in MITT?	#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.	New for 2021

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 1)	Continuing or Proposed New Start
Location: Northwest Training and Testing (NWTT) (continued)			
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
Title: **Humpback Whale Tagging in Support of Marine Mammal Monitoring Across Multiple Navy Training Areas in the Pacific Ocean** **Methods:** Satellite tagging, photo-ID, biopsy, visual survey **Performer**: Oregon State University	• What is the occurrence, movement patterns, and residency patterns of multiple humpback whale DPSs within Navy Pacific Ocean at-sea ranges (SOCAL, HRC, NWTRC, 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. #3: Establish the baseline habitat uses, seasonality, and movement patterns of marine mammals and ESA-listed species where Navy training and testing activities occur.	2016-2020

Project Description	Monitoring Questions	Intermediate Scientific Objectives (numbered as per Figure 1)	Continuing or Proposed New Start
Location: Northwest Training and Testing (NWTT) (continued)			
Title: **Characterizing the distribution of ESA-listed salmonids in Washington and Alaska** **Methods:** Tagging, visual survey **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 **Performer:** University of Alaska Fairbanks, NMFS Northwest Fisheries Science Center	• What is the distribution, seasonal variability, migratory pattern, habitat use, and population identity of Chinook salmon 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. #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: summer 2020

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

D

Animal Telemetry Tag Types

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

Tag Name	Acronym/ Model	Project #	Use[1]
Acoustic Coded Transmitters	VEMCO, V9 V16	N2, N5, G3	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 ID number which 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 m and 500 m, and the tags have an expected battery life of 172 to 651 days, depending on the battery size and power output (V7 = 136 dB, V8 = 144 dB, V9 = 145 dB) of the tag.
Advanced Dive Behavior	ADB	H6, S7, N1, G1	Provides short-term, fine-scale dive profile information and Global Positioning System (GPS)-quality locations.
Dive Monitoring	DM	H6, S7, N1, G1	Provides intermediate duration Advanced Research and Global Observation Satellite (Argos) tracking and data on dive behavior (duration, depth, and number of feeding lunges per dive).
Dive Duration Monitoring	DUR, DUR+	H6, S7, N1, G1	Provides data on longer-term movements and dive durations. DUR+ satellite tags are also equipped with accelerometers and lunge-detection software to monitor movement behavior.
Flipper	-	M1	The most common tag used on sea turtles. Made from metal or plastic and attached by piercing through the skin of flipper. The tags usually have a unique number on one side, and a return address on the other (in case someone finds the turtle far away from where the turtle was tagged). This tag does not transmit data.
Location-Only	LO	H4	Provides long-term tracking information via the Argos satellite system such as derived location, depth, temperature, light level, and wet/dry sensor. SPLASH and SPOT are specific types of location-only tags (see below).
Passive Integrated Transponder	PIT	M1	Tracks individual organisms (in this report, sea turtles) using electromagnetically-coded glass-encased microchips (i.e., reliable lifetime 'barcode' for an individual animal). Animal has to be caught and scanned; data are not transmitted.
Pop-up Satellite Archival Tags	PSAT	G2, G3, N2	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 satellite 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 SPOT6-275E	S2, S6, N4, H4, M1	Provides data on a variety of measurements, such as temperature, salinity, and depth.

Tag Name	Acronym/ Model	Project #	Use[1]
SPLASH	SPLASH, SPLASH10, SPLASH10-F SPLASH10-F-297A-02	H4, S6, N4	Provides horizontal movement and additional information such as vertical behavior (depth). The SPLASH10 tag includes sensors to measure depth, temperature, light level, and wet/dry periods (to determine surfacing). During the deployment, depth and temperature data are collected, analyzed, summarized, and compressed for transmission through the Argos satellites. The SPLASH10 tag is configured with 1 GB of non-volatile memory available for the archived data. The SPLASH10 tag must be recovered in order to retrieve the entire raw archived data set. The Low Impact Minimally Percutaneous Electronic Transmitter (LIMPET) configuration is sometimes mentioned in reference to SPLASH tag. The tag's small size allows for deployment high on the dorsal fin to enable frequent transmissions to Argos satellites. 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 of time.

[1]References: Mate et al. 2017a, 2017b; Seitz and Courtney 2021; Smith and Huff 2020; https://wildlifecomputers.com